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ARTERIES OF EMPIRE:
An operational study of transport and communication in Angkorian Southeast Asia (9th to 15th centuries CE)

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សរសៃឈាមនៃចក្រភព៖ ការសិក្សាអំពីប្រព័ន្ធដឹកជញ្ជូន និងទំនាក់ទំនងក្នុងសម័យអង្គរ(សតវត្សទី ៩ ដល់ទី ១៤)

និក្ខេបបទថ្នាក់បណ្ឌិត៖ មិតឆែល ហិនឌ្រិកសុន មហាវិទ្យាល័យបុរាណវិទ្យានៃសាកលវិទ្យាល័យស៊ីដនីយ៍

និក្ខេបបទនេះនឹងរៀបរាប់ កែសម្រួលការប្រើប្រាស់វិធីសាស្ត្រស្រាវជ្រាវថ្មីគឺ Operational approaches[1] ដើម្បីសិក្សាអំពីប្រព័ន្ធដឹកជញ្ជូនក្នុងចក្រភពអង្គរ។ ការសិក្សានេះនឹងផ្តោតទៅលើ សំណល់គមនាគមន៍បុរាណដែលលាតសន្ធឹងចេញពីក្រុងអង្គរទៅកាន់មណ្ឌលតាមខេត្តនានានៅអាស៊ីអាគ្នេយ៍ដីគោក។ ការសិក្សាពីជំនាន់មុនៗមក គេតែងយោងលើប្រវត្តិសាស្ត្រជាគោលដោយកំណត់ទីតាំងតាមសិលាចារឹក។ រីឯការសន្និដ្ឋាននោះទៀតសោត សឹងភ្ជាប់បណ្តាញគមនាគមន៍ទាំងអស់ទៅស្តេច ជ័យវរ្ម័នទី ៧ (ឆ្នាំ ១១៨១-១២១៩) តែមួយអង្គគត់ ផ្អែកតាមសិលាចារឹកមួយ។ វិធីសាស្ត្រថ្មីដែលប្រើក្នុងនិក្ខេបបទនេះ ផ្សំឡើងអំពីគោលការណ៍នៃទ្រឹស្តីបទ និង វិធីសាស្ត្រស្រាវជ្រាវច្រើនបែបយ៉ាង មានជាអាទិ៍៖

១. ទ្រឹស្តីនៃភូមិសាស្ត្រគមនាគមន៍ ពោលគឺ ចំណងទំនាក់ទំនងទីតាំង និង តួនាទីរវាងតំបន់សំខាន់ៗ
២. តឹកតាងនៃសំណង់នានាដែលផ្សំឡើងជាបណ្តាញគមនាគមន៍រួមមាន សាលាសំណាក់ ផ្លូវថ្នល់ជាដើម។ ផែនការសាងសង់ រយៈកាលនៃការប្រើប្រាស់ និង របៀបប្រើប្រាស់សំណង់ទាំងនោះ ក៏ជាគន្លឹះសំខាន់ក្នុងការសិក្សាដែរ។
៣. វិធីសាស្ត្រដែលអ្នកបុរាណវិទ្យាប្រើដើម្បីកំណត់ទីតាំង ពិពណ៌នា និង សន្និដ្ឋានអំពីរបស់របរដែលបញ្ជាក់ពីតឹកតាងនៃការដឹកជញ្ជូន (ទំនាក់ទំនង) ពីតំបន់មួយទៅតំបន់មួយ។ ការអង្កេតទៅលើ របាយ អាយុកាល និង តួនាទីរបស់បណ្តាញគមនាគមន៍សម័យអង្គរទាំងនោះបង្ហាញថាមានការកកើតជាន់គ្នាច្រើនជាងលើបណ្តាញដែលមានស្រាប់។
៤. សំគាល់ទៅលើតម្រូវការរបស់ចក្រភពក្នុងការប្រើប្រាស់បណ្តាញគមនាគមន៍ មានដូចជាបន្លាស់ផ្លូវព្រំប្រទល់ និង ការគ្រប់គ្រងធនធាន។

តាមការសិក្សាថ្មីនេះបង្ហាញថា៖

១. ពុំមានគម្រោងរួមមួយ (ប្លង់មេ) ដើម្បីកសាងបណ្តាញគមនាគមន៍ទេ
២. បណ្តាញគមនាគមន៍ ពោលគឺផ្លូវថ្នល់ធំៗ គឺគេកសាងឡើងពីលើផ្លូវចាស់ដែលកកើតរួចទៅហើយពីសតវត្សទី ១១ ដល់ទី ១៣។
៣. ស្ថានីយបុរាណ និង ប្រភពធនធានបង្ហាញថា បណ្តាញគមនាគមន៍ទាំងផ្លូវទឹក និង ផ្លូវគោកមាននាទី និង បម្រើបម្រាស់ផ្សេងពីគ្នាតែបង្គ្រប់ឲ្យគ្នាទៅវិញទៅមក។

ការសិក្សានេះបង្កើតគោលដៅស្រាវជ្រាវថ្មី ដើម្បីពន្យល់ពីនាទីនៃបណ្តាញគមនាគមន៍ ដោយយោលទៅតាមលក្ខណ្ឌ និង ទិដ្ឋភាពផ្សេងៗនៃសង្គមសម័យអង្គរ។ វិធីសាស្ត្រថ្មីនេះ បានផ្សារភ្ជាប់ទាំងតម្រូវការ និង សកម្មភាពនានារបស់ចក្រភពអង្គរ ដោយផ្សំបញ្ចូលគ្នានូវវិធីសាស្ត្រស្រាវជ្រាវទាំងឡាយដែលមាននាពេលនេះ៕

1កំណត់អ្នកប្រែ៖ ពាក្យនេះជាពាក្យបច្ចេកទេសថ្មី ហើយខ្ញុំពុំដឹងនឹងប្រែថាដូចម្តេចដើម្បីឲ្យងាយយល់នោះទេ ដូច្នេះក៏សម្រេចចិត្តទុកជាភាសាដើមដដែល។ ពាក្យនេះអាចសម្រាយមកថា៖ ប្រើបច្ចេកទេសថ្មីដែលមាន ដើម្បីសិក្សាអំពីគោលបំណង និង របៀបរបបនៃការសាងសង់ បម្រើបម្រាស់ និង ការវិវត្តន៍របស់ផ្លូវបុរាណ។

Abstracts

This thesis develops and evaluates the utility of an operational approach to the archaeological study of transport in empires, focussed specifically on the remains of the transport system built by the Khmer Empire (9th to 15th centuries CE) that radiated out from the capital of Angkor to its provincial centres across mainland Southeast Asia. Previous research on the Angkorian transportation system has focussed on culture historical approaches while interpretations of the systemic construction and function are largely linked to one ruler, Jayavarman VII (1181-1219 CE), through a single inscription. The operational approach used in this thesis is derived from an integration of several theoretical and methodological perspectives: 1) Transport Geography theory (i.e., nodes, links, cultural function); 2) historical examples of transport components (i.e., rest stops, roads) and the ‘life-cycle’ concepts that characterize them (i.e., planning, seasonality,); 3) the range of methods that archaeologists use to locate, describe and analyse artefacts of transportation; and 4) identification of the general imperial requirements of transportation (i.e., shifting boundaries, control over resources). A comprehensive investigation of the spatial, temporal and functional aspects of the Angkorian transport system identifies a general plurality of development and function. Results of this study show: 1) there is no single unified transport plan; 2) the transport components, including the routes over which the roads were formalized, were the product of developments between the 11th to 13th centuries CE; and 3) site and resource location indicate that the land- and riverine-based transport systems served different yet complementary functions. From this study new directions for research are identified emphasizing the role of transportation at various scales and in various aspects of Angkorian society. The operational approach is viewed as a vital step in connecting the diverse requirements and activities of empires within an integrated and methodologically-rigorous framework.

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On every path that I took during the last four years I was helped along by individuals who provided me with new direction, urged me forward or forced me to stop when things got lost…after a short respite I was always allowed to continue[1]. Among the numerous people who played any part in getting me to my destination I must recognize the efforts of those whose assistance was most valuable.

As a matter of practicality I would like to acknowledge first the various funding sources that enabled me and my family to move to Australia and undertake my studies. In particular I want to thank the Social Sciences Humanities Research Council of Canada, the University of Sydney and Australian government who graciously offered me scholarships so that I could attend this fine institution. Within the University I must also thank the Carlyle Greenwell Bequest, the Postgraduate Research Scholarship Scheme and the University Travel Grants program. Without these funding sources I would not have been able to obtain the core data sets for my thesis or attend numerous international conferences where I received vital input during the early stages of my studies. I also need to thank the Greater Angkor Project for providing funds to complete my ASTER survey.

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[1] Thanks, Lizzy

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A warning sign has just come up on the screen saying my processor is about to overhea

For Elizabeth

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Chapter 1. The Operational Approach to Studying Archaeological Transportation

> …to a greater or lesser extent, the tyranny of distance affects us all
> Hoyle and Knowles 1992:9

Transportation, movement and communication are ubiquitous and vital components of human activity. Goods, people and ideas are transmitted through space in a variety of different ways at all levels of society. The diversity of scales across which transport operates (e.g., international trade, local trips) makes it an important tool in informing on greater societal interactions with the landscape, both past and present. As societies increase in complexity there is an equivalent rise in the complexity of transportation and communication networks. In archaeological contexts, the study of transportation is slowly becoming *de rigeur* with more and more publications appearing on the subject (e.g., Erickson 2006; Keller 2006; Miller 2006; Snead 2006; Ur 2006). Despite this, the study of transportation both theoretically and methodologically is still in its infancy and most approaches focus on singular (i.e., location, description, analysis) than synthetic perspectives. Currently, there is no cohesive summary of the theories, components and methodological approaches to archaeological transportation on any societal scale, including states and empires. The role of transportation is a critical component in the functioning of empires, which relied on transport and communication in nearly every facet of social reproduction varying from tax collection, military mobilisation and dispersal, and pilgrimage to sacred sites. Surprisingly, given the florescence of recent studies on global empires (see Alcock et al. 2001; Yoffee 2005) few directly address the role of transportation as a structuring element in high-ranking societies (e.g., Barfield 2001).

The objective of this thesis is to address the following issues in the archaeological analysis of transport:

- create an operational approach for the study of transport in an archaeological context
- identify the importance of transportation for the study of past empires

- apply this new approach to the expansive transportation system of the Angkorian Empire, which controlled much of mainland Southeast Asia between the 9^{th} and 15^{th} centuries CE
- offer a new interpretation of the Angkorian transport system and the implications for our understanding of the Angkorian state

The general integration of transport and communication into society creates openings to a vast number of potential research questions. This study of Angkorian system uses an operational approach that is directed toward broad-scale analysis of the spatial, temporal and functional/resources aspects of the transportation system. Discussion focuses on the basic principles of the Angkorian economic, political and religious realms of society. It is not focussed on the specific details of the dynamics and administration of the Angkorian empire. Much of that basic work has yet to be done systematically for the whole of the Angkorian period (cf. Vickery on the pre-Angkorian period [1998]). Rather the emphasis is on an examination of how transportation would have operated to serve the generally recognized demands of the society. Beyond the summary by Im (1999) there has as yet been no comprehensive analysis of the Angkorian transport system. Within this re-examination is the critical investigation of the spatial, temporal and geographic relationships of the transport components and major settlement. The over-arching research question is as follows: Was the Angkorian transport system the product of a single ruler's reign as has been accepted through historical evidence, or was it the result of an accretional process that followed the expansion of the empire throughout the Angkorian period? An important result of this process is the creation of new directions for research emphasizing the role of transportation at various scales and in relation to various aspects of society. A key implication of an accretional process is that the transportation system was integral to the medieval Khmer and its society, not a relatively late imposition and therefore a novel alteration of that state and society.

The Rise of Transport Archaeology

Over the past decade there has been an increasing interest in the study of archaeological transportation. Trombold's edited volume (1991) can be attributed with renewing interest in the subject as it provided a range of theoretical and methodological perspectives of transportation and settlement from a variety of case studies set in the New World. Since this publication, transportation studies have slowly increased in the literature and has been applied to a wide range of different cultural contexts and incorporated new theoretical perspectives (e.g., phenomenological). Miller recently noted that transport archaeology has further divided into studies of movement – the actual experience of travel – versus studies of transport – which often focus solely on the origin and destination of goods (2006:281). Presented together these complementary perspectives represent a *chaîne opératoire* of transport; a researcher must therefore understand not only where something came from but the process of how it was obtained and reached its destination.

The increased interest in transport archaeology is connected to the theoretical and methodological approaches developed over the past thirty years in settlement/landscape archaeology. In order to study the relationships between settlements Clarke (1977) suggested that we must trace the relative movements and flow of activities between structures, sites and resource spaces. A spatial archaeology should also look at multiple scales of activity and recognize that regardless of the level, be it local, regional, or supra-regional, they are interrelated with one another and with the geographic constraints (Ibid.:9). Contrary to this settlement-based perspective, landscape archaeology suggests that the environmental *milieu* should be the basis of study, not just the archaeological remains (Wandsnider 1992:286). A landscape approach, therefore, aims to identify the development across the landscape rather than just the relation to the distribution of the settlement system (Ibid.). Transport, which acts to connect settlements and is also deeply imbedded in its physical surroundings, is therefore subject to these same scales and perspectives.

A second benefit of the growth of landscape archaeology is that the increased number of regional surveys has facilitated the collection of substantial quantities of settlement and transportation data. The importance of combining these two forms of information was recognized by Dowdle in his seminal work on the Arroux Valley road system,

> An investigation of both the road networks and the settlement patterns of an area, using one to shed light on the other, is more effective in creating a complete picture of settlement, land use, and economics than an independent study or either or both (1987:265).

A further advantage for studying transport is the development and accessibility of Geographic Information Systems (GIS). A GIS platform enables researchers to create, collate and spatially analyse the information derived from surveys, literature, or by remote sensing. Since transportation data exist at multiple spatial scales the ability to examine the spatial relationships between roads (regional scale) and sites (local scale) at the same time is a significant boon for transport archaeology. Most uses of GIS in transport contexts, however, have been limited to predictive applications (i.e., Whitely and Hicks 2003). Kvamme has argued that,

> the most exciting developments in GIS are in the analytical arena, for it is here that we actually see new research topics and strategies never before contemplated (1999:156).

While the application of GIS to the analysis of archaeological transport is slowly moving toward addressing these descriptive and analytical approaches of transportation (e.g., Jennings and Craig 2003), the full potential of GIS applications has not been explored. This thesis will demonstrate a range of different analytical approaches using GIS based on archaeological, historic, and geographic information.

Empires in Motion

A transportation approach is ideally suited to the study of complex societies such as states, empires or civilizations. At nearly every turn, empires would rely on some form of communication or transportation such as movement of goods into and out of their territory, facilitating the movement of pilgrims, or enabling armies to quell rebellions in provinces. General syntheses (Sinopoli 1994; Trigger 2003; Yoffee 2005) and comparative works (i.e., Feinman and Marcus 1998; Alcock et al. 2001) discuss the power relationships that enable these societies to florish in great detail. Ironically few of these studies include or focus on the role of transportation in maintaining these power-control relationships. D'Altroy, in the context of the Inka Empire, has noted some of the key points in studying settlement and transportation, namely,

> …we need to recognize that the distribution of imperial settlements and roads in a given region likely balanced regional needs with the strategic demands of administering an extensive, variegated polity (1992:71).

The location of settlement is often connected to the requirements of particular resources found in the landscape. Through their communication networks, empires locate resources in the landscape and establish settlement or mechanisms to incorporate them into their realm of control. An excellent example of a state's knowledge of the surrounding territory and the distance to which it will go to procure goods is the site of Atalla, Peru. Atalla, which is situated near one of the largest sources of cinnabar in the world, was known to the elite of the Chavín culture whose power base was locates some 450 km away to the north (Burger and Mendieta 2002:153). An examination of transport in an imperial context must therefore consider *why* settlements were built in the landscape and also whether it was directly connected to a formalized road system.

Smith pointed out that empires and states are often based on the actions of a single ruler or particular events, such as a conquest (2005:836). She argues that researchers often fail to realize that these events are often the result of routine activities, such as taxation, tribute, the use of infrastructure, and ritual performance, all of which may leave recognizable traces in the archaeological record. In order to understand the development of transport in an imperial context, we need to include the pragmatic and mundane operational activities of the state, as well as recorded events. The reproduction of these activities over time and through space is directly linked to the establishment of routes and the ultimate formalization of transport systems.

Using the parameters laid out above regarding the ways in which empires functioned, we can identify a list of developmental characteristics (i.e., fluctuations through space and time), and general requirements (i.e., economic, religious, political) that impact upon or are impacted by transportation. This operational approach to transportation is a potentially vital means for elucidating how a state controlled its resources, managed its territory and laid out their settlements.

The Angkorian Transport System, Texts and Imperial Issues

The Angkorian Empire (9th to 15th century CE) has been selected for the application of a broad-ranging operational analysis of transportation for several reasons. The primary reason for selecting Angkor is that it has the remains of an extensive road system with abundant infrastructure (i.e., bridges, resthouses, water tanks), which radiated from Angkor to its provincial centres. Research into this transport system has been largely limited to culture historical approaches and interpretations of the construction and function of roads and associated infrastructure are linked to king Jayavarman VII (1181-1219 CE) through a single Sanskrit text, the Preah Khan inscription. Interpretation of the remaining physical evidence of the road system has since been defined more by the historic documents rather than through complementary examination of text and material sources.

This leads to a second critical reason for locating this research at Angkor which is the need for a synthetic and integrated approach to the interpretations and data sets in the existing literature. Over the past 100 years substantial work, mostly by the École Française d'Extrême-Orient, has been undertaken on all aspects of the Angkorian society, including the transport system. Roads have been mapped, infrastructure has been identified and general functions have been ascribed to the overall system (i.e., Lunet de Lajonquière 1902-1911; Albrecht 1905-1906; Finot 1925; Coedès 1940). Yet, other than Im (1998; 2004) and specific studies of bridges (Bruguier 2000) and resthouses (Ittaratana 1998) there has been no attempt to analyse the transport system as an integrated whole. The function(s) of infrastructure and the reasons for the construction of settlements built at the end of a road are often mentioned (i.e., Jacques and Lafond 2004) though there is an apparent lack of rigorous, empirically-based testing of these conclusions in the literature.

A final reason for selecting Angkor is that it has not been considered within the archaeological discussion of global empires. The city of Angkor, situated in north central Cambodia, was the heart of an empire that controlled most of mainland Southeast Asia particularly between the 11th to 13th centuries CE and had all the trappings of any civilization including massive temple structures, a highly organized bureaucratic system, and Sanskrit and Khmer language inscriptions. The concept of empire in Angkor has been specified by historians with an emphasis on defining the chronology (Coedès 1937-

1966; Briggs 1951; Coedès 1968) and developmental stages (Wheatley 1983; Wolters 1999; Kulke 1986). A second wave of scholars (Mabbett 1978; Sedov 1978; Hagesteijn 1989; Hall 1985; Jacques 1986; Vickery 1986; Chandler 1996) has come to focus on the politico-economic aspects of Angkorian history and it is largely from these summaries that most of our understanding of the nature of this society is based. Discussion of Angkor as an archaeological empire, however, has remained isolated from broader operational comparisons with other states in global history.

BP Groslier, one of the most influential Angkorian archaeologists, argued that too much effort had been invested in collecting information and not enough in collating and comparing the data on a regional level (1986:32). His solution was that researchers need to adopt a geographic approach whereby the Angkorian Khmer are examined within their milieu rather than merely through the stone inscriptions that dominate the interpretations of the society (Groslier 1980:216). Stark, and others, have recently called for the adoption of multidisciplinary approaches using a varied range of data sets (i.e., archaeological, art historic, epigraphic, and paleoenvironmental data) to examine the political, social, economic and environmental contexts of state development (2006:409, 422; Fletcher et al. 2003; Fletcher et al. 2006).

Research in Cambodia is somewhat unique in that much of the countryside remains untouched by modern development. The recent political unrest during the Khmer Rouge and subsequent civil wars prevented a comparable re-organization of the landscape that occurred in Thailand. Many Angkorian sites remain isolated with little to no modern human activity to dramatically alter the archaeological record. Combined with the fact that many aspects of Cambodian rural life have embraced traditional technology, such as the ubiquitous ox cart which is seen on the Bayon bas reliefs, it is feasible to extend our view of the present into the Angkorian past.

An operational analysis of the Angkorian transport system combining multiple forms of data (i.e., archaeological, historic, geographic) in a complementary rather than conflicting approach will be applied in this thesis. The benefit of a complementary perspective is that it can add new types of information (e.g., archaeological, geographic) to existing and sometimes deeply entrenched debates that often arise from a single type of information (e.g., histories) and adds methodological rigour derived from logical interpretations. In addition, this approach aims to reveal the plurality of function in the Angkorian transport system and also the plurality of development. The Angkorian roads may have been initially built for a single purpose (i.e., military roads). Over time, however, this usage would have naturally changed to meet the demands of the current cultural *milieu*, just as the usage of the great *baray* (reservoirs) at Angkor appear to have changed over time (Penny et al. 2007; Dumarçay 2003; Dumarçay 1994). This functional plurality is directly related to a plurality of development which sees the transport system as result of repeated episodes of construction, use and abandonment. The application of this operational approach is necessary if we are to better understand the overall importance of transport during the Angkorian period.

The Approach: Operational Empire of Angkorian Transport

This following discussion is divided into three sections: transportation and imperial background, description of the Angkorian transport system, and mapping and analysis of the transport system.

Transportation and Imperial Background

The initial background chapter (Chapter 2) focuses on laying the theoretical and practical background to the study of transportation. This involves outlining the basic principles used in Transport Geography (i.e., nodes, links, cultural applications of transportation). These categories are then examined through a literature review of global case studies. These components represent the range of potential features that any transport system may include and as such act as a guideline for specific evidence in an archaeological context. The final part of this chapter outlines the concepts behind transportation. These concepts refer to the 'life-cycle' of the roads and represent the range of practical questions that can be asked of the component data (i.e., development, maintenance, decay).

Chapter 3 examines the range of approaches used by archaeologists to investigate past transportation systems. The objective of this chapter is to outline the range of theories and methods that have been applied and could be used in any context of road and transport investigation. An important point that will be raised is the general tendency of archaeological transport studies to focus on individual aspects (i.e., location, description, or cultural analysis) rather than an integrated, broad-ranging investigation of each of these different components or elements. The transport network analysis also needs to integrate information on all transport routes (i.e., both roads and waterways) in an overall landscape approach. In this chapter of the study emphasis is placed on identifying the trends in archaeological approaches and the kinds of methods used by archaeologists to address specific questions of the system.

The last chapter in this section (Chapter 4) deals with the theoretical aspects of transportation and looks at the subject of empires. Emphasis is placed on the spatial and temporal dynamics that affect all empires as well as the kinds of cultural mechanisms (i.e., economic, religious, political) that empires use to maintain control over their territories. Again, the emphasis here is on operational characteristics and does not enter into discussions about models of political control or debates about what constitutes an empire. Knowing the range of activities that required communication is sufficient evidence for the study of transportation; knowing how these processes operated is not required in this initial investigation.

The Angkorian Empire

The discussion of Angkor is divided into three chapters. Chapter 5 outlines the geographic and historical setting of the Angkorian period. The focus of this investigation is restricted to the 9th to 13th centuries because the chronology of the latter two centuries of the Empire is less certain, there was no further territorial expansion and substantial construction appears to have dramatically decreased (Jacques and Freeman 1999:13). It is acknowledged that the pre-Angkorian developments during the Funan and Chenla periods influenced the location of early transport and settlement of the later period (see Vickery 1998). However, the road system is, with few exceptions, connected to sites that were built or formalized during the Angkorian period. This investigation of transport is framed between the text-based ‘start’ of the Angkorian Empire, demarcated by the crowning of Jayavarman II in 802 CE, to the successors to Jayavarman VII in the late 13th century. Particular emphasis will be placed on identifying evidence for regional communication for the kings within this period.

Chapter 6 examines the Angkorian period in the context of an empire, specifically identifying the role of the capital, the spatio-temporal dynamics between the reigns of different kings and also the basic cultural mechanisms (i.e., economy, religion, political structure) that would have played a role in its transportation system. This review serves to outline the usual daily business of the Angkorian empire and people; most if not all of which require some form of transport or communication.

Chapter 7 outlines the history of research on Angkorian transport by reviewing each of the components in the transport system. A primary objective of this summary is to identify the critical research questions about the transport network that can be addressed through an operational analysis. This is achieved by integrating not only the summaries of each transport component but also identifying the methodological trends within past research. In particular, this thesis outlines the biases derived from the fact that the entire road system is linked with the reign of Jayavarman VII through a single text, the Preah Khan inscription. Through an operational approach, whereby information is integrated and examined in specific sequence (e.g., spatial, temporal, cultural) the transport information this thesis will demonstrate the inherent plurality of function and development currently obscured by the information derived from this inscription.

Mapping and Analysis

The final section of this thesis outlines three different approaches (spatial, temporal, resource-function) using the principles of the operational investigation of transport. By investigating these different approaches in sequence it is possible to identify not only the individual characteristics of transport (e.g., how it is built? when parts were added? what function did it serve?) but that these results can be integrated to address more detailed questions of Angkorian society (e.g., was it planned? did the spacing of infrastructure serve specific modes of transport?).

Chapter 8 begins with the process of creating a map and an inventory of the Angkorian transport components using remote sensing and archaeological data in a GIS. This follows from Cooley's suggestion that the first step is to understand the arrangement of transportation and then relate this to the society at large (1974[1894]:18). The characteristics and spatial relationships in the Angkorian case study are examined individually and collectively to answer the following questions,

- Are the transport components related to each other spatially?

- Is there a unified transport plan across the Angkorian system?

The temporal analysis (Chapter 9) is directed towards testing the assumptions that Jayavarman VII was largely responsible for the physical remains of the Angkorian transport system. Three separate approaches (temple construction/modification, communication zones, historic events) are applied using a combination of historical and architectural data sets. Each approaches relies on a broader range of historic data with the overall aim of addressing the question,

- Does the bulk of historic and architectural evidence support the notion that Jayavarman VII built the Angkorian road system?

The final analytical approach presented in Chapter 10 examines the physical location of main Angkorian settlements in relation to natural resources required by the Angkorian Khmer. Distance between major provincial sites to economic (i.e., food, tradable commodities), political (strategic access) and religious (sacred topography) resources are used to assess the range of potential functions of the Angkorian road and river systems. The primary questions within this chapter are,

- What resources are within the immediate access of Angkorian sites on and off the formalized road system?
- Does the establishment of major settlement relate to the imperial needs of the state?

Conclusion

The final chapter of this thesis summarizes the results of the spatial, temporal and resource-based analyses in a broader context. The emphasis is upon drawing out basic conclusions but, more importantly, to identify specific research directives that need to be explored to clarify or expand on the outcomes of this research. This discussion will include future avenues of investigation, specifically the introduction of other concepts of transportation (i.e., seasonality, maintenance) and archaeological methods (i.e., absolute dating methods). Further application of multi-spatial, multi-temporal and multi-disciplinary approaches will dramatically increase our knowledge of past transportation at any level of society. This thesis represents a first step towards this broader goal.

Objectives and Limitations of the Study

The objective of this thesis is to clarify the information about the Angkorian transportation system and rethink the preconceived notion of its construction as a one-off event. Discussion of the Angkorian transport system is focussed on the analysis of its spatial and temporal relationships and examines the degree to which it meshed into within the cultural landscape of the Angkorian Khmer.

Ironically, given the vast quantity of historic, architectural and archaeological data available we still have a limited systematic understanding of the actual functioning of the system that would enable a comparative investigation of the nuances of Angkor's imperial activities in relation to other states and empires. This knowledge gap is in part related to two decades of political instability in Cambodia at the end of the 20th century that limited the fostering of research that took place in other imperial contexts. While our knowledge of the politico-economics of pre-Angkorian Cambodia is well documented (see Vickery 1998) a cohesive investigation of the Angkorian period has not been completed. Two essential components required to build comparative models are a coherent understanding of the political economy and quantification of the labour force available to Angkorian rulers for temple and infrastructure projects and for the maintenance of monuments and infrastructure. Lustig's current PhD (n.d.) research is directed towards reconstructing the economic relationships of the empire through an investigation of the epigraphic data sets. Logistics have been dealt with broadly in the context of Angkor's rice production capabilities (see B-P Groslier 1979; Van Liere 1980; Moore 1989; Acker 1998) and basic calculations of temple construction (Groslier 1935; Dumarçay 1971) but has not been comprehensively examined for the whole Angkorian empire. Even a major monument such as Angkor Wat awaits a logistic analysis of its construction and its maintenance. The ability to make systematic, detailed comparisons to other empires is not possible for Angkor at this time but is an important direction for future research. The presentation of data from other empires in this thesis (see Chapters 2 and 4) is incorporated here as heuristic devices to identify the range of components used within past transportation systems and stages of empires (formation-through-collapse) in relation to the general needs for and the effects of transport development.

Summary

Through these various discussions this thesis will illustrate the value in undertaking an operational approach of past transport systems on a regional scale. The benefits of this approach include both a detailed investigation of transport but, more importantly, that this information extends our understanding of the archaeological remains of Angkor's transport and communication system. An operational study of transport therefore offers specifics and general insights about various aspects of past society. Specifically in the case of Angkor it shows that, while past historical approaches made substantial contributions to our understanding of transportation in the region, they represent only one aspect of a more complex picture. A synthetic approach allows the appraisal of previous ideas about transport by using a broader range of data forms and archaeological methods. Transportation systems are the result of accretion processes whereby routes become roads and the function of these connections changes through time. By taking an integrated view of transportation systems (e.g., roads) it is possible to evaluate their primary function but also their interdependence with secondary systems (e.g., rivers). This plurality of function and development is a critical perspective is assessing the dynamic nature of past transport systems.

Chapter 2. Transport Geography, Components and Concepts

> The character of transportation as a whole and in detail, at any particular time and throughout its history, is altogether determined by its inter-relations with physical and social forces and conditions. To understand transportation means simply to analyse these inter-relations
>
> Cooley 1969[1894]:39

The first step in the operational approach to archaeological transport is to identify the elements common to diverse forms of communication and movement in the past. Tenets developed in the discipline of transport geography (Cooley 1969[1894]; Taafe and Gauthier 1973; Robinson 1977; Rodrigue et al. 2006) are adopted here as an abstract framework from which general transportation analyses can be undertaken. Transport geography offers three important elements in this study. First, is that any transport system can be broken down into a series of components – nodes, links – and also can be viewd as complete networks. Secondly, by analysing the relationships between these components we can identify the function of the system. Lastly, transport geography has long recognized that transportation systems develop from and facilitate a variety of different cultural functions (e.g., economic, political, religious and social) simultaneously.

From this theoretical background, a review of the range of transport components (e.g., roads, bridges, rest stops,) is presented from global history. This summary provides a list of the potential features that could be expected in any transport system (e.g., paved roads, watchtowers, rope bridges). The chapter ends with a discussion of the concepts of transportation that govern the life cycle of any road sytem (i.e., planning, distance, maintenance, seasonality).

The Principles of Transportation

Transportation is a ubiquitous feature of human activity that, by definition, involves the movement of goods, people and ideas across the landscape. The selection and functioning of transport is guided by a diverse range of physical and cultural influences. C.H. Cooley's research on the social aspects of transport from the 19th century offers an excellent starting point for this discussion,

> The character of transportation as a whole and in detail, at any particular time and throughout its history, is altogether determined by its inter-relations with physical and social forces and conditions. To understand transportation means simply to analyse these inter-relations (1969[1894]:39).

Nearly a century after Cooley's treatise on transportation, transport geography was finally recognized as a formal subdiscipline of geography, largely based on the idea that transport is ubiquitous and multidisciplinary in nature (see Hurst 1974; Hoyle and Knowles 1992:3-4).

The overarching presence of transportation in every aspect of life presents a daunting methodological task for any researcher. Nevertheless, a set of basic principles of movement are suggested: 1) geographic space consists of points (e.g., nodes); 2) a variety of human activities are conducted at these points; 3) since human wants cannot be satisfied at any one point, there is a continuous need for interaction between points; and 4) the cost of interaction is relative to the distance between points (Lowe and Moryadas 1975:54). In order to study transport we must first reduce it to its basic attributes, essentially exposing the skeletal framework common to all transport networks. The transportation geographer does this first by identifying and examining the relationships between the physical components of transport. Once the skeletal structure has been identified it becomes possible to overlay the cultural and physical processes that led to its formation on the landscape (Taafe and Gauthier 1973:1). The following sections will outline the basic elements of transport geography and its important concepts and examine the different types of cultural impulses that led to its construction and use.

Components and Concepts of Transport Geography

The identification of the basic physical components is the first step in studying a transport system (Taafe and Gauthier 1973:5). Transport geography is concerned with identifying the relationships between nodes, linkages, networks and the modes of transport.

Nodes

Nodes are locations in the landscape where some form of significant activity occurs, originates or ends (Lowe and Moryadas 1975:57). These loci can be settlements, specialized sites (i.e, resource procurement), or rest stops. The importance of a node varies according to its function or specialization; for example, in the modern world this can be the production of manufactured goods, or the provision of retail trade or professional services (Ibid.). The significance of a particular node shifts through time with the corresponding needs of society.

Breaks and Termini

Breaks and terminals are specific types of nodes that play a particular role in the management of space, logistics, and extent of the network. A break is defined as 'an interruption of the movement at least sufficient to cause a transfer of goods and their temporary storage' (Cooley 1969:76). A break may be located anywhere that goods must switch from one mode of transport to another (e.g., boat to land transport, maritime to riverine vessels, or wheeled cart to pack animal). Rodrigue and colleagues use the term barrier rather than 'break' and identify absolute, which require a modal change or detour) and relative barriers, which result in an increased cost friction (2006:9).

Regardless of the terminology employed, two different types of breaks can be identified. The first are physical breaks found in the landscape such as mountain passes, cliffs, or rivers. As a result of these activities a resident population often grows around the break in response to the needs for manpower to function (Rodrigue et al. 2006:126). Cooley (1969:77) argues that commercial cities are nearly always present at or near physical interruptions, which results in the city gaining substantial regional importance. Physical breaks to transportation in a region can therefore be examined to determine how the state dealt with geographic impedances and the nature of settlement at these breaks can be used as an indication of its relative importance.

The second type is the cultural break which is related to commercial or economic requirements whereby ownership of the transported goods changes (Cooley 1969:76). As with the physical break, the cultural break also requires considerable infrastructure to load and unload goods, build storage facilities, and provide shelter and supplies to sustain the travellers. In time, the commercial city becomes a political city, whereby seats of industry and political power emerge as population and wealth flow into the city. The cultural/political break can also occur at the territorial division between two neighbouring groups (Ibid.:76-77).

It must be noted that not all crossings of linkages result in a break in transportation. Lines of transport (i.e., roads) that cross each other do not require the appearance of a break. A break is more commonly a feature such as a topographic shift (e.g., hills) or a water body. In looking for locations to cross these breaks we need to look at most easily afforded routes, such as passes, a suitable ford on a river, or an estuary (Cooley 1969:78).

The other specialized node is the terminal. The distinction between terminals and breaks is arguably somewhat fuzzy, as any end of movement could technically be called a terminal. The difference between them is that the terminal functions to provide a service to a hinterland (Rodrigue et al.2006:136). In this case the terminal is the location from which goods are then distributed to peripheral regions of a state. From another perspective, terminals can also be locations of manufacturing or resource extraction that act as collection points for the movement of goods into the network. An interesting feature of terminals is that they are frequently the largest single users of land in a city or region (Ibid.:130). Again, the size of the site is related to the considerable space required for storage or production of goods (Cooley 1969:78). Discovering why terminals are situated where they are is of particular importance in understanding the development and function of the network itself.

Linkages

Linkages are the physical connections that facilitate communications between nodes. Roads, paths, rivers, canals and ocean routes are all different types of linkages. The type of linkage is normally related to the nature of the communication (i.e., military roads, trade routes). The most important form of linkage in a terrestrial system is the trunk line. The trunk line provides the backbone for regional communication connecting major centres to adjacent settlements through the addition of smaller secondary routes. As with nodes, linkages are not necessarily permanent/fixed features and can be temporary as dictated by geographic or cultural circumstances (Lowe and Moryadas 1975:69). Linkages can also be studied at multiple scales of analysis. For example, a connection between two nearby way-stations is one form of link, while a series of roads that facilitate communication across a region between major commercial centres is another (Ibid.).

Networks

The overall pattern of nodes and linkages in a region comprises the network. Nodes connected by major and minor roads, roads and rivers or ocean routes each represent a form of network. The visible structure of each network varies greatly depending on the linkages and flows between nodes, their nature, size, function, and accessibility to the rest of the network (Taafe and Gauthier 1973:2). Networks appear in a variety of different forms such as radial, dendritic, linear, and grids. The differences between these different types are related to their politico-economic function and geographic stimuli. For instance, a radial network shows greater importance of a single node, the hub, from which all activity enters into or departs from. A grid network, by contrast, shows more heterogeneity in the relationships between nodes.

As with linkages, a network can occur at multiple scales including city, regional or supraregional levels. One of the most important characteristics of the network is that its form corresponds with the territorial structure of the region thereby allowing flows movements to take place (Robinson 1977:5). By studying the network an entire range of cultural information becomes apparent.

Transport Geographers rely on the study of networks to understand the character of a transport system. Network analysis varies according to the kind of attributes being used. The researcher can consider locational (i.e., geographic setting, size, form, number of nodes and links), modal (i.e., the infrastructure and kind, volume and direction of traffic that uses it), or structural attributes (i.e., overall layout of a network) in their analysis of the network (Rodrigue et al. 2005:2:11). Methods developed to analyse networks include the use of graph theory (Taafe and Gauthier 1973:100-116) and measures of centrality involving complex algorithms (see Hensher and Button 2000).

Accessibility

Participation in a regional network is defined by its accessibility. The easier it is to reach a node the more activities will take place and the more people will interact with the node. It follows ipso facto that sites that are distant from the network will not reap the same rewards. The nature of access is strongly influenced by the structure of the network with the result that the construction of routes privileges one node over another (Robinson 1977:65; Lowe and Moryadas 1975:75). Access is therefore one of the most important concepts in examining transportation and transport geographers have developed a means of measuring this attribute.

The means of understanding access stems from a comprehensive examination of the regional network. Robinson (1977) suggests that we start by asking the following series of questions: 1) which are the locations whose accessibility is significant?; 2) in what units is the accessibility to be measured?; 3) what transport mode is being considered?; 4) what is being moved?; and 5) how is the capacity of the networks and modes of transport involved to be included in the assessment? (Ibid.:65-66). The way in which access can be measured should follow these stages: 1) define the study area and selected locations; 2) select the mode of transport; and 3) establish the distance measure (Ibid:73). By adopting this kind of approach it is possible to assess the physical distances between sites and routes of transportation.

It is important to remember that node accessibility rarely remains constant. Its relative access will shift as the regional network develops over time. This raises the question, does accessibility encourage growth and create large towns, or, conversely, does a large town influence the growth of the network and therefore increase regional access? (Robinson 1977:74). The issue of large cities being more connected than smaller towns suffers from a similar circularity; the size of the larger town may in fact reflect growth as a result of transportation, and not necessarily that the site was chosen because it was large in the first place.

Network versus System

For the purpose of this study we need to distinguish between a transport system and the transport network. A formal definition of a transport system is that it is,

> …composed of a complex set of relationships between the demand, the locations they service and the networks that support movements. They are mainly dependent on the commercial environment from which are derived operational attributes such as transportation costs, capacity, efficiency, reliability and speed. Such conditions are closely related to the development of transportation networks, both in capacity and spatial extent. Transportation system are also evolving within a complex set of relationships between transport supply, mainly the operational capacity of the network, and transport demand, the mobility requirements of a territory (Rodrigue et al. 2006:38).

As such the transport system refers to the real-time function and life cycle of transportation and movement through a region. A network is a mechanism for recognizing the spatial relationships and measuring access between locations in space.

This abstraction removes the clutter of how the system functions. In this thesis the focus will be on identifying the transport system as part of the broader operational approach.

Modes of Transport

The last, but perhaps most important element of transportation is mode or traffic that utilized the network. The importance of traffic on a network is summarized by Robinson,

> …mode of transport influences the effect of distance as a resistance, and once a network is established the mode of transport can determine the distance between places in terms of time, cost, energy or effort (1977:55).

Traffic can therefore delimit the physical size of the links and the types and frequency of nodes. Over time, changes in modes of transport may require the establishment of new routes because the initial linkage is poorly suited to accommodate the new modes of transport. It is not surprising then that linkages and traffic are seen as different sides of the same coin with the one directly affecting the other (Hindley 1971:1). In the context of a society with no written record detailing their mode of transportation a detailed study of the physical characteristics of linkages could provide clues to the way that they moved across their routes. A variety of forms can be identified in both land- and water-based modes. Land transport in ancient contexts is broadly divided the categories of animal-, wheel-, and foot-based traffic (see Deloche 1993a). Water transport includes a broad range of different vessel types, use of animals and tracking, which involves towing vessels by ropes on land (see Deloche 1993b).

The abstract components of transportation provide the structural or formal picture of a regional network. Since transportation is integrated into most facets of human activity the true value of examining the physical components of a system is when it is re-integrated with the other subdisciplines of geographic inquiry (i.e., economic, political, regional, historical and population geographies) (Rodrigue et al 2006:3-4). Once the components of transport are outlined they are evaluated in relation to physical constraints such as physiography, hydrography, and climate (Rodrigue et al. 2006:8), and then integrated within the cultural *milieu*, which also influences and is influenced by its construction.

The Cultural Operations of Transport

Cooley argued that transportation was the means toward understanding the spatial organization of society and that its study must include its relations to every social institution (1969:40). In any level of society, the physical components of transport must be evaluated relative to the economic, political, religious, and social dimensions that may have guided its construction. Each of these cultural impulses has different motivations and impacts on the development of networks.

Economic

The need to move material with economic value from one place to another is the most pervasive aspect of transportation. From early transhumance and foraging to the formalized routes of empires, our history is largely shaped by the need for trade and exchange. As indicated above, economic motivation plays a significant role in both the theoretical and practical study of transportation. Geographers have largely pre-occupied themselves with the discussion of economic principles, such as catchment analysis, down-the-line trade networks, and central place theory, to assess the way people place themselves in the landscape (see Robinson and Bamford 1978; Rodrigue et el. 2006). In terms of regional development, the more complex the society the more specialized the network becomes. Production centres and trade routes appear in the landscape to facilitate broader scale redistribution of resources across the region.

We can therefore look at a transport network in terms of the types of goods produced at the various nodes and where, and how, these goods would be moved across the network. A purely economic transport system would tend to be integrative, likely connecting many centres of various sizes in a region. Through time, economic shifts in supply and demand or the introduction of new goods often cause changes in the location of routes and flows of traffic.

Political

Another common function of tranposrt networks is the exertion of political control. Within transport geography military goals of transportation are considered within the political context. The ability to move troops at any time of the year for the purposes of conquering distant regions, controlling provincial territories or defending the capital are all extremely important factors in the development of regional transportation. Military roads are often the first foray into a frontier region, followed soon afterwards by the socio-economic waves of people and goods along them. They are normally very well built and regularly disregard physical obstacles and generally avoid existing settlements (Cooley 1969:45). The flipside is that while the military road provides a means of facilitating attack it also acts as a weakness in defence; the road creates a direct route to the centre (Forbes 1964:11).

On a more general level, it is suggested that while the political state is the most conspicuous form of social unification, transportation is the most obvious example of the state is its physical form (Cooley 1969:104). The extent of roads is likened to the extent of the state. By creating good travel routes to regional centres the state is exerting stronger control over the region than neighbouring powers (Ispahani 1989:7-11). This control can take the form of facilitating royal visits of ceremony, dissemination of propaganda or decrees, and security throughout the region while simultaneously allowing the movement of tribute back into the capital (Cooley 1969:49; Ispahani 1989:2). Trunk lines, the main arterial routes in a region, are often constructed as political markers of territory and provide the basis for most secondary routes in a region. Construction of trunk and military roads, such as those built in Indian and Roman contexts, usually takes place during a period of political expansion or consolidation of an empire, as the capital resources required to build and maintain these routes is substantial.

Religious

The purpose of religious linkages is to facilitate the movement of ideas and people, either connecting settlements with holy locations or provincial communities to a sacred centre. The spread of religious dogma by leaders also involves the movement of holy items, such as books or ecclesiastical documents, in tandem with the regular perambulations of monks or clergy (Cooley 1969:58). The most conspicuous form of religious movement is pilgrimage. The regular movement of people, which can number in the thousands, to sacred locales is a global phenomenon. Intertwined with pilgrims' visitation of holy sites is the occurrence of festivals and location of festivals, which act as a means of diffusing both art and knowledge in addition to religious fervour at the location. Cooley argues that these festivals were among the earliest centres of incipient economic activity (Ibid.:56).

The effects of religion on a transportation network are normally less dramatic than political impulses. Unlike trunk or military roads the character of religious routes can vary from large formalized causeways to the simplest of paths. Bharwaj's (1973) study of

Indian pilgrimage shows that there are ranks of sacred places and corresponding levels of transportation routes.

Social

The least tangible influence on transportation is the realm of social relations. While inherently all aspects of society are affected by transportation, the drive to construct or modify a formalized network is never derived from exclusively social factors. The effect of transport is to reduce the time/distance of moving across the landscape. Roads built in proximity to settlements therefore encourage movement allowing easier communication between families or establishment of new ties between distant regions. Over time the shift in a route may act to compromise or sever families or end dynastic alliances. A further point made by Cooley that is central to the study of transport in this context is that urban locations were established along roadways for specific economic, politico-military and religious reasons (1969:75). For example, sites appear on the landscape because they have access to or can produce a commodity that is valued within the region (Ibid.:1969:82).

Transport Geography Summary

This summary of transport geography outlines the basic framework from which all studies of archaeological transportation can be made. All transport can be divided into its respective elements - nodes, linkages, networks and modes. Each network is subject to specific principles of transportation such as breaks and the limitations of access. Finally, transportation occurs in the landscape as a complex mix of cultural impulses that vary in their intensity and influence over the life-cycle of a network. Each of the cultural forces of transport can have significant influences on the development and use of a network system. It should be noted, however, that it is rare that a single stimulus would be solely responsible for the resultant transportation system. More likely they are a hybrid of varying levels of influence. From this review we can now turn to outlining the different forms that these components have taken in the records of global history.

Components of Transportation: Global Examples

From the review of Transport Goegraphy we can identify three types of physical components (linkages, nodes, modes) that would be part of a greater transport network or system. By reviewing the global examples of transport a comprehensive list of potential components is identified that can be used to assess the range of features one could expect from the investigation of a past transport network.

Linkages: Routes

Routes correspond to the linkages of the transport geographer. A route is the most obvious physical manifestation of a terrestrial network and is the starting point for most historic research into past transportation. Dowdle suggests that a route is,

> is the more complete reality behind a road…a road may exist for a great length of time, but its status as a route is dependent on its use at any particular time (1987:270).

The two main categories of routes that can be identified historically are land and water-based.

Land Routes

Land routes can be divided broadly into formalized (roads) and non-formalized (paths). Roads are distinguished from paths in that they are a prepared zone in the landscape, are generally more direct, show a considerable amount of labour investment and are planned (Beck 1991:67). By contrast, paths are seen as the result of wear. Ur suggests another difference is that roads speak of intentions, while tracks speak of actions (2006:1). The link between them is that they both function to overcome or minimize distances (Trombold 1991a:3). Paths and trails are less visible on the landscape although they would have been just as important as major roads in cultural transmission at local and regional levels. Snead (2002; 2006) has recently spearheaded the importance of studying trails in archaeological contexts by incorporating anthropological ideas related to movement.

Road Construction Techniques

The simplest formalized land routes are cleared or graded surfaces that are often lined with curbs, low or high walls (Beck 1991:75). Cleared roads were a common feature in ancient Egypt (Fenwick 2004; Gates 2006), Dahomey (Alpern 1999:15), India (Deloche 1993a:100), and Peru (Thompson and Murra 1966). Features found in association with these low-lying roads are drains, retaining walls, and steps (Thompson and Murra 1966:634). While the cleared road is not visibly impressive, the feat of clearing debris along the length of a road still requires considerable effort. Examples of cleared paths in

Africa, whose basal soil is extremely hard packed, were extremely effective communication routes (Hester et al. 1970:387).

Roads built up above the surrounding landscape are the second type of formalized land route and include raised earthworks including embankments, terrace ways, and causeways (Morriss 2005:80-100). The most conspicuous builders of artificially raised routes were the Roman engineers and their extensive network of roads in Rome's European provinces. The Great Wall of China, while not a road in the conventional sense, is another impressive form of raised route that served the dual function of a barrier and transportation artery (Luo 2006:46). New World examples are found in the Mayan sacbes (Folan 1991; Shaw 2001) and also the pre-Columbian raised roads in Bolivia (Erickson and Walker 2006).

A typical list of stages for constructing raised roads include: preparation of subsoil, preparation of foundation, and the laying of pavement or 'road carpet' (Forbes 1964:16). A primary consideration of road construction is the ability to drain water from seasonal flooding. Raised roads are therefore designed to deal with water drainage through levelling or the addition of other engineering structures (Ibid.:18). Mayan raised causeways, or *sacbes*, are equipped with culverts to allow the flow of water from one side to the other (Folan 1991:222).

Road Width

The size of a road is determined by and limits the type of traffic that can travel along it. For instance, roads designed to serve particular traffic (i.e., single cart) may not be able to accommodate larger vehicles. This would have a severe impact on march rates, column size, and vehicle wheel gauge of military units (Hassig 1991:22-23). Roads are not universally kept to the same width. Hyslop showed that variability in Inkan road width is related to access and distance to labour, whether the road was built or reused by the Inka, and religious or political purposes (1991:30). Road widths varied for similar reasons within the Roman period, reflecting the function of nodes connected to the network (Hindley 1971:42). A summary of the different roads in global history illustrated in Table 2.1 shows the range of road widths found in historic contexts. The largest roads tend to be those associated with imperial or royal functions and are often greater than 20 m in width. Lay suggests that the most common historical wheel gauge was 1.4 m to 1.5 m, which for a two-way road required a width between 4 m to 8 m; the average footpath required 0.5 m while bridle or cattleways needed a 1 m width (1993:36).

Road Straightness

Since a straight line is the shortest distance between two points, we would expect most connections between sites to be as direct as possible. The ability to build a straight road is largely delimited by the local topography. Topography, however, is not always the victor in determining how ancient groups moved across the landscape. Roman engineers were famed for disregarding topographic features across their empire. The adage 'straight as a Roman road' has generally been applied to the orientation of these roads as they normally follow the most direct route between two points (Margary 1967:504). Straight roads were not necessarily always the most desired form. Chinese roads were often built in a non-linear fashion with numerous bends and turns as a means of avoiding evil spirits who always travel in straight lines (Gregory 1931:114).

Road Surfacing

Surfacing is used to stabilize a road, to reduce wear and make it passable throughout the year. The decision to surface a road requires significant resources to build, both in funds and labour, and then requires a regular maintenance schedule. Forbes (1964:2) argues that artificial roads with prepared and preserved surfaces were a necessity once a civilisation became a large and stable empire. Paved roads enable a centralized government to rapidly deploy troops to hinterlands, or provide a year-round access for the movement of trade goods or tribute. From a political and religious point of view the ramifications of suddenly coming across a paved road would have a profound emotional and or psychological effect on travellers moving into a city (Laurence 1999:9).While paving is not universal it is more likely to occur in empires that are relatively stable or centralized to deal with the significant resources needed to build and maintain a surface.

The actual types of surfacing used historically are quite varied. Pounded bricks, laterite, lime, and mosaics of rough cut stones have all been used historically (Deloche 1993a:113; Gregory 1931:275; Folan 1991:222; Hirth 1982:323). Roman engineers were responsible for the most extensive use of paving which was designed to facilitate the movement of cart traffic (Laurence 1999:62).

Generally speaking the distribution of paved roads is restricted to the vicinity of major cities (Deloche 1993a:114). Processional roads in Persia employed breccia and limestone, both of which were obtained from distant sources. Inside the Persian cities, however, only sun-dried or baked bricks were found or the roads were not paved at all (Forbes 1964:73). Restrictions of the use of paving were also evident in Han dynasty China where only one of three lanes was paved, and this was reserved solely for transmission of the post (Pirazzoli-t'Serstevens 1982:74). Contrary to popular belief paving was also not a universal feature of all Roman roads. In both the Arabian and British provinces there were very few examples of the classic Roman paving found closer to the heart of the empire (Graf 1997:125; Margary 1967:21).

The decision to leave a road unsurfaced can be based on a number of different factors, such as lack of usable material, construction and maintenance expense, emphasis on fluvial transportation, or desire to prevent access into or out of the capital (Deloche 1993a:113-114; Hester et al. 1970:386) Another important consideration is that while paved or surfaced roads allow easier travel for wheeled vehicles, foot and animal traffic are often hindered by the solid surfaces. The use of paving therefore does not necessarily equate to improved functionality. Cleared roads such as those found in Nubia (Hester et al. 1970) and simple embankments are often just as adequate as the elaborately constructed examples.

Water Routes

Water routes such as rivers, canals and oceanic routes have played a major role in human movements for millennia. By constrast with roads, water routes represent ready-made 'paths' that require very little investment (with the exception of canals) to use. The greater investment lies in the construction of boats and abiity to navigate across the water body. For the purpose of discussing the in-land network of Angkor we will restrict the review to the role of rivers and canals.

Rivers are likely the first regional transportation routes utilized by all past societies. Riverine transport requires little initial infrastructure and has the advantage of avoiding physical and cultural obstacles found on land (Cooley 1969:53). It is argued that the great civilizations of antiquity (i.e., India, Egypt, Mesopotamia) arose next to great river valleys, in part because they are more predictable axes of communication than terrestrial routes (see Witffogel 1981; Deloche 1993b:5). Prominent centres found next to such rivers had access to greater trading ranges and established control, be it political, economic or cultural, over a larger area than those without such access (Rodrigue et al 2006:14). Land transport systems are often secondary to main rivers like the Ganges, which acts as the backbone or trunk line for regional transport (Deloche 1993a:114).

River travel is generally slower than land transport but is capable of moving substantially larger volumes of goods. The Roman Empire relied on rivers to supply bulk goods (i.e., cereals, building materials, wine) to their armies and distant settlements in mainland Europe at substantially little cost (Lopez 1956:21; Berry 1987:579). By contrast, goods of greater value were often transported by land (Cooley 1969:37).

Canals also feature prominently in many historic states. The transportation role of these constructed water routes is to extend inland the economy of movement by water, to shorten existing routes, or by-pass rapids or shallows (Cooley 1969:39). In contrast to natural rivers artificial canals require substantial resources and effort to construct. The integration and manipulation of inland water transport at a state level was a long-standing policy of the Chinese dynasties dating back to the control of the Yangtze River by the 3rd century BCE (Leonard 1996:9). The first recorded canal was built in 130BCE in the Han capital region (124km long) (Scarborough 2003:79). Beyond the obvious utility of water transport for troops and supplies, Chinese rulers had to deal with the propensity of their enormous rivers to suddenly diverge from their original course. In several instances rivers have avulsed causing massive, sudden destruction as recorded on the Yangtze in 1194 CE (Harrington 1974:36). This is called avlusion, whereby rivers changing from one channel to another, or abandoning a channel and creating a new one, usually during a single flood event.

Improvements on the Chinese canal system continued to the Yuan-Ming Dynasty Period (late 13th century CE) which coincided with the completion of the 1800km long Grand Canal (Harrington 1974:36; Leonard 1996:28). Begun in the Sui-Tang period (581-906 CE), the Grand Canal created a vital north-south access route to complement the existing east-west river network connecting Khanbalik (Beijing) to Hangchow (Harrington 1974:36). The importance of this canal was such that subsequent rulers continually made additions as a means of symbolically connecting their reign with the imperial control of the past (Leonard 1996:26). The entire length of the Grand Canal was also bordered by a paved road (Harrington 1974:36). This synergy of water and land transport reflects the broader trend in ancient transport that saw the duplication and interconnectedness of different forms of communication.

River networks must ultimately be connected to a terrestrial network (Cooley 1969:37). In northern India the rivers attracted substantial roads either intersecting or running parallel to the water course (Deloche 1993b:37). If they are not interconnected it may reflect the navigability of rivers in a region. Deloche suggests this is why majority of southern peninsular rivers in India were not connected to land routes (Ibid.). Connectivity of rivers to formalized land routes may therefore give an indication about how regularly rivers were used in the past.

Nodes: Support Infrastructure

Roads are only one part of the greater transportation network. While they provide the direction for movement, various forms of support infrastructure are needed to make travel possible – shelter, water, and shade. These needs are manifest in the real world through the placement of bridges, rest stops, water tanks, and trees.

Crossing Water

Rivers and ravines are the most difficult obstacles to land transportation (Deffontaines 1948:357). The ability to cross over rivers is a therefore fundamental requirement of any transport network. The most basic means of crossing a river is at a ford. Fords are points on a river where the depth is low enough to allow traffic to directly move directly across it. The main problem with fords, or riffles, is that they tend to move downstream with the flow of sediment in the river. Because fords are natural crossing points it is not unusual for other types of crossing mechanisms to appear at the same location. Where rivers cannot be forded the simplest methods for crossing are the use of floating devices (i.e., earthen jars, inflated skins, coracles) or the establishment of a regular ferry service (Deloche 1984:1). Animals are also frequently used to move across river. Elephants in particular are extremely useful for crossing bodies of water as they are adept swimmers. Elephants regularly take their riders across rivers and have been know to make oceanic trips up to half a league (ca. 2.4 km) from shore, or even between distant islands (Charney 2004:144).

Depending on the importance of the crossing a more solid bridge may be erected to facilitate frequent use. The simplest types include boat bridges, floating bridges – where wood is laid down transversely on the floating rafts – and suspension bridges (Deloche 1993a:52-61). From a cost perspective these structures are very effective but require regular maintenance. Bridges built by the Inka were made of poles and ropes and needed continuous maintenance (Thompson and Murra 1966:635). In a fusion of animal and simple solid bridges, the Chola king Rajendra was said to have created an elephant bridge whereby his soldiers crossed a channel over the backs of the animals (Deloche 1993a:128).

Permanent bridges fall into two basic categories: wood and masonry. Wooden bridges are often constructed first and are generally adequate for most forms of river crossing (Harrison 1992:249). Timber bridges share the same problem as suspension bridges in that they lack durability and therefore require periodic or seasonal repairs. For the Inkan bridges, obtaining access to wood of an appropriate size to repair bridges was exceedingly difficult in high altitude zones (Thompson and Murra 1966:637).

A ‘permanent’ solution to the problem is the erection of a masonry bridge. Masonry bridges, as a result of their construction material, are the most common archaeological evidence of ancient crossing locations. There are numerous bridge types based on their building material and construction technique; examples from India include *pakka* bridges (stone and brick), stone beam bridges, bridges built on massive hewn piers, bridges on columns, corbel vaulted bridges, and bridges with true arches (Deloche 1984:1-10). It is important to point out that unlike other bridges, the corbel arch is built on architectural and not engineering principles and as a result its massively thick piers restrict larger volumes of water than would a bridge made with a true arch (Ibid.:16-18). The raised aqueduct as built by the Roman is another important structure in the list of bridge types (O’Connor 1993:150).

Like roads, the decision to construct a masonry bridge represents a significant investment of resources. It is therefore uncommon to find stone bridges on every route or even along all parts of a single route. Looking at historic case studies, Chinese masonry bridges are clustered around cities and on important routes (Clark 1991:97,106). The Indian *pakka* bridges are also restricted to special places (i.e., capitals, pilgrimage centres) and did not play an important role in regional traffic (Deloche 1984:1; Deloche 1993b:19). Roman bridge construction is an exception to this rule as they built substantial masonry structures in most of their provincial territories (O'Connor 1993:63-131).

Rest Stops

Once a continuous route is established it eventually becomes provided with amenities for the traffic moving along its length. Categories of structures commonly found next to historic roads include resthouses and inns, postal stations, forts, chapels and shrines. Obviously, the role of these buildings is derived from the cultural role of the route, be it social, economic, political and religious in nature.

Resthouses and Inns

Stops are primarily designed to provide shelter from the sun, food, or security at night. Examples of resting places have been found among the Roman (Chevallier 1976:107-109) and Inkan (Hyslop 1990:278) road systems. However, it is the Indian subcontinent that provides the greatest array of information. The earliest formal requirement for the regular placement of resthouses appears in the 7th Asokan pillar edict dating to the Mauryan period (3rd century BCE) (Farooque 1977:4; Deloche 1993a:142). Indian rulers continued intermittently to build resthouses up to the 19th century (Deloche 1993a:177). The scale of resthouse construction varied considerably within this history. For example, Firuz Sah Tughlak in the 14th century ordered that 200 rest houses be built in Hindustan, while Ser Sah was supposed to have constructed 1,700 buildings of various materials during the 16th century (Ibid.:142,167). The distribution of resthouses tends to be associated with major routes (Deloche 1993a:164-165).

There is a considerable amount of variation in the form of resthouses. Mughal *serai* varied regionally and in relation to the importance of traffic or interest kings or patrons (Deloche 1993a:168). These variations are evidenced in the wide range of physical forms. South Indian rest houses can be constructed from a range materials from structures made of four-post and a palm leaf roof to clay or mud huts to brick or masonry buildings (Ibid.:160-161). The actual form of these latter buildings varies from small three-sided structures with terraced or vaulted roof in the country to large buildings with multiple rooms found closer to main towns (Ibid.:161; Farooque 1977:97-98). The resthouse recently found in Iran was approximately 30m by 50m (Potts, personal communication, March 2007).

Function of Resthouses, Chapels and Shrines

Resthouses in global contexts have been built to shelter people of all levels of society. The primary intent of Indian resthouses was to distribute medicine and food to the poor or to wayfarers that found themselves in difficulty (Deloche 1993a:142). Both Hindu and Mughal kingdoms in India recognized the need for rest houses although they served different purposes. Generally, Hindu resthouses had religious and economic purposes, and had names such as *dharmasala* (resthouse), *punyasala* (house of rest), and *agnisala* (house of fire) (Ibid.:142;166). Indian resthouses were normally built along the great axes of pilgrimage and offered meals to Brahmins and wandering monks (Deloche 1993a:164-165). Mughal *caravanserai* or *serai* by contrast were used solely for economic transactions (Ibid.:160). Serai are therefore more commonly found on trade routes. Resthouses were also built to shelter society's elite. Recent discoveries in Iran have identified a large royal rest house on the Persian road between Persepolis and Lydia (Dan Potts, personal communication, March 2007).

In medieval Europe, chapels and hospitals are constructed at various locations such as along pilgrimage routes, at the head of bridges, in heavily wooded regions and at the top of valleys (Deffontaines 1948:324). After the canonical rules of Charlemagne, the monks living at these institutions were similarly responsible for supplying pilgrims with shelter, fire and water (Ibid.). Smaller shrines are also found along road networks. These shrines were not places to stay but instead represent places to offer worship or reverence. Inkan roads were connected to a series of natural or man-made shrines called *huacas* around the empire (Bauer 1992:185).

Storehouses

Storehouses for food and supplies are also found along roadways. The best example of storage facilities is provided by the Inka, who created a network of regularly spaced storehouses, or *qollqa* (D'Altroy and Hastorf 1984:336). These structures functioned as a means of maintaining reserve materials for trade and tribute (Ibid.:347-348). By contrast with other way-stations, these storehouses were directed toward politico-economic benefit of the empire rather than the needs of the traveller.

Posting Stations and Couriers

One of the consequences of imperial expansion and control is the need to need to quickly transfer information over great distances with relative speed. This led to the organization of human or animal-driven postal or courier stations (Forbes 1964:80). During the Han Dynasty a hierarchy ranging from small posts, postal stations and larger postal centres were used to transfer messages around the country. These latter structures had substantial archaeological footprints consisting of horse stables, an inn for officials and authorized travellers, and also gaols for prisoners in transit (Pirazzoli-t'Serstevens 1982:74). Posting stations were a common feature of Roman design, as evidenced in the mansions found along the roads in Roman Burgundy (Berry 1987:552). The Achaemenid road system similarly had a series of way stations staged at one-day intervals for couriers to replenish themselves between Sardis and Susa Kuhrt 2001:116).

Military Forts

Military forts appear in frontier areas to defend newly acquired lands and protect territories from invasion. Roman forts were positioned at regular intervals equivalent to a day's march along roads and at strategic points in distant territories like Arabia and Britain (Johnston 1979:53; Graf 1997:123-125). A military road with forts is distinct from other routes as settlement normally appears nearby at a later date when the function turns to local and regional economic patterns. Roman camps along the Euphrates River were placed there to keep control of river crossings and natural landforms for the enemy to cross or to obtain supplies for garrisons and posts that rely on local sources (Dåbrowa 1997:111).

Water Tanks

Regular access to water is a universal need for all travellers. Water is used not only for human consumption but to support war mounts and beasts of burden (Charney 2004:192-193). In response to this need, tanks, ponds and wells are often dug near roads or in conjunction with rest houses. The need for water is most vital in hot climates where water is permanently or seasonally restricted. Without artificial water holes a route would be unusable for at least part of the year; as a result they are regularly found across India and the African provinces of Rome (Deloche 1993a:185; Hindley 1971:39). Water tanks can take a variety of forms. Excavated basins can sometimes be lined with stone while other types sit above ground and trap water by large earthen embankments (Deloche 1993a:185). Generally, tanks are rectilinear in shape, especially in South and Southeast Asia. The decision to build tanks adjacent to roads may be part of a state-based regional plan or are constructs made by people who inhabit the immediate area surrounding the road.

Trees

Another practical addition to a road network is the regular planting of trees. Trees provide shade for travellers along the way, a point that would have had significant impacts in regions with hot climates. The effort required to plant trees might seem trivial. However, the act of lining major transport arteries with trees was seen as a feat of exceptional political power. In India, the planting initiative began with Ser Sah (15th c. CE) and continued up to the reign of Jahangir (early 17th c. CE). It was during Jahangir's reign that the entire length of the 1,100km long Grand Trunk was finally lined with trees. This ability to create such immense tree-lined avenues was a political symbol of the king's philanthropy and determination to control the communication lines of his empire (Deloche 1993a:144; 147-149). Religious motivation was another factor influencing rulers to demand shaded roads. Astrologers during the time of Kublai Khan's (13th c. CE) China decreed that the planting of trees along the Grand Canal would provide the person responsible with long life (Harrington 1974:37). Another side benefit of this practice is that the specific types of trees can be planted to serve medicinal purposes or attribute religious significance (Deloche 1993a:144).

Unfortunately, tree-lined roadways have several drawbacks, among them the damage caused to road surfacing by tree roots and heavy drip-erosion from overhanging canopy. Ironically, the benefit of shade provided by the tree canopy can be countered by the fact that it prevents heat and sunlight from drying moisture on unsurfaced roads. Hedges placed on either side of the road are also a detriment as they prevent dust blowing off the worn road surface thereby creating mud during heavy rains (Gregory 1931:275-276). A more significant issue with tree-lined routes is security. Trees shelter bandits keen on pilfering the wares of unwary travellers (Ibid.:275). One solution to this problem was to monitor the location of trees to roadways. In 13th century England, merchants were protected by a statute stating no tree or bush be placed within 200 feet of the road (Lopez 1956:24). Beyond barring the placement of trees near a roadway, their absence from a road may be related to their utility as an immediate resource. In times of warfare in India the tree-lined ways were often destroyed, either to incorporate their raw materials or to symbolically disconnect the road from its political centre (Deloche 1993a:148).

Traffic

While roads demarcate the location of traffic flows it is the actual traffic that would have guided road planning and construction. As discussed above, the type of traffic directly influences road width, the location and gradient of the road, and the need for specific support infrastructure. The range of traffic types developed throughout human history is quite diverse. Mechanical conveyances in prehistoric and early historic contexts include human-powered vehicles (i.e., palanquins), animals (i.e., horse, camel, elephant), and animal-powered vehicles (i.e, chariots, ox carts). Water traffic includes vessels and tracking, which involves pulling vessels on ropes from the banks of the channel (Deloche 1993b:173). Vessels used to convey people and cargo vary from simple craft such as floats, rafts or skin boat, to dugouts, riding on the backs of animals (e.g., elephants) and any number of different boat types (Ibid.:129-143; see McGrail 1985). Tracking involves towing boats using ropes by people or animals from the banks of a channel. This was a common practice in India, often involving up to 20 tow men to track a laden boat to its destination (Ibid.:173).

Transport technology favoured by a state varied from context to context. In India, wheeled traffic was more common in the northern half of the country because roads were well established and regularly maintained (Deloche 1993a:260-262). Some types of transport, such as carts, while popularly depicted on temple walls, were restricted by the distances that they could manage and were never used for long trips (Ibid.:262). The type of traffic used is also connected to the quantity of material being moved. Transport of heavy goods (i.e., building materials, boats, or war machines) required the use of specialized forms of transport such as large barges or wagons with teams of oxen (Burford 1960:11; see Heizer 1966).

Transport Components Summary

This review of components from global history illustrates not only that cultures commonly reacted to meet the same demands of facilitating transport, but that there is a variety of different ways that these requirements are manifest. From this platform is it possible to assess the kinds of features that could be expected in the location of structures within a past transport system. This data provides the baseline for any cultural investigation of transport and can be couched now within the concepts of transportation which represent the ‘life-cycle’ of the roadway.

Concepts of Transportation: Global Examples

Imbedded within the historical components of transportation are concepts that can be examined in relation to the life-cycle of a transportation network. These include:

- Planning – Were roads formally planned in the past or were they slow agglomerations of transport components over time?
- Development – How did the transportation system develop over time? Was it guided by settlement and resource location?
- Extent and Boundaries – Does the extent of the formalized road network correspond to the maximum edge of a state's control? Or is it restricted to the heartland?
- Distance and Speed – How fast could people move across the landscape based on support infrastructure? How were distances measured in the past?
- Seasonality – Did transportation routes and traffic vary due to seasonal differences in weather?
- Maintenance – How much maintenance was required and who funded the work?
- Disuse and Decay – How does a transport network decay or become integrated into other aspects? What are the implications of disuse on regional settlement?
- Reuse – Are the components of transportation reused by later societies? Are the components used in the same way or modified to meet new socio-cultural needs?

By discussing the way that these concepts were manifest in various historic examples a general framework is established for studying the nature of the Angkorian system.

Planning

Planning refers to deliberate placement of roads in the landscape. Unlike paths which develop through habitual use, formalized roads are often the result of a deliberate scheme that requires the need for a specific route or network. Planning seeks to ensure that the network functions properly and is sufficiently standardized to facilitate the state's traffic needs. Evidence of planning can be derived from the physical remains or from historic documents. The Roman network is the most obvious physical example of a well-planned transport system. Road engineering, road dimensions, the inherent straightness of the roads and the avoidance of local settlements in favour of administrative centres are all direct evidence for state-level design. These roads were planned to be indestructible and reliable means of regional communication (Lopez 1956:17). The Inkan royal road system, which extended over 10,000 km, was supported by a suite of imperial features including markers, drains, retaining walls, steps, and paving designed to facilitate the expansion and maintenance of new territory (Thompson and Murra 1966:634; D'Altroy 1992:95).

Historical documents provide direct evidence of a single ruler or state's concern for transport planning. Centralized states often established guidelines to ensure that the system was standardized across its extent. The Hindu *Sukraniti,* a 19th century CE text describing proper conduct for nobility, contains a detailed section about the requirements for building and maintaining a good transport system. A ruler who is to build good roads from his capital ensures that there are taverns, temples and serais (rest stops) for travellers along it (Sarkar 1914:29). The *Sukraniti* also describes the number and different classes of roads (i.e., royal roads, smaller roads) that should be constructed and standards for distance, form and orientation of rest houses and water tanks (Ibid.:34-36; 166). According to Sarkar, the *Sukraniti* shows that ancient Hindus were not transcendental philosophers but recognized the societal needs to effect comfortable transport obligation to the society (Ibid.:35-36).

Development of Transportation

The development of a transport network refers to the manner in which it developed during the initial stages of states or empires. A critical relationship identified in transport geography is that between transport and development,

> …all existing transport networks have been inherited from the recent or more distant past, and not infrequently were designed to serve purposes rather different from those they are not expected to fulfil (Hoyle and Smith 1992:12).

From an archaeological perspective the way of determining how networks developed is to assess the nature of the nodes connected by the roads. This discussion requires delving into the complex relationship between routes and settlements. The initial goal of a transport route is to connect specific locations. Reasons for integrating these sites and the flow of communication along these routes vary depending on the particular circumstances at a particular time. As such we can identify the influence of sites on transport and the inertia of transport on new settlement.

Pre-Existing Sites

Sites are included into networks because they have something required by the state, such raw materials, political/strategic significance or sacred locations. From the economic perspective the need for mineral ores, for example, or prestige items leads to the development of a small community near their source. These small communities become responsible for the extraction, crude processing and distribution of materials to outlying communities and major centres (Cooley 1969:67-74). Strategic locations such as passes become primary targets for control which often forces leaders to create access routes to ensure the stability of the region. Sites with religious importance similarly draw local communities and routes develop with the annual perambulations of pilgrims (see Bharwaj 1973).

Transportation Stimulus for Settlement

Sites are also created as a result of the imposition of a transport network. Main routes, such as trunk roads or military roads, act as gravitational forces for settlement and secondary transport networks. These new routes heavily disrupt both pre-existing settlement and movement patterns in a region (Ward-Perkins 1962:398). With the appearance of new roads there is normally a corresponding drift away from old centres of population to new settlements growing up along them. It is important to note that while most of these new settlements are reactions to shifts in regional economics, the state can also be responsible for the location of new sites (Ibid.). The importance of road infrastructure such as bridges and resthouses acts to pull people toward them and it is common for new villages to appear within their vicinity (Deloche 1993a:164-165).

Generally, such major shifts in routing are rare and only affect regional settlement patterns when they prove more advantageous for movement (Robinson 1977:27). The main reason is that the cost of shifting land routes is prohibitively expensive. As discussed for bridges, it is easier to follow a longer path that can cross water barriers than it is to build a more direct road with no extant crossing. A less costly (and less archaeologically visible) shift might involve the transition from land- to water-based transportation. River systems or coastal resources are not barriers to travel but are an attractive option over the more costly and less secure land routes (Dobson 2005:11). Some states, like ancient Egypt, relied almost solely on water transport and as a result settlement was oriented toward the river and the region of seasonal flooding (Hassan 1997:52). Land transport was poorly developed in these regions.

Development in Imperial Contexts

Development of transportation systems occur in episodic or continual processes. Examples of transport changes are highlighted briefly within the Roman Empire and Post-Roman Period, Indian Empires, Chinese Dynasties and Inkan Peru.

Roman Empire and Post-Roman Europe

The Roman transport network, which extended further than any other in ancient history, was the result of episodic development over its 600 year duration. Few roads were built during the initial stages of the Roman Empire and there was a general lack of construction during the Civil War (Forbes 1964:125). The times of greatest development – during the reigns of Augustus, Claudius, Vespasian, Titus, Domitian and Nerva – correspond with periods of expansion and stability (Ibid.:127-128). By contrast, no roads or repairs were effected during times of unrest experienced under Nero, Galba, Otho and Vitellius (Ibid.:128). The greatest extent of Rome's network and the end of further road projects was reached during Hadrian's reign (Ibid.). In summary, Roman building appears to have coalesced between 400 BCE and 200 CE, while the provincial road system was constructed between 200 BCE and 200 CE (Ibid.:126-129).

Because Roman roads were originally planned to meet military concerns and not economic activity, they were constructed with little regard for existing regional patterns. Subsequent placement of Roman sites in a newly acquired region was guided by such factors as proximity to fords on the main river, the presence of an intersecting route with the main Roman road, location on a geological interface, or next to a river (Berry 1987:553). Roads and Roman *fora*, or markets, built in new territories were not linked to settlements; however, populations soon gravitated toward the major line of communication in the region (Laurence 1999:33).

Oscillation in the importance of Roman roads was a recurring theme from the fall of the empire (5th century CE) up to the rise of the Renaissance (14th century CE) in mainland Europe. Byzantine rulers continued to use Roman roads although their importance was much reduced. The reason for the Byzantine movement away from the Roman roads was related to their upkeep; cities were unwilling to commit resources to fix the roads and there was a lack of skilled labour to properly affect the repairs (Haldon 1999:51-52). The great burden of maintaining the roads and changes in traffic types led to the abandonment of these routes. Lopez argues that it was the lack of decent roads that led to the disintegration of the Carolingian state in the 9th century CE (1956:20). The need for centralized power to maintain the Roman routes is a recurrent theme. Cases where the local power was sufficiently centralized (e.g., England) or cities directly linked to the roads (e.g., Italy) experienced continuity of usage. In France, however, power was not centralized and as a result new roads developed more frequently and rapidly to connect centres aligned to one another (Ibid.:19-21).

Shifts in the mode of transportation, specifically the adoption of river travel, are another important characteristic of post-Roman transportation. Rivers became the predominant form of transport across Europe between the 5th to 10th centuries (Lopez 1956:21). This trend towards 'fluvialization' of transport in the Middle Ages was not restricted to Western Europe; shifts also occurred in Northern and Eastern Europe, Arabia, India and China (Ibid.:22). The later Middle Ages saw a return to the dominance of land transport with new roads being constructed to cope with the types of traffic and goods being moved. The lack of a powerful centralised state, the fact that slavery had largely disappeared and the rise of the merchantile class eliminated the need for large scale formalized routes. As conflict developed between medieval states detours around unfriendly territories began to multiply across the landscape. However, this eventually changed during the Renaissance when there was a rekindled desire, and ability, for construction of the straight line and monumental highway (Ibid.:21-28).

Indian Empires

From the Mauryan (3rd century BCE) to the Mughal period (16th to 18th centuries CE) transportation was a primary concern in the sub-continent. Roads and infrastructure were built and repeatedly used in the region, and the routes taken by sovereigns and traders were thus well-adapted for long-distance travel from an early period. As with the Roman period, the construction and maintenance of roads was not consistent. Following the demise of the Mauryans it was not until the Pallava rulers (9th century CE) that a resurgence in road construction and maintenance occurred (CRRI 1963:14). Political instability again played an important role in the lack of road construction in South India during the period between the collapse of the Vijayanagara Hindu empire (16th century CE) and the invasion of the Maratha (17th to 18th centuries CE) and Mughals (16th to early 19th centuries CE) (Deloche 1993a:74-75).

Chinese Dynasties

Sudden additions to the transport network have also been described in imperial China. The Han rulers of the Wudi period (104-87 BCE) were responsible for the construction of an elaborate road system for military purposes that were unrivalled by any but Rome (Pirazzoli-t'Serstevens 1982:16). Clark's (1991) study of Chinese economics and networks between the 3-13th CE shows that there was an important period of bridge building during the late Song Dynasty (12-13th CE). These constructions parallel a time of greatest economic expansion and also a massive agrarian shift from traditional subsistence to market economy (Ibid.:95). Perhaps the greatest example of slow accretion processes is the Great Wall of China which was completed over two millennia beginning with the Spring and Autumn (8^{th} to 5^{th} centuries BCE) (Luo 2006:42).

Inkan Peru

By contrast with the long durations of the previous examples, the Inka expanded their empire using 10,000 km transport network within a span of 70 years between Ecuador and central Chile (D'Altroy 1992:95). This network, too, was based on the bones of past constructions made by the Wari, Moche and Tiwanaku (see Beck 1991; Schreiber 2001). It is interesting to see the impact of a short-lived state on the transportation network. The Inka contribution was to add administrative centres (*tampu*) and storehouses (*qollqa*) along the newly unified main road (see D'Altroy and Hastorf 1984; D'Altroy 1992:95). Like the Romans, the new sections of highway bypassed much of the local population which acted to supply the storehouses built along the roadways (Ibid.:97).

States Without Formalized Transport

Formalized road networks are not always recorded for highly organized societies. This is not because they did not require communication systems, but instead makes the point that transport development varies depending on several factors. Forbes notes that while both the Persian and Greek empires had roads their physical footprint on the land was marginal and therefore we have no lasting traces today (1964:72; 96). Topography (i.e., mountains), lack of consistent centralized control or reliance on water transport can all be cited as contributing to this apparent lack of formalized communication routes (Ibid.).

The objective of this brief summary is to highlight that transportation systems develop from different origins, at different rates and in relation to different requirements. Roads were constructed by empires as basal systems (Roman Europe) that became used for centuries while others exploited and formalized pre-existing transportation routes (Inka). An important characteristic that binds these examples is the increase in transport construction during times of expansion (Augustan Rome; Song China; Inka). Transportation systems, however, are not universal for state-level societies and rarely access all sites within an empire's territory.

Extent and Boundaries

Generally, boundaries of ancient control are not physically defined, requiring us to conceive of them as nebulous political, economic and social boundaries (see Van der Leeuw 1981:294; Marquardt and Crumley 1987; Stark 1998). A potential solution to this problem is to consider the remains of transport. Ispahani has suggested that the road network is the skeleton of the political region controlled by a given kingdom (1989:6).

By studying the extent of a formalized network we can posit the approximate size of the territory that is directly controlled by the state. For example, 23,000km of Inkan road network stretched along of the Andes while 84,800 km of Roman road extended over Europe, the Middle East and North Africa (Hyslop and Rivera 1984:39; Hindley 1971:25). Single roads, such as the Grand Trunk road in India, can also indicate the primary zone of control. This road extended over 1,100 km, connecting the northwest frontier around Lahore to the Ganges delta (Deloche 1993:148). The question that rises from this is obvious: does the visible road network with its associated support infrastructure accurately reflect the extent of an empire or region of state control? Smith (2005) recently discussed the issue of mapping the regions of imperial control. The general practice in archaeological literature is to define maximal areas based on the 'edge' of archaeological evidence. Smith (2005) urges against the use of 'amorphous blobs' and suggests that extent of transport networks is a better indicator of internal diversity. The termination of the road could thus be used as a means of delineating the core from the periphery of a state. Many boundaries should be represented as 'fuzzy' lines rather the exact borders.

Unclear boundaries are not always the rule. The extent of the Roman road system, for example, truly represented the limits of their political influence (Nicasie 1997:455-456). Beyond this 'border' was a zone of commercial activity, but there was no physical extension of Roman control into this zone (see Curchin 1997). Rivers were another major boundary chosen by the Romans to demarcate their territory (Hodgson 1997:62).

An important consideration when demarcating the boundary of a transportation network is *when* it reached its maximal extent. It can be argued with some certainty that while the largest network likely corresponds with the period of greatest expansion and centralized control, it is not necessarily true that this occurred at the end of that period. This is directly related to the dynamics of road building and the fact that the visible remains can represent several different construction periods. Dating the dynamics of the physical transport components through historic or archaeological methods is therefore paramount.

Distance and Speed

Knowing how far or how long it will take to move between settlements or nodes are important issues in facilitating state control. The limits of travel appear in two formats in the historic literature: the spacing of infrastructure or the speed at which traffic can move in a single day.

Distances and Spacing

D'Altroy argues that distance is best conceived in terms of transport costs and communication capabilities (1992:20), as these factors can be easily applied to an examination of military logistics and ease of economic and political integration (1992:20). For example, it has been suggested that provision of cities with perishable agricultural commodities in the past would be limited to a radius of about 50km (Rodrigue et al. 2006:14). Societies therefore adapt to these restrictions by placing markers and support infrastructure along their networks.

Erection of road markers or mileposts is the simplest and most common method of notifying the traveller about their current location. In order to control distance and identify space, rulers incorporated markers at specific points along road networks. This requires that the centralized authority develop, and disseminate information about, a standard method of measurement. For example, Mughal monarchs developed the royal *kos* while the Romans used the mille to delineate space (Deloche 1993a:150; Morriss 2005:238). The actual markers used to demarcate distance in India ranged form of rectangular pillar stones, raised stones, or small stacks of stones and many of these techniques date back to the Mauryan period (Deloche 1993a:151). The actual placement of such markers also varied from region to region. In Nubia, sandstone road markers along cleared roads were found at 1.2-1.5km intervals, the same distance used by Roman builders in Europe (Hester et al. 1970:385).

Resthouses, post and way stations are also placed at regular intervals to break up the journey between primary centres. Table 2.2 shows the range of distances for *serais* and post from historic contexts. Even with the maximum (42 km) and minimum extremes (0.8 km), the mean distance for these rest stops is approximately 20 km.

Speed

Speed is the temporal concept of travel that is relative to the mode of transport used to span the distance. Unlike distance, which is determined by the placement of infrastructure, speed is derived from historic documents or limitations of individual forms of traffic. Deriving speed from historic studies is established by dividing the total distance of the trip by the number of days required to complete the journey. For example, the Royal Road in Persia connecting Sardis Ephesus to Susa, a distance of 2,600km, was traversed by special messengers in nine days, while a regular army would take ninety to cross the same distance (Forbes 1964:80). The messengers would have travelled at 288km/day while the army moved at 29km/day. Another trip between Susa to Babylon was travelled in two days, at 100 miles (161 km) a day. The reason this was possible was due to numerous staging posts which housed a sizeable stable of horses (Hindley 1971:21). Roman messengers, travelling by relay vehicles and draught animals could cover between 50 (80 km) and 80 miles (128.9 km) a day, which means that news could be sent out from Rome to most towns in Italy within five days (Laurence 1999:81-82). Other examples of historic land speed travel listed in Table 2.3, show that the majority of these rest stops are positioned much closer than the Roman messenger service.

Beyond the addition of sails and extra oarsmen, speeds of water transport are largely dictated by the actual flow and direction of the watercourses or seasonal weather patterns in the case of oceanic routes. Deloche’s (1993b) study of Indian water transportation provides excellent examples of speeds which are described with other historical examples in Table 2.4.

Load

A more complex aspect of traffic speed incorporates is the issue of load capacity. The weight of goods that a vehicle can be burdened with directly impacts on its speed and the distance travellable in a day. Historic records offer a list of goods that were moved between locations. From this information, archaeologists and historical geographers have attempted to reconstruct the effect of loads and calculate maximum distances for that particular mode of transport (i.e., Drennan 1984). Examples of the range of weights carried by vehicles in historic contexts are presented in Table 2.5.

Seasonality and Cultural Cycles of Movement

The ability to travel year-round is largely predicated on the impact of seasonal climatic fluctuations. Two aspects that can be discussed within this subject are firstly the physical effects of seasonality on transportation and navigation and secondly, the cultural responses (e.g., activities in the seasonal round, festivals, etc.) developed within this yearly cycle.

Physical effects on transportation routes include such natural impedances as snow, mud slides blocking passes, or floods. Generally, it is assumed that the impact of these phenomena is much greater on unpaved roads and paths than on paved roads (Haldon 1999:53). Since the focus of this discussion is sub-tropical Southeast Asia, we can ignore the role of cold weather factors and focus instead on the influence of the monsoon.

Within a monsoon climate both the wet and dry seasons produce dramatic conditions that seriously affect the way people move around the landscape. Generally, the most favourable months for travel and communication are the first half of the dry season (December to March) as the latter part of the dry season (March to June) is the hottest time of the year (Deloche 1993a:277). The greatest concern for land transport during the dry season is access to water. As a result, routes are constructed to take advantage of natural sources (i.e., springs, ponds) or are supplemented through the construction of artificial holding tanks (i.e., wells, tanks).

Ironically, the lack of water in the dry season is the greatest adversary for movement during the wet. Soil conditions and agricultural practices are directly related to the type of road conditions in these regions. Heyne argued that in areas of sugar and rice agriculture roads will be narrow and bad during the rainy season, while elevated areas with sandy soils will have good roads throughout the year (see cf. Deloche 1993a:279). Soils that have low permeability, very often with a low sand content, are largely impassable for pack or wheeled traffic during this season (Ibid.). The cultural reaction to conquer high water levels is through roadway improvement. A raised road made of stable, permiable soils shortens the distance between sites and also facilitates year-round social contacts (Hassig 1991:22). Generally, however, these routes are likely to be used only for short distances and are normally well maintained only in proximity to towns or villages (Deloche 1993a:146). The switch from embanked to low lying road may also reflect the nature of the soil being crossed.

Seasonal shifts are not restricted to land routes. River navigability is affected by the velocity and discharge of the river, gradient and depth of the river bed, formation process of alluvial deposits, strength of currents, direction of prevailing winds and the ability to use tracking (tow ropes) (Deloche 1993b:171;6). In the rainy season, surging rivers are often too dangerous to use. The Romans attempted to use water extensively in their Arabian provinces but this was often restricted to seasonal traffic and was only practical downstream (Dåbrowa 1997:109). Low water and sand bar formation are the greatest obstacles during the dry season, which means that cargo would often have to be transhipped from large to smaller vessels with shallower draft (Deloche 19093b:37).

Cultural Practices and Seasonal Cycles of Movement

As a general rule, the movements of pre-industrial societies were strongly influenced by seasonal changes. During the Indian monsoon there is a general reduction activity (Deloche 1993a:274). Both state and individual transport needs are affected and therefore adapt to these constraints. Military excursions might also be restricted by season unless a formalized road could take traffic all year round. The dramatic effect of seasonal change is demonstrated in Hannibal’s losses to snow over the Alps on his way to sack Rome. In Southeast Asia, most land based military forays were timed to avoid the rainy season (Charney 2004:191).

Trade and movement of goods were also affected by the ability to move and also the availability of goods. Within the calendar year, one of the most important limitations to regional movement is the agricultural cycle. Travel is restricted not only by the physical ability to undertake journeys but also the seasonal preoccupation with agricultural work. We therefore need to consider the amount of time required, in the case of rice, for growing, transplanting, weeding, harvesting and processing and how this fits within the monsoon cycle. From this perspective, transportation is often linked to those times of year where it is economically feasible – after the harvest (Hassig 1991:22). If a capital is reliant on agricultural goods from a distant province it is crucial to take into consideration the seasonal constraints on growing, processing, and moving goods across the landscape. A network built to facilitate this purpose could therefore reflect the time of year when movement was most crucial.

As agricultural practices develop it is common to see the development of religious festivals and pilgrimages that coincide with particular times of the agricultural calendar. Pilgrimage is a global component of religion that normally takes place during specific times of the year. The dry season is the slack agricultural season in monsoon regions and so pilgrimage during this season does not interfere with agricultural activity (Bhardwaj 1973:220). Hindu tradition actually views the wet season as unfavourable for travel and there are no religious processions at this time (Deloche 1993a:274). The dry season therefore provides better conditions both climatically and economically for the practice of religious perambulations.

Maintenance

One of the disadvantages of constructing and relying on a route is that it must be maintained in order to function. This is aptly stated by Forbes,

> The road is…drawn into the vicious circle of development of means of transport and perpetual upkeep of the surface, from which there has been no escape to the present time (1964:2).

Cooley even suggests that for the Roman and Peruvian roads, ‘if a single mile is unpassable there might as well be no road at all’ (1969:105). The extent of political control is therefore delimited by the accessibility and completeness of the road network. If one centre is taken away, like a damaged electronic relay, control over the distant areas will be impossible. While this viewpoint is somewhat extreme, it reflects the need to continually fix and upgrade routes.

Damage to transport routes can be caused be several forces, including seasonal weather, traffic, trees or deliberate destruction. Seasonal monsoons and other weather conditions (e.g., winter freeze-thaw action) can have deleterious effects on any form of road. Roads composed of less durable materials are susceptible to erosion and have to be rebuilt. Regular repairs are even required of the paved *khoa* roads in India at the end of the rainy season (Deloche 1993a:113-114.). A direct result of the massive investment required to maintain these *khoa* roads is that they are often found only near cities where access to materials and labour was sufficient (Ibid.:114). Generally, the more important the road is to the centralized authority the more likely that it will be maintained on a year-to-year basis. Strategic roads were also more regularly maintained during the Byzantine period (Haldon 1999:53).

Historic documents list military engineers and maintenance crews whose job it is to level ground, remove obstructing trees, break stone boulders blocking a route, fill in low land, and construct boat bridges (CRRI 1963:16). Often only those roads travelled by the king were well maintained and therefore traffic often tended to stick to these routes (Deloche 1993a:122). An extreme example of this was recorded in the kingdom of Dahomey where the king’s royal road was kept completely bare of all grasses or other vegetation (Alpern 1999:20).

Funding

The issue of who provides the resources to repair roads depends largely on who constructed the network. In the case of military roads, armies are largely responsible for providing the necessary labour and resources. Historically the other methods for obtaining funds for road maintenance are religious commitment, corvée labour, taxes on landowners that abut the roadways, local community tax, funding initiatives, and tolls to use the roads (Lay 1993: 99-104).

Roads in the Chinese countryside were the responsibility of local rulers and their communities (Gregory 1931:117), and a similar situation was found in India (Farooque 1977:13) and Rome (Laurence 1999:54). Religious personnel, such as monks or clergy, were commonly associated with the improvement of highways and infrastructure in many Buddhist countries (Deffontaines 1948:358) and during the Middle Ages in Europe (Gregory 1931:96; Cooley 1696:57).

Funding requirements also extend to the servicing of infrastructure as well. Rest stops must be allocated with sufficient resources (e.g., foodstuffs, medicines, etc.) to continue serving travellers along the routes. Resthouses in India relied on charitable donations or the revenue of their lands to stay open for weary travellers (Deloche 1993a:163). Donations to these institutions could also come from kings, queens, rich land owners or merchants seeking religious merit (Ibid.). The construction or regular maintenance of bridges was also part of the donations from wealthy individuals in medieval England (Gregory 1931:97). In Peru, wooden bridges were the responsibility of the local peasantry on a rotational basis (Thompson and Murra 1966:637).

Labour

Maintenance requires access to physical labour. Estimates of how many labourers were needed in the past are obviously related to the scale of work required. For example, during the time of Aurangzeb (late 17th CE) the Indian royal roads required some 1000 labourers to clear the all of the roadways (Deloche 1993a:120).

Labour can be divided into unskilled and skilled categories. In India, the source of general labour can be extracted from corvée labour, or in some instances criminals or debt-owners (Sarkar 1914:35). By contrast, skilled labour is often a recognized position in the state hierarchy. Road builders appear in the Ramayana (*Yodha-Kanda*) as part of the army, and were responsible for making new roads and fixing old ones (CRRI 1963:16). Officers in Mauryan India (4th to 2nd BCE) were placed in charge of repairing paved and unpaved roads and also erecting mile posts along the routes (Hindley 1971:18). Jahangir (early 17th CE) specified that craftsmen, stone-cutters, carpenters and navvies were sent ahead to repair a route in Kashmir (Deloche 1993a:120). Similar specialists were employed by the Roman and Assyrian armies (Deffontaines 1948:357; Forbes 1964:71). Ultimately, the lack of such skilled labour can be extremely detrimental to imperial goals, and is cited as a reason for the decline of the Roman road network during the Byzantine period (Haldon 1999:51-52).

Water Transportation Maintenance

By contrast with roads, rivers and lakes require very little effort to maintain. The most significant impact on transportation comes from the shifting of river sediments. The temporary solution for this problem is to dredge the river, removing sediment within the channel and allowing water to flow. However, in Roman Gaul the need to constantly dredge a river ultimately led to the river being abandoned by imperial interests (Berry 1987:580). It is possible that rivers may have been abandoned as links in a region. Canal maintenance, however, necessitates a comparable level of investment to roads. In China, successive emperors paid substantial attention to their water ways, spending tax money to construct dikes, dredge sandbars, maintain sluices and replace ferry cables (Harrington 1974:12).

Disuse and Decay

A route's life in the transport network comes to an end when either traffic ceases to flow along it or maintenance of the road stops. Both factors can result from a shift in either the economic role of the route or a dimunition in the authority of the centralized power responsible for its construction. Disuse can come about as a result of the following:

- Inability of local communities to maintain bridges and roads;
- Decrease in need for long distance travel (i.e., economic/political relations with distant centres);
- Deliberate closing of roads to prevent plunderers or invaders;
- Shift in settlement pattern away from road to agricultural lands (i.e., away from upland to river valleys);
- Movement away from wheeled traffic. Foot traffic prefers firm ground rather than hard stone surfaces ;
- Local reuse of stone from road surfacing for domestic and farm purposes (Lay 1993:57-59).

Another factor that can be added to this list is the construction of new roads. The effect of these roads leads to a slow accretion of settlement along the new route and an abandonment of the old roads (Ward-Perkins 1962:398).

Roads that are abandoned fall into a steady state of decay. Margary identified a natural progression of decay with specific events and some of their effects in the context of roads in post-Roman Britain:

- Wooden bridges disappear (if locals did not fix the bridge the road would become useless)
- Washouts would occur in hilly districts (severing the road at culverts and creating awkward obstacles)
- Trees would be blown down in forest districts (blocking further passage)

- Roads become ‘neutral’ property breaks
- Metalling surfaces wear away (rutting the surface and making it impassable) (1967:23)

Given the varied types of disuse and evidence of physical decay, Hassig argues that studying why a road was abandoned is as important as understanding its continued use (1991:32). This applies to roads that are not currently in use. The fact remains that many roads formalized in the past (e.g., Roman) are still used as the backbone for modern transport. Once established, formalized roads are rarely abandoned completely.

Reuse

The majority of transport networks are inherited from the past. The reason that roads are used continuously is often dictated by physical characteristics – such as following the easiest or most direct path established in the past – and through historical considerations such as exchange patterns within a region (Rodrigue et al. 2006:11-12). Other factors that guide re-use are connection to important nodes, network durability, and physical extent. The legacy of Roman roads in Europe is the best example of reuse. Beyond the sheer strength of the roadways, it is the spread of Roman roads that has led to most later transportation networks using them as the regional template (Cooley 1969:47). This relates also to the presence of infrastructure such as bridges which acted as the best means of crossing riverine obstacles (Lopez 1956:17). Interestingly, the Romans also reused and upgraded the existing transport corridors made in prehistoric Gaul (Dowdle 1987:291).

The assumption is that the reuse will always focus on the most highly advanced or expansive roadways. However, this is not always the case. Following the collapse of the Roman Empire, the inhabitants of Etruria returned to the settlement and movement conditions that prevailed before Roman incursion into the area (Ward-Perkins 1962:400). Similar upgrades have been identified on Mauryan period roads (4th – 2nd centurie BCE) by the Guptas (3rd – 5th centuries CE) and then the Harsha rulers (early 7th century CE) (Farooque 1977:4). Inkan highways were also a product of re-integration from earlier periods (D’Altroy 2001:210).

Often it is the resilience of the infrastructure that leads to network reuse. Harrison's (1992) study of British bridges raises the important point that while medieval roads were quite poor constructions the routes maintained regional traffic flow because of the quality of bridge infrastructure. The ability to easily cross a river was deemed more valuable than construction of a more direct route that had no practical means to cross the river (Ibid.:255-256). New bridges were therefore only built if the network demanded higher volumes of traffic, access to new locations or if the river itself changed its course (Ibid.:255-259). Where these bridges collapsed, locals often reverted to earlier technology, such as ferries or boat-bridges, which were less difficult to maintain (Lopez 1956:19-20). In both instances the crossing point was deemed the lynchpin for a route.

Summary

This review has served to outline the basic elements for the study of transportation. Using the principles of transport geography, a transport system can be broken down into a series of components. Through the examination of transportation in global history, it is apparent that each component can take a variety of forms and that the extent and number of components constructed in each example often differs. Regardless of these differences, the fact remains that the study of transportation must begin with a discussion of its basic components. The final part of this chapter introduced the general concepts of transportation. The importance of explicitly identifying the stages in the life-cycle of a road is that they represent the framework on which any investigation of transport must be based. An examination of the relationships between transport components tends to be couched in terms of one of the concepts of a road's life cycle. For example, the spatial relationship between different nodes (e.g., resthouses, wells) may indicate an overarching plan for transport infrastructure. The study of trade along a route relies on the concept of distance and speed. An investigation of whether a road was developed for military purposes must incorporate the issue of planning. A final point to be made is that several concepts (e.g., seasonality, decay) involve the impact of environmental variables. While abstracted in the form of nodes and links, a transport system is ultimately imbedded within and relates to its immediate landscape. Whether explicitly or implicitly described, the concepts of transport are a crucial aspect of any investigation. The following chapter outlines the methods commonly used in archaeological investigations of transport.

Chapter 3. Archaeological Approaches to Transport

Moving from the basic components and historical examples of transportation we can now examine the range of approaches applied in archaeology. From the perspective of the scales and the units we study transport is unique in archaeological discussion as there are individual artefacts that range from the site (i.e., bridges, resthouses) to region (i.e., roads) and supra-egional scales (i.e., networks, systems). The formation of each of these components and the scales that they operate in can also be examined in terms of multiple cultural stimuli factors. As a result the study of archaeological transport is potentially as vast as any other sub-discipline. An important distinction is made between studies of trade, which focus on the end points, and transport, which emphasizes the way that goods, people and ideas are moved across the landscape. The chapter will outline the development of transport archaeology and also highlight some of the important theoretical concepts incorporated from other sub-disciplines (e.g., settlement/landscape archaeology) and the introduction of new methodological approaches (e.g., GIS). The remaining discussion outlines the trends in archaeological studies of transport, which can be divided into three types of investigation: location (i.e., mapping, survey), description (i.e., physical, temporal) and analysis (cultural function).

Perceptions of Archaeological Movement: Trade and Transport

Within the archaeological literature a formal division can be made between the indirect (i.e., trade goods) and direct (roads, infrastructure) study of past human movement. Archaeologists have long focussed on indirect movement through analysing trade and exchange in past society. Snead makes this point quite clearly, that archaeologists have typically been interested in what happens at either end of the journey and not in the journey itself (2006:1). Movement is implied through the study of production, procurement, and sourcing of artefacts recovered from the archaeological record. Artefacts, such as ceramics (e.g., Nichols 2002), metals (e.g., Burger and Mendietta 2002) and lithics (e.g., Yacobaccio et al. 2004) are used as the baseline for establishing connections between points in the landscape. Rarely do these studies investigate venture *how* goods were moved between locations (see World Archaeology 1993 volume 24[3]).

In situations where trade maps are published the connections are normally represented using a series of straight lines that, as Close argues,

> …tells us only the shortest distance between source and artefact; they say nothing about the pattern of human movements (2000:51).

Another traditional approach of the archaeologist has been to emphasize a route that follows logical topography for long-distance travel (Snead 2006:1). This perception of the route does not take into consideration the practicalities of movement. That being said they do provide the basal connection from which more detailed investigation can take place. These routes are heuristic devices for future research.

Finding the Way: Transportation and Movement

The archaeology of transport is concerned with what happens 'along the way'. Gates argues that the road, often discarded for lack of archaeological value, can provide important cultural information by examining its construction and documenting the kinds of interactions that took place along it (2006:315). While roads had been recognized in the past there was little theoretical or methodological development to integrate them into general archaeological discourse. The recent upswing of interest in roads and transport is largely attributable to Trombold's (1991b) edited volume on roads and settlement hierarchies in the New World. This book established detailed terminological and typological parameters for transport (i.e., Hassig 1991; Trombold 1991b; Earle 1991) and provided a range of approaches from the study of formalized roads (Trombold 1991b; Gorenflo and Bell 1991) to simple paths (Sheets and Sever 1991; Sever and Wagner 1991). The archaeology of transport has only recently been solidified as a distinct sub-discipline.

Important Benchmarks for Transport Archaeology

Two important developments that have solidified the archaeology of transport are the establishment and incorporation of approaches established in regional archaeologies (i.e., settlement/spatial/landscape) and the development of new technologies capable of dealing with the varied nature of transport data (i.e., remote sensing imagery, GIS).

Settlements and Landscapes

As discussed in Chapter 2, regional perspectives are a vital part of archaeological study. The regional theories adopted in transportation studies have their basis in settlement and landscape archaeologies. Settlement archaeology, as defined through Willey's (1953) Virú Valley project, considers information from sites to infer site location and function in a settlement system (Wandsnider 1992:286). In order to study the relationships between entities at this level we must, as Clarke suggested, trace the relative movements and flow of activities between structures, sites and resource spaces (1977:8). The settlement archaeologist needs to recognize that the multiple scales of cultural activity (local, regional, supraregional) are interrelated with one another and to geographic constraints (Ibid.:9). By contrast, landscape archaeology emphasizes the importance of considering natural landscape rather than just the archaeological remains (Wandsnider 1992:286). The landscape archaeologist aims to identify development of a settlement system in relation to environmental *milieu* in which it is set (Ibid.). The theories of landscape archaeology also seek to move beyond the material record to assess the phenomenological aspects of a site's context (see Tilley 1994; edited volume by Ashmore and Knapp 1999). A site is viewed relative to its emic importance and meaning within the landscape and shapes and is shaped by the cultural group living within it.

Regional approaches provide an important range of theoretical and methodological concepts that can be readily applied in the archaeology of transport. Reflexivity of scales, recognition of the dynamic between landscape and material culture, and the examination of meaning are all important aspects of ancient transport studies. Attempting to extract the meaning of transport and movement has been advocated specifically in the study of trails and paths (i.e., Snead 2002; Sheets 2006). Snead's (2002) work in the US Southwest seeks to extract the social meaning and value of movement. This approach reveals the basic elements of movement that would affect individuals travelling on paths, trails or royal roads. Ideas crafted within the archaeology of transport should not be separated into paths versus roads but should be included in a holistic perspective. Many of the same principles of roads apply to their less formalized counterparts.

New Technology for Transportation Research

It can be argued that one of the limiting factors for archaeologists studying transportation is dealing with the scale of transportation remains. The extent and potential variability in structures and geo-cultural stimuli are extremely vast. Advances and increased availability of technology for locating and analysing transport have dramatically increased over the past decade. As will be discussed in detail below, declassified imagery and new remote sensing imagery from satellites have greatly expanded our ability to locate and contextualize roads. The development and accessibility of GIS programs is the other significant advance for the study of ancient transportation. A GIS has several important advantages. First, the researcher is able to integrate digital information such as remote sensing imagery with archaeological (i.e., sites, artefact distribution) and geographic (i.e., topography, rivers) data sets. Second, this information can be used to create accurate maps of archaeological transport systems (see Altawheel 2005; Jennings and Craig 2003; Jennings 2006). Last, and perhaps most importantly, GIS contains a range of spatial analytical tools that can be displayed in a graphic format on top of the mapped region as opposed to separate statistical tables.

The application of GIS to transportation studies has emphasized the role of predictive modelling. Cost surface analyses that produce a best fit line or identify a transport corridor have been the most common applications of GIS (i.e., Limp 1991; Douglas 1994; Whitely and Hicks 2003). These studies have emphasized the role of topography and only recently have attempted to incorporate cultural factors of movement (see Belcher et al. 1999; Bell and Lock 2000). Instead of finding the shortest distance between point A and point B, Anaya (2001) used cost surface models in conjunction with textual and geographic information to predict the location of a ‘lost’ Mayan city. Viewshed (study of visibility between points in the terrain) and line-of-sight analyses have also been used to study transportation both directly as travellers move across the landscape (Mack 2004) and indirectly from the perspective of settlement (Madry and Rakos 1996). Mack’s (2004) application of Viewshed analysis evaluated the flow of pilgrims and control of visibility through the city of Vijayanagara. A potentially invaluable yet largely untested set of analytical tools for archaeological inquiry is found in the subdiscipline of GIS-Transportation (GIS-T). This sub-discipline was developed specifically to deal with modern transport systems and deals with assessing logistics and distances/timing along routes, an approach known as Linear Referencing (see Miller and Shaw 2001). Aspects of GIS-T will therefore play an important role in this thesis, though the goal is to incorporate the techniques and not focus on the specifics of the technology.

A further technological advance that has greatly increased the ability to record road data is the widespread use of Global Positioning Systems (GPS). The real-time mapping of sites roads (as tracks) and sites (as points) allows the surveyor to produce an exact map of the transport network as he/she travels along it (i.e, Johnson and Wilson 2003; Fenwick

2004). This digital information is easily integrated into the GIS platform for future analysis.

Location

Location, or discovery is the first step in any study of roads and transportation and it is important that all segments of a road network are known before any kind of descriptive or analytical investigation can begin (Trombold 1991a:2). Sources available for archaeologists include remote sensing data (aerial photographs and satellite imagery), ground surveys, site locations, historic documents and place names. In all instances as many different approaches as possible should be employed.

Remote Sensing: Aerial Photography and Satellite Imagery

The development of aerial photography during World War I led to a renaissance of archaeological field survey and greatly aided our ability to identify sites and communication networks (see MacLeod 1919; Crawford 1923; Reeves 1936; Williams-Hunt 1949). Various formats of aerial photographs (e.g., black-and-white, colour, colour-infrared) have played a primary role in mapping roads and trails in the US Southwest (Obenauf 1991; Motsinger 1998), Costa Rica (Sheets and Sever 1991), northern Peru (Beck 1991) and pre-Roman Burgundy (Madry 1987). In addition to their relative affordability and excellent resolution, aerial photographs require substantially less 'interpretation time' than the more complex satellite data.

Developments in satellite technology over the past 15 years have greatly increased the quality and availability of data acquired from space (see Lillesand and Kiefer 2000). Archaeologists are now able to access a range of imagery that includes the conventional visible spectrum as well as thermal, short-wave, thermal infrared bands. The various formats of satellite imagery offer a range of resolutions, based on pixel size (e.g., 1 m, 5 m, 90 m). While many formats are not useful in identifying site level features, the regional scale of roads allows use of a wider array of remote sensing applications. Studies focussed on roads have used CORONA (Kennedy 1998; Kouchoukos 2001; Ur 2003; Altawheel 2005), radar (Madry 1987; Sheets and Sever 1991), Thermal Infrared Multispectral Scanner (TIMS) (Sever and Wagner 1991) and aerial photographs (Madry 1987). Advanced Spaceborne Thermal Emission Resisitivity Radiometer (ASTER) data, which will play the major role in mapping the Angkorian landscape in this discussion, is a relatively new technique that has been applied by Altawheel (2005) to map hollow ways in Mesopotamia and Jennings (2006) as a backdrop for locating settlements in the context of Middle Horizon Peru. While many studies emphasize a single type of remote sensing imagery, the best results are obtained through a combination of multiple data sources as they serve to cross-check the interpretation of features. Access to high resolution imagery provided by the GoogleEarth website offers researchers an excellent means for corroborating purchased data sets.

Historic Documents

Texts and maps are common starting places in the search for both visible and destroyed roads (Dowdle 1987:285). A distinction can be made between original sources, such as royal decrees, and secondary sources, which include records from later states or traveller's accounts. Original sources that directly discuss transportation are rare in the archaeological record. A few empires, such as the Persian Achaemenid (Kurht 2001:116) and Romans (see Chevallier 1976; Dowdle 1987:273) have substantial written records detailing the planning, construction and use of their transportation network. Second-hand accounts, which include retold histories, traveller's records and maps, are more easily accessible to archaeologists working outside the Classical world. Documents such as Marco Polo's (1903[1254-1323]) travels along the Silk Road give first-hand evidence of life on the road and its location. Hyslop and Rivera's (1984) survey of the Inkan highway in the Atacaman desert relied on the early accounts of 16th to 17th centuries CE (1984:36). Using either original or secondary sources has inherent biases for investigating transport. Royal decrees may outline exactly when a road was built by a particular king; however, the road may have been built previously and the record is merely an upgrade as a display of power. Roman emperors constantly rebuilt the existing roads as a symbol of continuity to the past and demonstration of their power that continue as a political symbol into the future (Laurence 1999:39). Second-hand accounts may be more culturally 'neutral' in describing the components of the road, in a context where modern development has destroyed the evidence. Many of these interpretations are laden with personal biases and incorrect assumptions of road function.

Toponyms

Roads can also be identified by locating modern place names that refer to ancient transportation on modern maps. A village with a name suggesting an old path or crossing may indicate that the site was part of a past transportation system, even though its physical remnants may have disappeared today. The use of toponyms is a common method in Roman studies (see Chevallier 1976:127).

Site Locations

Termini and evidence of transportation components such as bridges and resthouses are commonly used to define the location of a route. End points include production and consumption sites identified in trade networks or sites of similar ages within a region. The use of transport components to identify roads is summarized in Deloche’s discussion of Indian water tanks,

> …should the ensemble of these works (tanks) be represented on a map, it would be seen that they form a dotted line, quite slack in the arid region but becoming denser in the humid zone, running parallel to the lines of the road network (1993a:184).

Studies have relied on bridges (i.e., Clark 1997:107), storehouses (Hyslop and Rivera 1984; D’Altroy and Hastorf 1984), canals, and walls (Beck 1991:69) to indicate the presence of a past route. Not surprisingly, this approach has been widely applied in a variety of archaeological regions including Greece (Fracchia 1986), Roman Israel (Dorsey 1987) and the US Southwest Obenauf 1991:38).

Ground Survey

Ultimately, the most important phase of locating roads is ground survey which serves to verify that features identified from remote sensing or historic sources are, or are not, visible on the ground. The nature of roads is such that they are often well-suited to ground surveys; if a road is in good condition it can be followed directly along its length. Extensive ground surveys of ancient roads have been undertaken for Persian and Roman roads in Anatolia (Starr 1963), Inkan roads in the Atacama Desert (Hyslop and Rivera 1984) and Roman roads in Nubia (Hester et al. 1970). There are two problems associated with ground surveys. The first is the converse of remote sensing: we often cannot see the road properly during ground surveys because it is too big. Methods for recognizing the roads during surveys can be borrowed from the list identified by Margary (1967) during his surveys of Roman in Britain. He identifies the following features to indicate a road in the landscape:

- Presence of embankments
- Faint ridges in the ground (i.e., wear from cart tracks)
- Traces of paving (i.e., metalling, gravel, slag, stones) or hard surface beneath the ground
- Shallow hollow caused by removal of road for stone or cultivation
- Presence of slight terracing on a hillside
- Ditches, often filled over time, would show excessive growth
- Derelict roads, covered with soil would have parched grass in dry times due to stoney underlayer
- Hedgerow (tree) lines (Ibid.:25; 513)

Variations of these characteristics should be identifiable outside the Romano-British context as road-building leaves similar traces. Beyond verification, Hyslop argues that comprehensive field survey is a critical element to determine why some segments are apparent in aerial photographs while others are not (1991:31). Ground surveys allow archaeologists to record the different road construction techniques and also learn what kinds of environmental characteristics led to its preservation or destruction (Ibid.). As mentioned earlier, most survey today involves the use of GPS systems. Data collected from a GPS can be used to test the accuracy of data mapped initially from remote sensing imagery.

A second problem in undertaking ground-based road surveys is the sheer effort required to complete the task comprehensively. Roads can span enormous distances and it may take several field seasons to properly cover its entire length. A further complicating issue is whether the road can be directly surveyed on the ground. Many roads are overgrown and are inaccessible except by foot. In Cambodia the existence of land mines is a serious safety issue.

Summary of Location

An effective methodology for locating past routes should combine each of the methods listed above in conjunction with data relating to the environmental and topographic context (Hyslop 1991:31). The number and combination of different approaches used in the location stage is largely restricted to the availability of remote sensing imagery and the research goals of the project. The benefit of using multiple forms of survey data is that they provide a reciprocal verification of the objects mapped during lab and field research (Dowdle 1987:292).

Description of Components and Networks

Once the components of transportation are located the next phase is to describe their basic character. Individual components, such as the links (roads, canals) and nodes (resthouses, bridges) can be described in the same manner as a more conventional artefact (see Clark 1977:8-9; Van der Leeuw 1981). Since these components are related to each other in a broader network they can also be investigated at this broader scale.

Artefacts of Transportation

Like portable artefact analysis each transport component can be described in terms of size (i.e., length, width, height), architectural style, and construction technique. Studies of road construction can also involve locating the source materials. For example, Capedri and Grandi (2003) used chemical and petrographic analysis to determine the location of paving stones used to surface Roman roads. In addition to describing the structures themselves, archaeologists employ excavation to recover evidence of the remains around each component (i.e., ceramics, architectural evidence, pollen, etc.). This evidence of cultural activity contributes to a greater understanding of how and when the structure was occupied in the past and how it functioned within the broader transport system.

Traffic is another facet of transportation that has been evaluated through archaeological investigation. These studies are particularly relevant when situated within broader conceptions of past movement. As discussed in Chapter 2, the development of roads is tightly linked to the traffic demand at the time of construction and physical evidence of track rutting has been used to identify the most common type of vehicles in ancient Greece (Pike 1967) and the Indus valley (Law 2006). In cases where vehicle tracks are not available archaeologists have used the characteristics of transportation – road width, spacing of resthouses, paving type, trajectory or directness – to hypothesize the type of traffic and its limitations. General studies of the limitations of transport costs (see Limp 1991; Brannan 1992) have been undertaken in Mesoamerican contexts (Drennan 1984), the US Southwest (Malville 2001) and the Great Basin (Jones and Madsen 1989).

Network/System Description

Describing the network involves the overall shape of the transport skeleton and the synthesis of all of its requisite parts. Following from the discussion of network analysis applied in Transport Geography (see Chapter 3), an archaeological approach to description should examine the: 1) network pattern in terms of variables such as connectivity and centrality; 2) magnitude of transported volume of goods measured by width and wear of roads; 3) types of facilities constructed, including roadbeds, steps, ramps, bridges, causeways and drainage culverts; and 4) labour invested in improvements (Earle 1991:11). Earle adds that we should measure variability along the road in relation to environmental variables (i.e., topography, hydrology, surface conditions), the economics of transport (i.e., types of goods/people moving, technology of transport) and the organization of society (Ibid.).

In examining the network without the influence of cultural forces archaeologists tend to focus on measuring the relationship between sites connected in a regional network. These studies have normally employed measures of centrality and Graph Theory (i.e., Gorenflo and Bell 1991; Santley 1991; Jenkins 2001). However, other models such as location-allocation have been applied (Bell and Church 1985; Jennings and Craig 2003; Jennings 2006). A side effect of these studies is the development of distance measures within a network. By comparing the location of roads, road infrastructure and the hierarchy of settlements (based on size) within the restrictions of traffic, topography and resources it is possible to produce a model of minimum and maximum distances needed for regional communication (see Bell and Church 1985). It is from these distance measures that we begin to unravel the logistical considerations of past communication systems.

Description of components and network is a crucial step in the archaeology of transportation. However, in order to move beyond cataloguing towards reconstructing the networks we need to add the element of time (Dowdle 1987:270).

Temporal Approaches to Transportation Networks

Any study of transportation networks is limited by the ability to distinguish temporal change. Unfortunately, the issue of dating roads has vexed archaeologists seeking to define specific periods of use. The age of a transport network is normally derived from absolute and relative dating techniques.

Absolute Dates

Absolute, or calendrical, dates for roads are derived from direct historic records written by the road builders themselves or via scientific analysis of construction materials. Historic records can take the form of maps or decrees that outline the construction efforts of a particular king or ruling group. This type of data is not available to all groups but is common among several Old World empires such as the Road books of Rome (see Chevallier 1976) and Persian histories (Kuhrt 2001:116).

In absence of historic evidence the archaeologist can utilise scientific techniques such as isotopic (commonly radiocarbon or ^{14}C) and luminescence (thermoluminesence or optically stimulated luminescence) dating. The greatest problem with ^{14}C dating is that the average date is often not suitable for establishing detailed chronological ordering of a transportation network. For example, the 1-sigma range of a calibrated date empire and therefore would not be useful in contexts such as the Inka which lasts only 80 years (see Stuiver and Reimer 1993; Hyslop 1990:3). A good carbon sample, however, that is properly calibrated could provide a date range of 40 years. A further complication for using ^{14}C is the availability of datable material. Some roads do not have definable strata in their sections and, perhaps more importantly, since road embankments are often constructed of material sourced from adjacent soils. Organic material incorporated into their structure, therefore has no value for dating the construction event.

A more promising technique is luminescence – either Thermoluminscence (TL) or Optically Stimulated Luminescence (OSL). TL relies on heat-sensitive signals while OSL measures the decaying energy (light) ratios in quartz grains (Roberts 2005:297). The target materials used in these approaches – minerals rather than organic matter – suggest that luminescence studies could be favourably applied to the study of transportation. Historically luminescence dating (typically TL) has focussed on pottery (e.g., Mazess and Zimmerman 1966) but recently the role of OSL has also increased utility within the realm of settlement archaeology in several regions (i.e., Australia [Roberts et al. 1998], North America [Feathers et al. 2006], and Europe [Lang and Wagner 1996]). While roads have not been directly examined with OSL, recent studies have been applied successfully to dating canals in southern Cambodia (Sanderson et al. 2003) and dams in south-central India (Shaw et al. 2007). OSL testing could be extremely useful in sampling roadways that are built up from surrounding soils that are exposed to sunlight during re-deposition.

Unfortunately, this process would require numerous samples and, given the cost of OSL dates at present, would be extremely prohibitive. In the future, application of luminescence dating to date transportation could have an important impact on the chronological ordering of roads.

Relative Dates

While the absolute dating of transportation has some inherent difficulties Chevallier provides a more positive outlook for relative dating,

> …relative dates can perfectly well be obtained by a little logical reasoning when we examine the relationships between two or more features in the landscape (1976:124).

Relative dating of transportation focuses on the cross-cutting relationships between roads and the places that they connect; the date is derived from sites that are attributed to particular periods (Schreiber 2001:72). Obviously, these relative dates must rely on some form of absolute dating technique that has been applied to different parts of culture’s material remains. An advantage of roads is that, since they span such great distances, we need only observe the multiple connections between one road and other roads and sites to establish some form of chronological control (Beck 1991:70). Cross-cutting relationships are the most common form of dating roads and involve an examination of road layout, association with agricultural sites, details of construction (i.e., engineering and planning), and settlements connected to the roadway (Schreiber 1991:244; Beck 1991:70; Fracchia 1986:444-445; Dowdle 1987:291). Given the potential problems associated with absolute dating road embankments, it should not be surprising that relative dates are the most commonly applied method. The source of these relative dates is largely derived from artefact studies from individual sites. Ceramic seriation, art historic periods, and architectural styles of monumental buildings are all used to provide chronological information to the site.

A key factor for successfully using relative dating, and in particular cross-cutting relationships, is that researchers must undertake complete surveys of every feature that comes into contact with the road (Beck 1991:70; Hyslop 1991:32). Hyslop adds that this process would be greatly helped by the publication of associated materials from surface collections or excavation (Ibid.).

The Issue of Reuse

The major limitation of any dating technique is determining what point in a road's life we are studying. The subject of reuse has already been discussed as an important concept of transportation in Chapter 2 and archaeologists have developed different means of dealing with this problem. Roads are difficult to date because they span large distances and are inherently diachronic – most are not the result of a single act of construction, use and disuse. This process applies to the entire network as well,

> all the roads that existed in the most highly developed phase of a given period were not necessarily in use at the same time, nor did they all come about at the same time or for the same reasons, or operate at the same level throughout the period (Dowdle 1987:270).

A road may thus experience numerous re-workings by the group(s) that built it, experience periods of disuse and later be incorporated into a new group's transportation network. Hassig argues that reuse is most common when the prior roads serve the same terminals in the later period (1991:25).

The impact on archaeological chronology is obviously substantial. Reuse can cloud the physical evidence from historic records which claim that roads were built by particular rulers. Schreiber makes the important point that it is not who built the roads but who used and maintained them that is important (1991:251). A road that is continually used however is less easily dated from recovered sherds or through seriation techniques (Hyslop 1991:31-32). Again, the most appropriate method is to use settlement-archaeological methods to prove this connection.

The best practice for identifying when a road was used is to examine the construction record of associated structures (Dowdle 1987:291; Hyslop 1991:31). By slowly building up the amount of information at the site level it is possible to combat the issue of re-use and get a more concise picture of the chronology of the greater network. The Andean road network is an excellent example whereby associated infrastructure demonstrated reuse, or later amalgamation. While originally associated with the Inka their network was actually built up through routes developed by the preceding Wari (Schreiber 2001) and Moche (Beck 1991) cultures.

Analysis of Transportation

Deriving the cultural significance of a transportation network is the last stage of investigation. Having answered the where, what and when questions we are left with addressing why the transportation network was constructed. Archaeological studies have emphasized the same range of cultural stimuli as discussed in relation to imperial power – military, economic, political, religious. A fifth approach that transcends imperial concerns is the social and phenomenological roles of transportation and movement.

Military

One of the initial reasons for constructing a road network is to facilitate military expansion. Military networks tend to be straight, well-built, and often avoid previously settled communities. The classic example of this type of militarily-derived network is the Roman system (Margary 1967:18). Roman engineers disregarded topographic constraints such as slope and tended to follow tracks where visibility was of greater concern than access to economic resources. In the New World, networks that show evidence of military logistics and planning have been identified among the Aztecs (Santley 1991), around La Quemada in Zacatecas (Trombold 1991b), and the Wari and Inka of Peru (Schreiber 1987). Distinguishing marks of a militaristic network often include the recognition of garrisons and forts, such as the Roman building found in their Arabian territories (Graf 1997:124).

Economic

Archaeological approaches to evaluating the economic character of transportation focus on both network layout and the type of infrastructures placed along them. The layout of a network at a broad level can be a basic indicator of its role. Hassig has argued that an economically-driven network will contain numerous roads connecting towns into the regional network (1991:24). More statistically derived analyses have relied on economic models commonly applied in Transport Geography (see Chapter 3). Graph Theory (Gorenflo and Bell 1991) and Central-Place Theory (Hassig 1991:19; Santley 1991) have been used to assess centrality and market principles in ancient settlement hierarchies in Old and New World contexts.

Economic character has also been evaluated from infrastructure distribution and limitations of traffic. In Peru, storehouses were used to asses the maintenance of Inkan staple and prestige finance (D'Altroy and Hastorf 1984:334l Jenkins 2001:). When considered diachronically, the permanence of infrastructure has been used to assess economic changes within a region. Harrison's (1992) examination of masonry bridges in medieval Europe shows that bridge construction was conducted during a time of economic growth. The permanence of these bridges, and the fact that they provide access across 'dangerous' waterways, influenced the direction of economic transactions for several centuries after their construction.

Mathematical simulations have been employed to test the logistic constraints of certain types of traffic involved in long-distance trade (see Drennan 1984). Law (2006) focussed on the way in which resources, specifically minerals, were moved and the physical constraints that these goods had on limiting modes of traffic.

From a landscape perspective, the construction of raised roads can have an important role in structuring local economic activities of past groups. Examinations of Maya *sacbes* (Folan 1991) and pre-Columbian raised roads in Bolivia (Erickson and Walker 2006) both emphasized that these roads functioned to demarcate land and alter natural irrigation. The ability to hold back water and demarcate economic space is an important perspective when studying the collateral effect of roads beyond their physical footprint.

Political

Political studies of transportation can be divided into those that act as political statements and those roads that facilitate the transmission of political interests. In the former incarnation, the focus is on the construction of imperial or formalized roads. Schreiber (1991) identified that the Wari normally constructed formalized roads near settlements. The Via Appia leading into Rome changes from a simple path to a more formalized road closer to the city (Laurence 1999:19). The road therefore is a statement that the traveller is entering into the territory of the empire or capital itself. Causeways built to main cities or temple complexes would have functioned in similar ways (see Trombold 1991b). The size of the road may also be an indicator of political investment. Since political influence does not leave as many tangible tracks we are at a disadvantage in studying its role in regions which lack historic records.

Determining the political function of networks is based on the spread of imperial power from the capital. The transmission of political interests along a road in an archaeological context is derived from the distribution of monumental architecture, and portable symbols of political power (i.e., ceramics, art styles). Regional centres with the same building aesthetic as the capital are constructed to act as representations of the centralized bureaucracy. The selection of the site is often related to its strategic locations such as defence or regional access.

Infrastructure is also an indicator of political power as it is often the king who is responsible for its initial construction. Royal resthouses, such as that recently discovered in Persia (Dan Potts 2007, personal communication) are often built along main roads to facilitate royal pilgrimages, tours undertaken by the king on an annual basis to visit the provinces (Sarkar 1914:50-51). Location of masonry bridges can indicate the importance of a particular route or region to the ruling state. A road laden with bridges suggests that year-round communication is a necessity. In addition to bridges, Harrison argues that the type of causeway leading up to the crossing indicates the importance of the bridge within the network (1992:248). A further role of bridges in demarcating political power is the distance that these structures are built away from the capital.

Religious

The religious function of roads comprises network plan, connections to important sites, and the types of infrastructure built along it. Organization of the road network can reflect broader religious ideals. Bauer (1992) argues that the layout of the Inka roads shows cosmologically-based design. His analysis of the Inka ceque/huaca system radiating out of Cuzco suggests that the network is a manifestation of broader Inkan belief structures possibly relating to astronomical alignments (Ibid.:202). Religious networks can also occur as more abstract concepts. Ray (2006:320) suggests that the spread of Buddhism was facilitated by the creation of its own network of communication.

The terminal nodes of roads are often religious hot spots for a cultural group, either within a capital, such as Tenochtitlan (see Charlon 1991) or to a specific place in an empire such as the Oracle of Delphi (Bowden 2005). These roads are designed to bring people, or pilgrims, to them for worship and sacrifice. The result of encouraging such movements is the need to construct support infrastructure so that pilgrims can travel great distances to reach their sacred destination. Deffontaines notes that the pilgrimage ways in Europe, the *roumieux* and *paumier* ways, were distinguished from other types of roads not on the basis of their structure or layout but by the presence of hospitable establishments (1948:324). Shrines are also commonly built along roads to commemorate sacred places (see Bauer 1992)

One structure that, at face value, may appear to have no inherent religious importance is the bridge. Deffontaines provides some ideological gravitas to the role of the bridge,

> the bridge marks the place of peril and instability on the route; also sometimes it was placed under the protection of the divine; sometimes it was supplied by a chapel or a religious building; it was notably the case for the bridge of Avignon; in Tonkin and in Laos, the bridges covered in trees often possessed, at best, a little altar dedicated to the divinity that protects them (1948:358).

While perhaps too literal, the bridge can act as the connection between worlds such as the Buddhist rainbow bridge. This may be the case for bridges into sacred centres but it is an unlikely interpretation of a structure spanning a river in peripheral regions.

Social and Phenomenological Approaches

The final analytical dimension of transport is its social function. Roads reflect and actively influence social structures at any level of group organization (see Folan 1991; Mathien 1991; Erickson 2006). Roads, paths, and trails acts as social glue connecting disparate settlements that may or may not have had active communication prior to the road's connection. Snead's (2002) recent examination of changes in ancestral Pueblo trails attempts to look at how movement reflects changes in the social order of the local population. As they leave little tangible evidence it is difficult to determine social factors from the archaeological record.

Concepts borrowed from landscape archaeology and phenomenology have recently been applied to transportation with the intent of contextualizing it within the human experience of movement. No longer are we restricted to studying a shopping list of features but can begin to examine roads as actively shaping and being shaped by human experience. Examples of this approach are Pasztor et al's (2000) examination of the visual impact of travelling along a Viking road on travellers to a sacred site, Mack's (2004) GIS study of pilgrim movement at Vijayanagara, Gate's (2006) study of Graeco-Roman 'hidden' ways built in the Eastern Desert provinces. Historic sources have also been examined for their discussion of transport as a concept, rather than of the physical structure itself. Keller's (2006) examination of the evolution of travel and transport word meanings in Maya stele is a unique approach to studying how language changes over time.

Caveats of Function Studies and Holistic Dynamism

The previous discussion has served to identify the range of cultural factors that contribute to the development of a transport network. Two interrelated points must be made before undertaking any new examinations. The first is the need to utilize a holistic, or dynamic, approach to the data. Trombold argues that,

> The macro or holistic perspective allows us to gain an understanding of their role in society, switching focus from individual linkages to what they connect, where they lie in relation to what they connect and, beyond that, to the configuration of the entire system (1991a:5).

By looking at the corpus of transport components in a given region it should be possible to assess the level of organization and the function of the roads in the past (Hassig 1991:24; Beck 1991:69). In the end, most studies conclude their analyses by suggesting that the transport network reflected multiple cultural factors (i.e., Spencer and Redmond 1998). This not meant to dissuade archaeologists from studying the importance of one facet of transportation. Problem-based research requires a basic premise to test; testing all available possibilities would be largely prohibitive for the average archaeological project. The point is that road studies exist in a broader dynamic of cultural and environmental stimuli.

The second factor to consider is the issue of over-inferring the function of a transport system based on the sites connected to it. Trombold argues that multiple locations (i.e., shrines, small settlements) on a route can disguise the original purpose (1991a:6). A potential solution to this is to,

> consider the types of activities contained by the largest or most prominent settlements in direct association with the network. These could then be compared with the types of activities contained by other sites both on and off the roads, positive and negative evidence would then be effective in isolating the road-associated functions. The effectiveness of this will depend upon the knowledge of the region archaeologically (Ibid.).

By hi-lighting the five cultural factors that influence the construction of transport networks it is important to remember that no road likely served a single function. Each factor is co-related or dependant on the other. A common thread that links the study of each of these factors, and their interrelationship is to adopt a dynamic approach.

Broad Scale Comparisons

The culmination of a transport approach is the comparison of networks diachronically and pan-regionally. With the increased amount of research focussing on transportation publications are beginning to assess both the internal development and network differences. Miller (2006) recently discussed transport differences between the Indus and Mughal periods in northern India. Sheets (2006) has included a comparison of monumental entrances in various chiefdoms in the Americas. When comparing different transport methods Miller argues that we must be able to consider natural environment, cultural context, changes in transport technology, and data bias for both case studies (2006:282).

Summary

The study of transportation, by necessity, includes the investigation of where and how people or objects moved across the landscape. Trade (object focussed) and movement (transport focussed) are integrated concepts that are often treated as disparate entities in the archaeological literature. Over the past two decades, increased interest in the subject of transport has brought in new theoretical perspectives and methodological approaches. Researchers focussing on a transport system have access to a wide range of techniques for locating, describing and analysing its function. An important gap is the lack of synthetic approaches and a tendency to focus on one of these stages of investigation. In order to fully exploit the utility of transportation it is argued that we need to create an overarching approach to identify the baseline characteristics required for an integrated examination of more detailed research questions.

The proposed solution is to follow a rigorous operational approach at each stage of investigation. The location of transport structures requires a multi-pronged series of surveys – remote sensing, historical, geographic and on-the-ground verification. Within the study of movement or transportation, the archaeologist must properly describe the physical characteristics of individual components and evaluate their spatial relationships within the overall system. Chronological controls (e.g., relative, absolute dating techniques) are therefore crucial for each of these data sets. The palimpsest nature of transport and settlement is a significant issue which must be recognised even at a most basic level, before any proper cultural analysis of function can be undertaken or must be deliberately treated as a palimpsest. Once these levels are separated and examined in a systematic method (i.e., Location, Description) then a set of specific culturally-based questions can be established for analysing the transportation system. Given the type and scale of data sets it is argued that GIS provides the best mechanism through which much of this research can be completed. By following this series of archaeologically based methods an integrated database will be created that will enable the study of the transport system to be integrated within broader concepts of society.

Chapter 4. Empires in Motion: Theories and Perspectives

The application of an integrated operational approach is directed toward the study of transportation in an empire. Empires depended on the ability to communicate within and beyond their borders. This chapter outlines the basic definitions and characteristics of empires in relation to the need for managing and accessing space. Territorial extents, temporal and scalar dynamics, and the forms of control and power are also discussed to structure propositions about where, when and why transportation systems were (or were not!) constructed. The objective of this chapter is twofold. First, empires are dynamic entities whose control and influence shifts spatially through time. Secondly, empires have several mechanisms that require development of formalized routes to ensure access to specific commodities. The following review is intended as the cultural backdrop to outline why transportation is such an integral part of archaeological investigation. The intent of this discussion is therefore not directed towards questioning the theoretical issues of empires or the actual methods of control used by elites but to outline the dynamic qualities and operational requirements of empire.

Defining Empire

Debate about the nature and definition of empires and their smaller cousins, states, is a considerable topic in archaeological literature (see Feinman 1998; Alcock 2001; Trigger 2003; Yoffee 2005). Not surprisingly this corpus of work has produced a variety of different definitions and attributes that distinguish a society as being an empire. A description of empire offered by Conrad and Demarest summarizes some of the most salient points,

> a state encompassing a large territory and incorporating a number of previously autonomous, culturally heterogenous societies, one of which dominates the others. The dominant society, which has achieved its position by military force, exploits resources formerly controlled by the subordinate societies (1984:5).

More specific attributes that Schreiber (2001:71) would include are rapid expansion (usually by conquest), subcontinental in size, populations in the millions, control over diverse ecozones, cultural diversity, central administrations that support themselves through tribute/tax extraction, standing armies, a single capitol, and marked by expansion of monumental architecture. The physical consequence of the processes of empire is the marked appearance of ‘dramatic material remains’. Within the imperial corpus we can expect any combination of large scale architecture, landscape modification, road systems, urban centres, temples, burials, art representations and elaborate prestige goods, and varieties of texts (Sinopoli, 1994:169; Morrison 2001a:6).

At a basic level, these definitions and characteristics identify a culture that is sufficiently organized to control vast areas of space, often on a subcontinental scale. The problem for archaeologists is that underneath this basic veneer are innumerable variations that result from processess unique to each case study. Morrison argues therefore that we need to look at empires from a dynamic rather than typological perspective and base discussions on imperial processes and histories to mutual benefit (2001:6). While there are numerous definitions of empires and civilizations, the summary categories suggested in Sinopoli’s (1994) review of empires are used as the foundation for evaluating the impulses for developing a transportation system.

Empires in Rest and Motion: Dynamics and Phases

Temporal Dynamics

Empires have extremely variable durations and extents. Many empires did not last past the progenitor ruler while others persisted for hundreds of years. Most empires with multiple rulers experienced cyclical patterns of political expansion and fragmentation over a number of years (Sinopoli 1994:168). This type of dynamic has been emphasized by numerous authors (Adams 1988; Feinman 1998; Yoffee 1998). The approach offered by Marcus (1992; 1998) emphasized this process in her Dynamic Model. Comparing ancient Mesoamerican states and other global empires (i.e., Andean, Mesopotamian, Egyptian) she argued that they were not static entities and experienced repeated peaks (maximum territorial extent; four tier settlement hierarchy) and troughs (state breakdown; three settlement hierarchies) before they collapsed into history.

The important point to be drawn from this model is that the study of empires cannot assume uni-linear development. Buildings, infrastructure and political relationships were likely reused or altered by subsequent kings and extents of the empires (Smith 2005:838). It is the job of the archaeologist to extract these shifts from the material record. Unfortunately, few absolute dating techniques are available that can provide sufficient temporal detail to identify rapid expansions into the landscape; commonly available and datable items such as ceramics are not effective in marking changes at an imperial level (Sinopoli 1994:173). As such we need to develop new techniques that rely on seriation or cross-cutting relationships to assess their place in time. These techniques rely largely on an analysis of imperial remains through space.

The classic approach for examining the oscillations within an empire is to define phases of expansion, consolidation and collapse. Each of these phases has important consequences for transport studies.

Expansion

All empires begin by taking control over territories, starting with their immediate vicinity and spreading out to satisfy the goals of the ruling elite. Expansion studies therefore focus on the way in which the empire solidified its position in the landscape. A critical feature of successful expansion is the concept of the ruler who, as either founder or consolidator, was charismatic, dynamic and brilliant (Sinopoli 1994:163). These individuals created alliances between elites in new lands that enabled sufficient resources and power to be accumulated to achieve their goals. We see this pattern in rulers such as Alexander, Genghis Khan, Asoka or Jayavarman VII whose names and reputations encouraged newly conquered territories to capitulate often without need for military recourse (Ibid.).A direct result of expansion is that it becomes more cosmopolitan over time, incorporating new ethnic groups as new territories are added to the administrative core (Barfield 2001:29). It is important to note that empires do not expand infinitely through space but are constrained by particular factors such as distance (i.e., supply and defence logistics and communication costs), geographical/ecological frontiers that they could not successfully occupy and the borders of empires with similar power (Sinopoli 1994:163; Barfield 2001:32). Morrison's discussion of Vijayanagaran expansion posits a dynamic of conditions based of 'center' (material/organizational base and elite intent) and the 'objects' of domination (ecology, socio-political organization of new cultures) (2001b:256). A final point to consider is that empires are rarely formed by single events of expansion. In studying the extent across the landscape, particularly rapid military action, however, it is often difficult to identify evidence of multiple phases of activity given the resolution of archaeological analysis (see Schreiber 2001).

Consolidation

Once a ruling group has established its presence in new territories it must shift its focus from conquest to maintaining. Political and economic strategies of both constructive (i.e., new institutions, royal marriages, administrative structures, ideological systems) and destructive (i.e., replacement of autonomous local institutions, control of labour) forces are employed by empires to consolidate their connections and ensure resource flow into the capitol (Sinopoli 1994:163-164). During this stage relationships established by the charismatic ruler must be fostered by subsequent emperors to maintain the structural connections of the empire's diverse holdings (Ibid.:163). The ability to consolidate is associated with periods of stability between the controlling elite and their subjects; Yoffee suggests that this period in an empire is made possible when 'those in the periphery consider that the resources they provide to the center also return benefits to them' (2005:139). The multiple ethnicities brought under the aegis of the new empire were indoctrinated within the new world order in different ways. Morrison (2001) identifies substantial variability in the degree and form of incorporation of territories in Vijayanagaran empire. By contrast, the Qin consolidation of China in 221 BCE established the legacy of a China that was bound by cultural uniformity which exists until the present day (Yates 2001:356).

Collapse

Imperial collapse is characterized by the dissolution of the centralized institutions that created and maintained the relations of control between the political centre and its territories (Sinopoli 1994:168). The centre can no longer secure the important resources from its territories that are essential for the proper functioning of the elite bureaucratic system (Yoffee 2005:139). Given the often dramatic cause of demise (i.e., conquest, environmental destruction) it is not surprising that the subject has a storied history in both archaeological (*World Archaeology* volume 33-3) and popularist literature (i.e., Diamond 2005). Tainter's detailed examination of collapse lists eleven potential themes leading to collapse including resource depletion, new resources, catastrophes, insufficient response to circumstances, interaction with other complex societies, intruders, class conflict, social dysfunction, mystical factors, chance concatenations of events and economic factors

(1988:42). While Tainter chooses to emphasize the economic explanation others have argued for political (Yoffee and Cowgill 1988; Yoffee 2005) and religious (Moreland 2001) factors stemming from both internal and external agents. It is widely accepted that collapse is rarely attributable to a single factor, but results from a complex interaction of several cultural and natural forces.

Spatial Dynamics: Extents

All empires are concerned with the conquest of space. Technically there is a point where imperial control ceases. Defining this line, however, is not always a simple task. The most common means of demarcating imperial extent is through mapping the distribution of monumental architecture, royal inscriptions and boundary stones, and then connecting the maximum area defined by these features. Schreiber (2001:73) suggests that the spatial extent of an empire is defined by the extent of direct imperial investment, such as infrastructure. As an important part of imperial infrastructure, imperial roads are seen as an excellent measure of the size of the empire. The greatest caveat in relying on roads is that the archaeologist is able to clearly distinguish 'imperial' constructions from others in the landscape (Ibid.).

Following from the discussion of Marcus' Dynamic model (1992; 1998) it is apparent that a single map of an empire is an inappropriate method for symbolising areal control through time. There is also a reaction to the utility of representing 'areal blobs' through time. Smith has criticized the utility of such representations as simplifying the complex nature of imperial mechanisms (2005:837-838). Mapping the spatial and temporal relationships of imperial networks structures is a more informative method for understanding how and when empires were made manifest across the cultural landscape. Evaluating where an empire extended across the cultural and physical landscape is complicated by an underlying positivist perspective,

> In a sense, we must be able to evaluate both what is there materially and what is not. A lack of known material evidence for imperial occupation at any location may imply any of several situations, among them 1) lack of imperial control, 2) indirect rule under a hegemonic system, 3) short-term imperial occupation, or 4) lack of archaeological investigation (D'Altroy 1992:73).

While it is likely that extent is demarcated by imperial remains, this advice should be heeded before making our maps.

Control and Power Relationships

Empires exert control over territories through different kinds of power relationships. The relationship between ruling elites and subject groups depends largely on the empire's goals and their ability to exert and maintain levels of control. Capitols extract different kinds and amounts of resources (i.e., labour, food, luxury goods) depending on their immediate and long-term needs. The concepts of control and power provide the theoretical structure for understanding the mechanisms used by various empires. Control refers to the relationship between the central authority and its provinces. Discussions of these processes are often rooted in the concept of World Systems Theory outlined by Wallerstein (1979). D'Altroy summarizes the various models of control as core-periphery, tributary-capitalist, metrocentric-pericentric-systemic, hegemonic-territorial (1992:9). Each model is developed to account for the variation in level and type of actual control exerted by the dominant state over its territories. Regardless of which model is used, two strategies common to all centralized authorities are: 1) the maintenance of security at the central polity and 2) extraction of resources the expanded benefit of a limited segment of the population (D'Altroy 1992:9, after Adams 1979).

Sources of power have been defined in many ways (see Blanton 1998). Yoffee describes power as 'the means by which leaders attempt to control the production and distribution of goods and to manage labor' (2005:33). For the purposes of this discussion the methods for maintaining imperial territories are achieved through the combination of 'coercive and persuasive controls that took military, political, economic and ideological forms' (D'Altroy 1992:9).

Military Power

Military force is perhaps the fastest and most dramatic manifestation of imperial power. It is often the first type of power exerted into new regions and quickly results in the seizure of land, revenues and slaves, used for both labour and sacrifice (Sinopoli 1994:166). Extensive military force was a critical component of many great empires during their expansion phase(s) – Rome and Persia for example. Following the consolidation of an empire, military power continues to play an important role in maintaining imperial security through quashing provincial rebellions and defending the capitol. Conquests are rarely a single event, with resistance, rebellions and cycles of reconquest frequently occurring (Ibid.:163).

A second form of military power is the use of coercive diplomacy. In this form, empires are able to effect control through the sheer terror of an army's strength and brutality rather than physical action (Sinopoli 1994:167). As a defensive strategy the subject regions submit to the new order in an effort to prevent the destructive results of military intervention.

The ability to exert military power in either form lies in the ability of the empire to maintain a free-standing army (Sinopoli 1994:167). These units are often situated at the capitol or in key areas of the empire depending on the importance of a region. Barfield argues that empires tended to station the majority of their troops at frontiers rather than at the political centers (2001:32). Where they were located in the Khmer empire is an example of a basic unknown. These human resources are paired with specific physical infrastructure designed to facilitate quick movement into the territories. Garrisons, watch towers, defensive fortifications and military roads are direct responses the needs for military intervention (Hyslop 1990:146-190; Graf 1997). An excellent example of ensuring power at home is discussed in relation to Constantinople by Haldon (1995). He argues that there were passive (walls, earthworks, ditches) and active (soldiers) components in the overall defensive scheme, with an army of up to 20-25,000 (Ibid.:144-145).

While military methods are often employed for initial control it is economic and political power that represent the more enduring and efficient means of solidifying control over an empire's territory (D'Altroy 1992:9).

Economic Power

Economic power aims to control access to natural resources, materially productive labour, goods, and services (D'Altroy 1992:11). As empires expand into new areas they gain access to new resources and soon after become dependant on these revenues in the form of tax or tribute during the consolidation period (Sinopoli 1994:165). Some of the common mechanisms for economic power are tribute levies, direct taxation, control of mercantilism, and mobilization of labour (D'Altroy and Hastorf 1984:334).The structure and intensity of economic control is therefore affected by administrative structure, distance to accumulation points (capitol or regional centre), distribution of centralized institutions (centres) and the economic-symbolic significance of specific products (Sinopoli 1994:165). At Vijayanagara, Sinopoli and Morrison identified control over production and reproduction on two levels: 1) humans, their labour, social and biological reproduction, and 2) nonhuman resources such as land, raw materials and tools and the ability to mobilize these goods throughout the area of control (1995:83). D'Altroy and Earle (1985) make a further distinction between empires that focus on the production/control of staples (staple finance) and those that control high status or valued goods (prestige finance). Obviously, any study of economics must recognize that there are multiple levels of economic organization at work that vary with the products of sources, cultural significance and environmental backdrop (Sinopoli 1994:165).

Empires intensify their productive capability over time through the construction of new forms of infrastructure. Productive intensification can alter the organization of labour and communities, while intensification around a capitol likely reflects the need for a stable and reliable subsistence base, possibly indicating the difficulties of transportation (Sinopoli 1994:166). Schreiber describes a practical approach for studying the development of economic control systems,

> Empires are typically too large to be run from a single capital, and local centres are established to house administrators, maintain control over local polities, organize and store tribute for later transshipment, organize labor for the construction and maintenance of imperial facilities, etc. Typically those centers will be located near local population centres or production zones. The size and internal diversity of a regional administrative centre will depend on the variety of functions carried out there, and perhaps the size and diversity of the region under its control (2001:73).

Another important point is that imperial control will focus on the resources that are most needed for the survival of the empire and its institutions and these will be gauged according to their distance from the core zone, their value (relative), and ease of control (Sinopoli and Morrison 1995:83).

From this description we can borrow from ideas raised by Morkot (2001) in his discussion of the relationship between the Egyptian New Kingdom and Nubia: the issue of exploited versus invested territory. Exploited territory is largely devoid of imperial infrastructure and receives no direct benefit or improvements from the core; invested territory is sufficiently important that direct features are placed in the landscape to improve access to local resources. Morkot's recent investigation of the resource and archaeological evidence suggests that Egypt actually invested more into Nubia than was previously thought (Ibid.:241-242). Determining whether a peripheral region is exploited or invested should be identifiable through the archaeological evidence.

Evidence of economic power is best represented through remains such as ceramics, prestige goods, etc. – whose origins are readily identifiable. As Jennings points out, trade is marked by the importation (e.g., ceramics) and exportation (e.g., resources) of goods (2006:353). Markets and other bureaucratic structures, while at a larger scale, are also identifiable through architectural and or textual evidence. It should not be surprising that the majority of archaeological approaches to economics focus on the goods themselves, and end points of the economic process (see examples in Alcock et al. 2001). Rarely do they consider the strategies and exact methods of distribution across the landscape. A few examples are evident in the literature but it is rare to find a truly transport-based study of economic power.

Political Power

Political power refers to the alliances and connections that bind external groups to the centre. D'Altroy describes this type of power as 'the ability to dominate the processes of managing consent, judging and decision-making' (1992:11, from Service 1975). The extent to which foreign elites are incorporated into the imperial political machine varies considerably and is often based on pre-existing political structures, the strategic and resource value of a territory and level of resistance to imperialism (Sinopoli 1994:164). Two principal elements of early empires are support of elite institutions (i.e., administration, religious sectors, nobility and military) and providing sumptuary goods for maintaining political relations, ceremonial activity and validating status (D'Altroy 1992:12). D'Altroy raises an important point that,

> …in an imperial system facing an increasing administrative load, a single strategy of rule would have been inadequate to the complexities of political transition,

because the varying natures of subject societies would have created problems in application of political power (1992:20).

Processes of political power include economic subvention, forced resettlement, cultural instruction, granting of wives, bestowal of elite goods or symbols of the empire to the local elite and placement of permanent administrators (D'Altroy 1992:23; Sinopoli 1994:164; Yoffee 2005:37). States also consolidate their power by tracing their legitimacy through past states, such as in the Carolingian reverence for Roman imagery (Moreland 2001) and, possibly, the Satavahana rulers connection with earlier Mauryan empire in India (Sinopoli 2001:176).

Defining the type of administrative facilities of an empire archaeologically is extremely difficult. Texts are the most conspicuous source documenting the way in which power was managed and expressed in distant areas. Trigger (1990) argues for the importance of recognizing the monumentality of political architecture as a measure of political power. Outside of these two sources the physical objective of political power is often linked to the economic needs of the empire: resources, land and labour. A truly political resource would be a strategic location that provides no immediate economic resource other than affording access.

Religious and Ideological Power

Religious power or ideology can be divided into those processes that emphasize the role of ideology as a motivating action and those where ideology is used to provide legitimation for and explain of inequalities between the ruling elites and subject populations (Sinopoli 1994:167). Motivation of action is part of a 'pre-ordained' order coming from higher powers to exert control over others.

Imperial leaders often seek to control the sources of legitimacy. This often takes the form of taking over local religious beliefs or the creation of new forms built on traditional beliefs (Sinopoli 1994:167-168). Yoffee adds that control also extends to knowledge, ceremonies and symbols in complex societies (2005:38). Kings solidify their relationship by constructing physical or historical connections between themselves and important rulers in the past. The material remains of religious legitimation are therefore commonly represented by the investment in new or existing temples or other religious monuments (Sinopoli 1994:171).

The importance of religious power is perhaps the most contentious within the archaeological literature. Generally, religious ideology is de-emphasized as an explanatory factor of imperial expansion and control in favour of the more pragmatic issues of economy and politics (D'Altroy 1992:13). The most famous example supporting a primary role of religion was presented by Conrad and Demarest (1984). They argued that 'religious, political and philosophical conceptions of the Mexica and Inka were united by a belief in a supernatural order' and these beliefs led to the dramatic imperialism of both cultures (Ibid.:5). Brumfiel's re-examination of this process, however, suggests that the Aztec state religion was targeted for a specific group, the young men who formed the core of the army, and not a world view applied across the empire (2001:309). Another example of the importance of religious power is the Carolingian empire. Moreland and Van de Noort (1992) argued that the spread of the Carolingian rulers across 5^{th} to 9^{th} century CE Europe was closely linked to the spread of a Christian ideological code which was reproduced in the social organization of society and a re-birth of Roman ideals (Ibid.:328). The religious code was disseminated by the Church through its buildings, mosaics and gospel books. It should be noted that both of these studies emphasized that religious factors were necessarily linked to more 'pragmatic' aspects of political and economic power.

The material record of religious power is often the most stunning significant remnant of past empires. The pyramids of Egypt, temples of the Indian empire or the city of Angkor Wat are among the largest buildings created in human history. The extension of religious architecture is a common feature in many societies such as Tiwanaku (Goldstein 1993:22) and Roman politico-religious iconography (Laurence 1999:43). Other representation on portable objects (statues, pottery, painting), on the architecture (lintels, bas-reliefs), and also on sacred texts (stone or paper) is often of equal calibre. Each source seeks to reinforce the ideals that are ultimately connected to the empire's ruling elite.

Combined Aspects of Power

The discussion of the form of power emphasizes how it operates and is represented in the material landscape of empires. It should be pointed out that no empire ever succeeded from utilizing a single form of power, but relied each of them. D'Altroy suggests that strategy and power used by early empires is best conceived through combinations of military, political, economic and religious factors (1992:24). He also argues that these types of power are not locked together and that any study of them should be investigated and not assumed (Ibid.:20). Yoffee also makes the important point that the combination of these different forms of power act to reinforce the others, giving the elite a stronger hold over vassal communities (2005:38).

Dynamic Perspectives

The summary of empires presents a vast array of concepts and data sets that are embedded in all aspects of society. Effective study of these factors therefore requires specialized cooperation and the realization that numerous perspectives can be employed (Morrison 2001a:6). One of the most appropriate means of studying such complex entities is to utilize a regional dynamic approach.

Regional Dynamics

Crumley and Marquardt's (1987) study of the Arroux Valley in Burgundy represents one of the best models for examining cultural dynamics from a regional perspective. The focus of their research was not on the Roman Empire but on the regional historic dynamic between the cultures of Burgundy, their immediate geographic environment, and the subsequent impact of Roman dominance. As such the Arroux Valley project sought to demonstrate that,

> how a group adjusts to a geographic area reflects much of the group's history, organization, and values, and in turn such adjustments influence that group's perception of the physical and the constructed environment (Ibid.:1).

In order to unravel the layers of human activity the researchers fused multidisciplinary, multitemporal, and multiscalar methods (Ibid.:3). This involved environmental, historical, geological and transportation approaches that were analysed and contrasted against each other to produce a more holistic picture of the Arroux valley region. They argued that regional development can only be achieved through the juxtaposition of archaeological, historical and contemporary ethnographic data with natural sciences (Ibid.).

One of the significant characteristics of the Arroux Valley study was the recognition of the need to consider environmental milieu as a critical component of the analysis. While such studies have played a primary role in historical geography (i.e., Ward-Perkins 1962) comparable approaches to empires and regional archaeology are much rarer. In her study of the Vijayanagara Empire, Morrison argues that we must examine the underlying ecological dynamic of the area – including environmental conditions, flora, fauna, human demography and organization of production, distribution and consumption (2001b:258-259). She points to the importance of studying the technology of agriculture in relation to the ability of subjects of the empire to create proper infrastructure to support this industry,

> …irrigation networks cannot exist and the production of irrigated crops such as rice cannot take place without suitable water, appropriate slopes and soils, and particular climatic conditions (Ibid.:259).

The leaders of Vijayanagara therefore followed a policy of agricultural expansion into new regions and promoted intensification of existing cropping regimes by creating irrigation structures (Ibid.). While this is a case specific example related to a single aspect of Vijayangaran imperial processes, it points to the need to consider the pragmatic side of imperial controls in our discussions. The ability to grow resources, smelt ore, or travel across the landscape is directly related to the geographic milieu.

Further support for the regional perspective is provided in Stanish's (2001) review of regional archaeology in the Inka region. In this detailed summary, he argues that looking at data from a series of sites at a regional level has significant benefits over smaller scale investigations. These include: 1) ability to ask and address research questions not possible from site level study; 2) that by controlling for context, the whole of the information collected from a region is greater than the sum of the individual sites; and 3) the ability to gain insight into long-term diachronic patterns of land use (Ibid.:217). This 'simplified' approach summarizes the way in which empires and the material remains that they produce can be evaluated to produce new questions.

Perhaps the most important aspect of a dynamic approach to regional studies is the fluidity of new results being able to feed back and remodel our research questions. In the study of Inkan Peru, the regional history was not undertaken to conflict with the histories, but to complement them (Stanish 2001:216). This marriage of information facilitates a better understanding of imperial processes such as growth, consolidation and decline, aspects of the dynamic model outlined above. As a result new questions will be formulated which are not possible if we consider only intensive work from one or two sites (Ibid.:217). Within the analysis of regional scale patterns we must remember that the results similarly operate within the site and supraregional level. We should not be restricted to ‘top-down’ or ‘bottom-up’ approaches, but need to measure how they inform and contextualize one another (Thomas 1999:98). An important point that Morrison makes when investigating states comparatively is that while similarities in states and empires can be identified the nature of the data sets is subject to the material culture and archaeological prejudices and possibilities of that region (2001a:7). Variations exist in the archaeological data and traditions as well as the documentary records and historical approaches (Ibid.). Such a statement is not meant to discourage investigation of similarities but to take into consideration gaps in academic growth by region.

Summary

It is readily apparent that numerous facets of an empire are reliant on the conquest and control of space to achieve their goals. Ironically, though most studies of empires note the importance of communication, only a few directly investigate the subject of transportation. At the regional level, an empire’s communication-transport system is prone to repeated fluctuations as it expands, solidifies and perhaps loses its territory. Physical evidence of these expansions is marked through the transport infrastructure and imperial architectural and art styles. The question of when such a system reached its visible maximum must therefore be evaluated within this dynamic. Reasons for expanding a transportation system are dependent on a range of imperial requirements. Ores from a mine need to be moved to the production site and on to their final destination for consumption, soldiers need to march quickly to quell uprisings in provinces, messengers need to courier news of marriage alliances to distant provinces. Effective transportation and communication are therefore a critical component to the success of imperial enterprise. Temporal dynamics similarly influences our investigation of control as the original goal of a route is likely to change to meet new demands or may even create new demand itself.

Summary of the Operational Approach

The discussions in Chapters 2, 3, and 4 have outlined the basic parameters of an operational approach to transportation. We can now talk about the basic components and concepts of all transportation systems, the archaeological approaches used to find and analyse transport, and identify the specific reasons why transport systems were needed by empires. Individually, these characteristics provide important insight for any transport system. The true value of these characteristics, however, is derived by integrating them into a single, operational perspective (see Figure 4.1). For example,

- historical components give the range of archaeological features to be identified from remote sensing and ground survey
- archaeological questions are based in concepts of transportation; addressing each concept leads to a better understanding of the life cycle of a road
- description of spatial characteristics must take into consideration the accessibility of each node
- imperial dynamics requires a careful examination of the chronology of road components
- evaluation of cultural function must be couched within the requirements of the empire being studied

By following the archaeological stages of location, description, and analysis, the operational approach provides a holistic and methodologically rigorous method that can be applied to any study of transportation in the past. The following chapters will evaluate the use of this approach to clarify and systematise an understanding of the nature and the context of the Angkorian empire.

Chapter 5. Towards A Geographic and Historic Setting of Angkor

From the theoretical and methodological approach to transportation we can now turn to the investigation of the Angkorian Empire. As discussed in the introduction, the Angkorian Empire is an ideal test for applying this approach as it had an extensive transportation system. In addition the interpretation of the material remains of this system has been previously based on a few historic documents and has not been broadly synthesized nor analysed outside of the cultural historic paradigm. A further reason for choosing Angkor is that it not been included in the general discussion of an archaeological empire despite the fact that it clearly possesses the necessary features to qualify it. The following chapters will outline the geographic and historic background of Angkor (Chapter 5), describe the inner workings of the Angkorian Empire (Chapter 6) and outline the history and components of the Angkorian transport system (Chapter 7).

Before outlining the geographic and historic setting of the Angkorian Empire, it is necessary to review the sources of data used to describe this culture. In particular, until recently there has been a tendency to rely on historical documents largely to the exclusion of other types of data. The following discussion will also describe the important geographic features that serve to delineate or structure the core territory of the Angkorian Khmer. In particular, the role of the Tonle Sap Lake is highlighted as both a provider of food but also as the basis for a significant communication system. The outline of Angkor's history focuses on the succession of kings, particularly between the 9th to 13th centuries. After the 13th century there were still kings but until the 16th century we know little about them. An emphasis is placed on describing the actions of individual kings within the 9th to 13th century that would have had an impact on the development, expansion, and modification of the transport system (see Dagens 2003; Jacques and Freeman 1997; Jacques and Lafond 2004).

The 'Posters of Stone': Historic Sources in Angkorian Studies

Knowledge of the proto- and historic periods in Southeast Asia has been derived from a combination of text- and archaeologically-based data sets. The historic information regarding the Angkorian period is in the form of stone inscriptions written in Sanskrit and Khmer, from accounts of foreign visitors such as Zhou Daguan (late 13th century) and also documented histories of the Chinese, Vietnamese and Cham. Coedès stated that,

> The most important task facing researchers at the outset is to identify the ancient place names and establish the reign dates – in other words, to sketch a geographical and chronological framework (1968:xix).

Historians have therefore reconstructed the histories of many Southeast Asian states, often from the use of well-dated foreign texts, identifying their king lists and inferring their development from this medium alone (e.g., Coedès 1968). In the context of Angkor, synchronic aspects such as the nature of political structure, royal power, and law were considered much later by historians (Mabbett 1978:1; see Wolters 1999 [1982]; Wheatley 1983; Kulke 1986; Hagesteijn 1989). While these scholars have laid the foundation for our current understanding of the sequence of events and type of politico-economic structures utilized by the Angkorian kings there has been little research directed towards incorporating the material evidence to confirm or complement the historic associations. Given the large amount and assumed accuracy of this historic information it is not surprising that the emphasis on archaeological approaches has lagged considerably behind. While some archaeological excavation was undertaken in the past (i.e., Malleret 1959; Courbin [Dumarçay and Courbin 1988]) they have been largely overshadowed by the historic records and their intent has often been directed toward locating the physical evidence of historic interpretation (see Stark and Allen 1998; Stark 1998:182).

Groslier argued that there has been an over-emphasis on collection of data and discussion of the chronology of the Angkorian period, with little regard for collation and analysis of the material within its physical milieu (1986:32). These historic and geographic issues have been raised recently by Stark (1998; 2006), who identified several issues implied by relying solely on historic data:

- the discontinuous nature of evidence caused by historical changes in India and China
- differential preservation of Khmer inscriptions, with the supposition that many texts were written on perishable material (i.e., palm leaf)

- human error and bias of the writers and
- the intellectual framework of the historian undertaking the analysis (i.e., Indian-trained scholars applying their ideas *carte blanche* to Southeast Asian problems) (Ibid.:180-182).

Archaeological inquiry can be used initially to fill the gaps in historical knowledge and also act to support or counter arguments based solely on written texts (Ibid.:197). It can also be used to address subjects that cannot be completely extrapolated from historic studies. For example, reconstructing an economy requires information about subsistence system, craft production, and patterns of commodity distribution; the rise and fall of a polity needs chronometric dates in order to relate construction sequences and stratigraphic change from excavation of historic period sites (Ibid.:186). Archaeological information is represented by the vast distribution of monumental architecture, such as temples of varying sizes decorated with detailed lintels and bas reliefs, massive earthen infrastructures such as canals and water reservoirs, and significant portable remains including statues, lintels, and ceramics.

Further impetus for turning toward a multidisciplinary approach is the inherent disagreement in the interpretation of historic texts. Initial histories from Indian-biased scholars have met with stern counterattacks either from re-translation of the data (see Bhattacharya 2005; Jacques 2006) or through re-interpretation using a different branches of historical inquiry, particularly economics (see Sedov 1978; Vickery 1998). Even within these new re-worked histories, there is much argument about the correct approach.

Sinopoli's (2006) recent review of the study of empires in South Asia illustrates a similar issue, where the focus of research has emphasized historical data and archaeology's role is to merely prove or disprove various points. An alternate approach has been the adoption of multiple data sources that are directed from a problem-oriented archaeology (Ibid.:341-342). Researchers of the empire of Vijayanagara have therefore moved beyond the dynastic history to look at more pragmatic issues of social economics and landscape politics (i.e., Sinopoli and Morrison 1995; Morrison 2001; Mack 2004). This perspective is a critical direction for Angkorian studies if we are to begin to comprehend how it worked as a cultural unit and has been adopted through projects run by APSARA, the EFEO (MAFKATA 2003-2007), Lower Mekong Archaeological Project (Stark et al.

1998; 2001; 2006), and the Greater Angkor Project (Fletcher et al. 2003; Fletcher et al. 2006; Penny et al. 2006; Lustig et al. 2007).

In summary, any study of the Angkorian period must include both archaeological and historic information. Stark lists two important methodological considerations to this approach. First is that these data sets need to be used in a complementary fashion with one filling in the gaps that cannot be addressed in the other (2006:316). Second is the need to gauge the relative importance of historic and archaeological information (Ibid.). This information must also be couched within its geographic setting and be approached from a problem-based perspective. With these goals and limitations in mind it is possible to outline the geographic and chronological background of the Angkorian Empire.

The Geographical Setting of Angkor

At its height the Angkorian Empire extended across the majority of mainland Southeast Asia, stretching from the Mekong Delta to northeastern Thailand and from the Malay Peninsula to the coast of Vietnam (Figure 5.1). Groslier suggested, however, that the heartland of the Angkorian Khmer between lay between the Se Mun valley, the Tonle Sap and the middle Mekong (1986:39). This core area is situated entirely within the lower Mekong River catchment (Figure 5.2). The Mekong, along with the Chao Phraya and Red Rivers, is one of the major rivers of mainland Southeast Asia and extends over 4800 km from Yunnan to the South China Sea (Douglas 2005:193). It is important to note that the presence of the Khone Falls, on the border between Laos and Cambodia, blocks fluvial traffic along its length. As a result, the Mekong could not have been used as a single transport link from one end to the other.

A second, and perhaps more influential role of the Mekong on the Angkorian Empire, is its relationship with Tonle Sap Lake. Seasonal monsoon rains increase the volume of the Mekong to a point where it exceeds the flow of the Tonle Sap River which meets the Mekong at Phnom Penh. This reverses the Tonle Sap River back into the Tonle Sap Lake causing the lake to quintuple in size, reaching a maximum area of 16 000km^2 (MRCS/WUP-FIN, 2003). The resulting floodplain around the lake provides rich soils for the production of flood rice and other agricultural products. In addition to the rich soils, lining the edge of the lake were vast flooded forests that act as breeding grounds for fish and other animals. The massive quantities of fish that enter to spawn make the Tonle Sap one of the richest freshwater fisheries on earth (see Lambert 2006). Modern fish yields from the lake average up to 50 000 tons annually and as a result fish represents up to 60 per cent of Cambodia's animal protein intake (Douglas 2005:207). Paleoenvironmental research shows that this pulsating system has been operating since at least the Early Holocene (Penny 2006:319).

Overall the region surrounding the lake is characterized by low relief topography with irregular rocky islands (i.e., Kulen, Krau, Tbeng hills). The heart of Angkorian settlement is situated in this floodplain around the Tonle Sap Lake which contains many navigable rivers that connect to this important body of water. This strategic location provided considerable geographic benefits for the establishment of an empire.

To the north of the Tonle Sap Lake, the Dangrek range is an important geographic and cultural feature in the Angkorian world. Extending some 130 km in length and averaging 300 m in height it forms the physical border between Thailand and Cambodia (Aymonier 1901:202). While the other mountain chains (i.e., Annamite, Elephant, Cardamom) appear to have bounded Angkorian settlement, the Dangrek seems to have played no part as a boundary in Angkorian geography, with regular communication between the Tonle Sap floodplain and the upland area dating back at least to the first few centuries CE (Groslier 1986[1973]:39). Travel would have been facilitated by the location of a dozen different passes although most of these would have been only accessible only by foot (Aymonier 1901:202).

Above the Dangrek, the Khorat Plateau has been called the 'second home' of the Angkorian Khmer (Groslier 1986[1973]:39). This region is a steep-sided upland separated by mountains from central Thailand and the Chao Phraya valley to the west and from Cambodia to the south by the Dangrek Range (Gupta 2005a:51). The Khorat Plateau is drained to the east by the Mun and Chi Rivers, which spill into the Mekong. Like the Tonle Sap lowland, the Khorat Plateau between the Mun is characterized by a relatively flat lands that would have served as viable land for agricultural purposes.

In summary, the area in which the Angkorian kings settled is heavily influenced by the rich resource potential of the Tonle Sap and the Mekong River. The secondary rivers associated with this system would offer an excellent natural transportation network while the surrounding regions are rich in natural resources ranging from agricultural to forest and mineral products. The seasonal monsoon amplifies the importance of the region through the Tonle Sap and also provides vital water for dry rice irrigation across the Mekong Lowland.

The Historic Setting of Angkor

The Angkorian Empire developed out of the socio-political structures of the Pre-Angkorian states of Chenla and Funan (see Vickery 1998, 2004; Miksic 2003; Stark 2006). These early periods set the stage for state development with the appearance of bureaucratized political systems, adoption and spread of Indian religious ideals, and connections with international trade networks. During the Angkorian period there are several important shifts, including the association of the king as the *chakravartin*, or universal monarch, and *devaraja*, or the 'god who is a king' (Coedès 1968:99; Jacques 1985:286; see also Filliozat 1954). In conjunction with this political and religious association of the king, there is a dramatic spread of Hindu and Buddhist ideals reflected in both the type and frequency of artistic production and monumental architecture. The construction of state-level temples and massive earthworks for the movement or containment of water provides an important marker of the physical extent of Angkor's territory. Kings documented their conquests and religious piety through the proliferation of stone inscription written in both Sanskrit and Khmer. It is from these inscriptions and monumental works that the majority of our knowledge of Angkorian history has been derived. Table 5.1 presents the order of kings within the Angkorian period. The following section highlights the activities of kings[2] and discusses their role in developing Angkor's imperial policies, their regional movements and the level of international relationships. Each king would have impacted on the resultant settlement plan, however the emphasis is on those kings that made the most significant impact during the Angkorian period. Figure 5.3 illustrates the sites within Angkor discussed below.

Jayavarman II and Indravarman I: The Beginning of Angkor

Historically, Jayavarman II is known as the first king of Angkor and began his reign in region in 802 CE. Based on the Sdok Kok Thom inscription written two centuries after his reign, Jayavarman II is said to have established the cult of *devaraja*, the ideal god-

[2] This review is not intended as an exhaustive discussion of the historiography of the king list or the major debates stemming from the inscriptions. More detailed summaries are already published to serve this purpose (see Briggs 1951; Coedès 1968, Mabbett and Chandler 1995; Dagens 2003; Coe 2004).

king uniting man with Shiva on Mount Mahendra in the Kulen Hills north of the Tonle Sap (Coedès and Dupont Heine-Geldern 1942; Filliozat 1954). The rise to power by Jayavarman II is associated with an expansion from his purported base at Vyadhapura (Banteay Prei Nokor) in southern Cambodia (Vickery 1998:346). From this locale he then subsumed new territory beginning with Bhavapura (location uncertain) and secured alliances with Sambhupura (Sambor) further up the Mekong (Wolters 1973:26, 29). Using his increasing body of supporters he extended his control by re-conquering the lands of Malyang (attributed variously to the southwest and south of the Tonle Sap Lake) which were an important locale in the political workings of his predecessors (Coedès 1968:102; Wolters 1973:23; Vickery 1998:315-16). From this location Jayavarman II eventually moved up the Tonle Sap Lake and established his first capital in the Kulen Hills (Wolters 1973:23).

Some time after his coronation in the Kulen Hills, Jayavarman II established a new capital at Hariharalaya, near modern Roluos, supposedly to take advantage of the resources of the Tonle Sap and its floodplain. With the exception of Jayavarman IV, this plain would become the political home of Angkorian kings for the next six centuries. Following the death of Jayavarman II, Indravarman I continued to use Roluos as his capital and is historically associated with the construction of the Bakong temple mountain and the first great reservoir baray (Indratataka) (Jacques 1997:68; Jacques and Freeman 1999:202). It should be noted that while the construction of the temple is attributed historically and architecturally to this king, recent remote sensing analysis (Pottier 1996) and radiocarbon dating of the temple moat indicates that the earliest construction of the enclosure extends back to the 8th century (Penny et al. 2006). While this complicates the argument regarding the initial establishment of Angkor it does not diminish the overall importance of region in the early 9th century CE.

Yasovarman I

Yasovarman I is associated with moving the capital once again, this time centred at the Phnom Bakheng. This new city, referred to as Yasodharapura, would become the political core for most of Angkor's kings over the next 500 years. Yasovarman I himself is responsible for numerous constructions including temples on the nearby mountains around Angkor (Phnom Bakheng, Phnom Bok, Phnom Krom, Phnom Dei) and beginning work on the 7 km by 2.5 km East Baray (*Yasodharatataka*). Outside of Angkor, Yasovarman I is credited with the construction of 100 wooden ashramas across his domain; some of these structures have been identified by steles erected at Angkor and also in all corners of his kingdom at Ba Phnom in the south, Vat Phu in the north, Tbhong Khmum east of the Mekong, and in Battambang to the west (see Coedès 1932; Pottier 2003). The most famous of his ashramas was constructed at Preah Vihear, which is situated on a spur of the Dangrek 525 m above the Cambodian plain (Briggs 1951:110). An inscription from Phanom Wan in Thailand also mentions Yasovarman I, which indicates that his rule extended into the Khorat plateau at this time (Woodward 2003:119; Jacques and Lafond 2004:155).

Jayavarman IV

Of all the Angkorian kings, Jayavarman IV is perhaps the most intriguing because of his decision to move the capital away from Angkor to the site of Koh Ker. After apparently usurping power in a struggle with Harshavarman I in 922 CE he decided to construct a new capital 80 km away from the core political centre on the Tonle Sap Lake. Work by Vickery on the family lineages in the inscriptions has softened the claims that Jayavarman IV was a usurper and has demonstrated that the king was actually a legitimate heir based on the laws of the time (1986:108). The Koh Ker region includes some 30 temples that are built in a distinct architectural style famous for its oversized nature. This trend is illustrated in the fact that Jayavarman IV constructed the largest temple mountain in the Angkorian world in the Prang and several enormous *shivalingas* (Figure 5.4a-b). An important point to be made is that Jayavarman IV built his capital within a twenty year period. Following his death the capital was returned to Angkor and interest in Koh Ker waned with only a single inscription of the following king, Rajendravaraman, evident at the site (Jacques and Lafond 2004:188). In fact, until the recognition that Prasat Andon Kuk is a late 12th century laterite hospital built by Jayavarman VII, it was believed that Koh Ker was completely abandoned (Ibid.:197).

The reason for selecting Koh Ker as the capital by Jayavarman IV remains a mystery to Angkorian scholars. He chose to move away from the resources of the Tonle Sap, and the immediate environment around his new capital does not appear to be particularly well-suited for the type of intensive rice agriculture found at other locations. It is not surprising that the abandonment of Koh Ker has fit well with scholars' perceptions of the isolated and disagreeable nature of the region. Parmentier noted the harshness of the region suggesting that you cannot take the same paths in different seasons and freshwater sources are extremely rare (from Jacques and Lafond 2004:156). Jacques comments that there is no reason why this region would have been less unrewarding then as it is today, but posits that mineral resources may have brought the capital there (Ibid.). This is an important line of inquiry that will be discussed later in this thesis.

Rajendravarman and Jayavarman V

After shifting the capital back to Angkor, Rajendravarman set out to reintegrate the empire briefly fragmented by the reign of Jayavarman IV. At Angkor he began several important architectural works including Pre Rup and the East Mebon. Outside of Angkor the distribution of inscriptions and temple construction was heavily focussed toward the northeast (Briggs 1951:130, 133; Jacques and Lafond 2004:117). Rajendravarman's tenure as king was also characterized by wide-scale warfare including a specific conflict against Champa (Parmentier 1948:107). His immediate successor, Jayavarman V, who built the 'unfinished' temple of Takeo at Angkor, followed the same political and regional trends, remodelling many of the northeastern temples such as Preah Vihear and Prasat Neak Buos (Vickery 1985:231; Parmentier 1948:108). Jacques also suggests that this king played a part in the initial construction of Preah Khan KS, based on strong stylistic similarities in the central tower of the main enclosure (Jacques and Lafond 2004:278).

Suryavarman I

The rise to kingship of Suryavarman I is a significant benchmark in the Angkorian period. After an initial period of disruption and regional conquests the king enacted an Oath of allegiance over the provinces to consolidate his power over rivals and contemporaries (Briggs 1951:151-52,168; de Mestier du Bourg 1970:300). Kulke argues that Suryavarman I's conquests were directed not toward destruction of the old regime but the construction of a new great kingdom and that he should be considered the founder of the Imperial Angkor (1986:12). Suryavarman I has also been associated with a switch to Buddhist patronage and that his political skills were such that he managed to successfully syncretise his preferences with pre-existing Shaivite beliefs (Coedès 1968:135).Vickery has pointed out that subsequent research has shown that he was no more Buddhist than any other king (1985:227).

Suryavarman I's efforts within the capital were limited to the completion of the Phimeanakas temple, construction of the Royal Palace (all of which were later enclosed by the walls of Angkor Thom), and initial work on the Terrace of the Elephants, and

West Baray (Jacques and Freeman 1997:132-134; Jacques and Lafond 2004:203). Outside of Angkor, Suryavarman I's architectural imprint was much more substantial as he laid the initial foundations for many temples to be modified by future kings (Preah Khan KS, Phnom Chisor) (Briggs 1951:160; Jacques and Lafond 2004:203-231). This prolific building programme is attested to by the inscriptions that show a two-fold increase in the number of *puras* (cities) built during his reign (Mestier du Bourg 1970:308). In addition to temples, Suryavarman I also marked the limits of his territory by erecting four linga called *Surahvaramecvara* at each of the cardinal points: Vat Ek (west), Preah Vihear (north), Phnom Chisor (south) and an unknown site known only as *Icanatirtha* on the edge of the Mekong (Jacques and Lafond 2004:203-204).

Suryavarman I developed important interactions with the Khorat plateau which, by contrast with other regions under his control, are well documented from archaeological and epigraphic data. Both pre-Angkorian and early Angkorian kings participated in relationships with Khorat but Suryavarman I's rule sees the introduction of dramatic settlement changes. These include the appearance of rectangular walled and moated sites, rectangular *barays*, and rectangular temple enclosures (Welch 1998:208). Welch argues that before 1000 CE this region was not integrated with the Khmer state, but that following the construction of Phimai, it would become a strategic administrative centre for the next 300 years (Ibid.).

The politico-economic control that Suryavarman I exerted over most of mainland Southeast Asia is apparent in the movement of ceramics (Hall 1985:173; Welch 1997) and the content of inscriptions. Desire to open up trade routes led Suryavarman I to expand connections to the west, which ultimately led to the aggressive conquest of Luovo (Lopburi) and into the Malay Peninsula (Hall 1985:176-177). He also made alliances with Champa and China during his reign and it appears that he maintained peace for at least part of his reign (Briggs 1951:160; see Hall 1975).

Following Suryavarman I's death, the reigns of both Udayadityavarman II and Harshavaramn III appear to be dominated by years of internal and international conflict with states to the east, specifically the Cham, Dai Viet and Chinese (Briggs 1951:176-178). This is followed by a new era in Angkor that shows a marked shift in the focus of power away from the northwest.

Jayavarman VI

A new dynastic family based in the Khorat Plateau took control of Angkor during the late 11th century. Jayavarman VI represents the first of the Mahidharapura rulers who appear to be derived from the northwest part of the empire (Dagens 2004:30). Even more so than Suryavarman I, Jayavarman VI left no tangible record of his reign at Angkor; he did not construct a state temple or *baray* at the traditional capital (Jacques and Lafond 2004:301). Haendel has recently suggested that an inscription (K527) of Jayavarman VI in a door jamb of Pre Rup is indication that he took up his residence at this temple (2004:161). Unfortunately, there is no other indication to support this claim. According to Briggs (1951:179), Jayavarman VI set up his capital at Mahidharapura, whose location is currently unknown but is assumed to be above the Dangrek, where he is also associated with the foundation of Phimai (Groslier 1973:146). Jacques argues that there is no proof that Mahidharapura is around this site (Jacques and Lafond 2004:301). Both Jayavaraman VI and his successor, Dharanindravarman I, appear to have maintained their control away from Angkor. This was to change dramatically, however, with the crowning of Suryavarman II.

Suryavarman II

Suryavarman II took the throne in 1113 CE, returning the focus to Angkor as the centre of the Khmer political world and extending its control to a new height. Like Suryavarman I, this new king came to power after a prolonged period of regional political fragmentation and in-fighting and subsequently enacted an extensive building programme and large-scale campaigns against foreign states with the hope of extending Angkorian territory (Chandler 1996:49). A further similarity with Suryavarman I is the emphasis on a new facet of the Hindu-Buddhist ideology, which saw Suryavarman II devote his royal cult to Vishnu, represented in the magnificent structure of Angkor Wat (Mabbett 1978:6).

Unlike his family who ruled largely from the north and left no visible footprint at Angkor, Suryavarman II enacted a substantial building programme at the capital that included Banteay Samre, Thommanon, and Chau Sey Tevoda (Boisellier 1954:222-223). This penchant for construction was mirrored across his empire with additions or completions to numerous temples (Vat Phu, Preah Vihear, Preah Khan KS) and likely the first phase of Beng Melea (Ibid.; Jacques and Lafond 2004:323).

The inscription evidence of Suryavarman II indicates a fierce mandate of territorial expansion, including over a decade of conflict involving massive expeditions against the Dai Viet and Cham (Mabbett 1978:6). Not all regions were treated as enemies of the state. The cosmopolitan nature of Suryavarman II's control is attested through the depiction on Angkor Wat of foreign militia into his military ranks, specifically the 'Thai' warriors (Figure 5.5) (Jacq-Hergoualc'h 1979:130-134). This military penchant may have been driven by the desire to solidify economic ties with the Chinese under the Sung Dynasty (Hall 1985: 207).

The death of Suryavarman II was followed by an immediate period of disunity, with numerous disruptions during the reigns of his successors Dharanindravarman II and Yasovarman II (Briggs 1951:205-207; Coèdes 1968:163). From this period of relative chaos emerged the last great king in Angkor's history, Jayavarman VII.

Jayavarman VII

The long-standing account of this king's reign suggests that he claimed the throne of Angkor four years after the supposed sack of the capital by the Cham in 1177 (Coedès 1968:169-170). Recent revisions of this event and the political relationship of the future king with the Cham suggest a much different story. Michael Vickery's re-examination of the broader history of this time period concludes that,

> All of this suggests that the traditional academic history of the time needs revision. There is no good evidence of a great Cham conquest of Angkor in 1177, certainly not with the details supplied by the Chinese. During the time when Cambodia was in turmoil in the 1160s and 1170s, there may have been more or less successful raids from Champa, while the future Jayavarman VII was in Vijaya, and, we may assume, was part of the Champa political scene (2004).

Whatever his role in the events of the 12th century, Jayavarman VII became one of the most important warriors, organizers, builders and public benefactors of Angkorian society (Briggs 1951:215). He shifted royal patronage towards Buddhism and the new king's religious preferences had a profound impact on many of his royal works. For instance, Jayavarman VII is reported to have distributed 23 images of the *Jayabuddhamahanatha,* himself as the Budda, across his empire (Briggs 1951:229). The building and inscriptions programme associated with Jayavarman VII was vast. Within

Angkor he was responsible for at least part of the construction of Preah Khan, Ta Prohm, Banteay Kdei, the Bayon, the walls of Angkor Tom and the Jayatataka *baray*, not to mention numerous smaller sites (Ta Nei, Ta Som, Neak Pean) (see Cunin 2004). Beyond the capital he added to existing buildings (Phimai) and constructed new enclosures (Banteay Chhmar, Ta Prohm Bati, Muang Singh) and innumerable smaller, specialized temples (Cunin 2004). Two of these specialized temples, the hospital and resthouse, are particularly important. According to the Ta Prohm inscription (1186 CE) Jayavarman VII erected 102 hospitals across his territory (Coedès 1940:344). Approximately 50 of these structures (Figure 5.6) have now been identified by their characteristic architectural plan or foundation stele (Coedès 1940:344-346; Pottier et al. 2006). It should be noted that hospitals are associated with settlement and major temple sites, and not with the transportation system (Christophe Pottier, pers. comm. January 2005).

The inscription from Preah Khan of Angkor (1191 CE) states that Jayavarman VII was responsible for the construction of 121 resthouses (*gîtes d'étape*) along three Angkorian roads (Figure 5.7) (Coedès 1992[1941]:160-161). Detailed discussion of these buildings will be in Chapter 7. Beyond the organizational power required to build these temples, the construction of services for local inhabitants – in the form of hospitals and resting places – appears to show Jayavarman VII's concern for gaining merit and a greater sense of beneficence (Mabbett 1978:35). Both of these would have been essential qualities in the campaign to expand an empire.

The architectural and artistic characteristics of Jayavarman VII's reign are so dynamic that four separate phases have been identified (see Stern 1965; Cunin 2004). Recent studies of these styles indicates that, while many of the buildings are the product of Jayavarman VII, there is suspicion that many of his works were built, finished or modified by his successors. For example, Jacques has suggested that the famous face towers (Figure 5.8) at particular temples (i.e., Prasat Preah Stung at Preah Khan KS, Banteay Chhmar) may have been built or finished by his successor Indravarman II (Jacques and Lafond 2004:294; 373; see Cunin 2004). This suggests that the kings of the early to late 13th century played a much more active role in the building programme of the Empire than we have previously assumed.

From the beginning of Jayavarman VII's reign he was involved in repeated interaction with foreign states including the Malay Peninsula, Myanmar, Sri Lanka and the Sung Chinese (Briggs 1951:216-223). Like Suryavarman II, he spent considerable efforts in the early part of his reign in consolidating old provinces (Malyang) and repeated wars with the Cham and Dai Viet on the east coast of Vietnam. He repeatedly took the capital of Vijaya during the late 12th and early 13th centuries (Michael Vickery, pers. comm. April 2005). Toward the end of his reign there was increasing resistance to Khmer control, both in Champa and the Malay peninsula (Briggs 1951:238).

The home of Jayavarman VII remains unclear, though we know that he spent part of his life in Cham territory (Briggs 1951:205). His connection with the Cham has been re-interpreted to suggest that perhaps Jayavarman VII ascended the throne with the help of Champa (Michael Vickery, pers. comm. May 2007). Jacques has posited that he may have mounted his attempt to take the throne from a base to the east, possibly Preah Khan KS (Jacques and Lafond 2004:289). He further posits that his family may have had connections to the northwest as the site of Banteay Chhmar may have been constructed for his father (Ibid.:351-352).

Jayavarman VII's imprint on the Angkorian landscape has remained among the most visible, and most studied of all the kings who ruled this empire. His reign represents the zenith of Angkorian power in mainland Southeast Asia. It may be that his actions in religion, construction and warfare taxed Angkorian society such that it never reached the same stature (Mabbett 1978:7).

Later Kings and an Important Guest

Following the death of Jayavarman VII the history of events and architectural developments becomes much less clear. The reason for this is a marked decrease in the number of inscriptions and cessation of new stone temple construction (Jacques and Freeman 1997:278). As noted above, Indravarman II and Jayavarman VIII may have played a more active role in the architectural works attributed to the previous king (i.e., Jacques and Lafond 2004:373; Jacques 2006), but the efforts of these kings are substantially muted by comparison with the previous four centuries.

The status quo at Angkor appears to have been maintained at least until the late 13th century, based on the account of Chinese visitor Zhou Daguan. Zhou's visit to Angkor is

1295-96 translated from the Chinese by Pelliot (1902) visit to Angkor provides a picture of Angkor in bloom, and gives us a list of the civilian and administrative practices of society. He talks about the extent of the empire as consisting of 90 largely unidentifiable provinces, its local resources and economy. Zhou also discusses the types of land and river transportation employed in the region (Ibid.). The record of Angkor from this point on is restricted to foreign accounts and there has been little direct archaeological investigation of the period leading up to the abandonment of Angkor as the capital.

The Angkorian Timeline and Transport

This review of the most active Angkorian kings demonstrates the extent of movement and communication present at the beginning of the Angkorian period. Given the limited extent of information beyond the 13th century CE this study will focus on defining transportation up to this point in time. There is no doubt that the pre- and post-Angkorian periods played a role either in structuring or later modifying the visible remains of the transport system today. Many of the Angkorian period sites on the road system have their origins in pre-Angkorian settlement. The reason for not investigating the pre-Angkorian movement at this time is guided by the need to establish a solid baseline of Angkorian period transportation. By studying this period in detail first we can then extend our inquiries to consider how earlier (or later) communication patterns affected the development of the transport system.

Summary

The study of Angkor has been guided almost exclusively by the use of historic texts. Historians over the past century have produced an excellent platform of the temporal developments between the 9th and the 13th centuries CE. A general trend in Khmer studies that was identified by Groslier (1986 [1973]) and more recently by Stark (2006) is the lack of data synthesis and integration of geographic factors. An integrated discussion of the geographic features in the Angkorian territory emphasizes the important role of the water system, specifically the Tonle Sap Lake and the Mekong River as both a natural communication system and important provider of food (e.g., rice, fish) and other resources. The Dangrek Range, unlike its eastern and southern counterparts, did not serve as a border to the Angkorian Khmer. The elite of Angkor appear to have communicated freely across this range and established several important sites in the Khorat Plateau.

The review of Angkorian history to the 13th century CE highlights the role of particular kings in the development of communication in the region. The reason for examining the activities of kings in detail at this stage is to provide a context for the investigation of the chronology of the Angkorian transport system. Having established the spatial and temporal background, we can now investigate their dynamics within the Angkorian period and outline the basic political, economic and religious functions of Angkor within the context of an empire.

Chapter 6. Angkor, the Archaeological Empire

Angkor is examined in this chapter within the context of the operational scales and multifaceted cultural requirements of empires. While historians have long discussed Angkor in terms of development and internal structure, there has been little evaluation of these traits in terms of the comparative discussions of archaeological studies of empire. As indicated in Chapter 1, a systematic and comprehensive picture for the politico-economic dynamics of the Angkorian period is not currently available; emphasis is therefore placed on identifying the structural elements rather than on the details of specific regional functions of the empire. Three critical points need to be raised that will assist our investigation of Angkorian transportation. First, is to outline the characteristics of empire for the medieval Khmer. This includes examining Angkor as a capital and the archaeological evidence of the Angkorian settlement plan, which is derived largely from temples. Description of the variation in temple form, layout and associated features such as tanks, is important as these locations represent the nodes to which transport ultimately connects. The second point is to demonstrate that Angkor was not a static entity but is subject to the spatio-temporal dynamics described by Marcus in Chapter 4. This will be presented by identifying phases of expansion and consolidation and the kings associated with these actions. The final point is that we need to summarize the broad characteristics of the cultural mechanisms of imperial control that the Angkorian kings used to maintain their territory. At the end of this review a holistic picture of Angkor as an empire in motion is constructed to guide the analysis of the spatial, temporal and geographic relationships of its transportation network.

Defining Angkor as Archaeological Empire

The study of Angkor as an archaeological empire must start with identifying how it compares to the basic components of pre-industrialised empire. Coe has already identified many of the imperial characteristics of Angkor (see 2004:97); by comparing this list with those presented in the review of empires in Chapter 4 we find that Angkor has the following characteristics:

- periods of rapid expansion (see below)
- a maximal extent that covered most of mainland Southeast Asia
- an extent that controlled several ecozones; however, settlement was dictated by

land favourable to rice agriculture

- a population that would have been substantial, with the population at Angkor possibly reaching 300-700,000 people
- a population that would have included Mon, Malay, Cham and Thai groups as well as local Khmer
- a centralized hierarchical politico-economic organization that would have included taxation as a means of extracting funds for the capital
- writing displayed in Sanskrit and Khmer inscriptions
- no evidence of a standing army
- a distinct imperial artistic style
- a capital that remained, with the exception of the period at Koh Ker, at Angkor for the duration
- a period of 'dramatic' expansion of the Angkorian settlement plan and material culture
- monumental architecture that was used as a point of control in distant provinces

With the possible exception of the standing army, Angkor meets all of the basic criteria of an archaeological empire. Since the capital and settlement, in the form of temples, are pivotal nodes that guide the study of transport, further examination of the last three characteristics mentioned above must be clarified.

The Capital

With the exception of Jayavarman IV, and perhaps Jayavarman VI, the city of Angkor served as the heart of the Angkorian Empire for over 600 years. We now know that the layout of Angkor, thanks to the work of recent work by Pottier (1999) and Evans (2002; 2007) spans an area of 1000 km^2 (Figure 6.1). Within the greater urban area, state temples were built by successions of kings as well as village-level temples, hundreds of water tanks (*trapeang*), and vast areas covered in ricefields (Figure 6.2a-b). Surrounding these structures is an elaborate network of canals and embankments that formed an important hydraulic network that led researchers to conclude that Angkor was the largest hydraulic city in Southeast Asia (see Groslier 1979; Evans 2007). Kummu (2003) divides this hydraulic network into three zones: a Collector zone, composed of canals that funnel water from the Kulen toward Angkor; the Aggregator/Holding zone, which represents the immense water storage reservoirs around the core of the city; and lastly the

Drainage/Dispersal zone which transfers water into the rice field system. This hydraulic network also played an important role as a raised earthen transportation network for travel around the centre. A few of these embankments connected Angkor to its outer territories in the form of the five main roads that radiate out from the site. The dual nature of water control and transportation is an important characteristic of many Angkorian building practices. When looking at the agricultural potential of Angkor and its hydraulic network, studies have shown that this region could have supported an estimated population of 300,000 to 750,000 (Lustig 2001:84). Overall, the size of Angkor has the distinction of being the largest pre-industrial city in the ancient world (see Fletcher et al. 2003).

Angkorian Settlement: Temples and Tanks

The definition of Angkorian settlement is based on the visibility of temples, water tanks and earthen infrastructure. Direct evidence of villages and habitation is largely missing from the archaeological record as it was constructed of perishable materials. Although mounds near temples such as at Trapeang Phong (MAFKATA 2005) and along embankments at the site of Tomnup Barang (Greater Angkor Project 2004-2006) do provide some information about settlement, the basis for defining the extent of Angkorian settlement has relied heavily on the location of temples and water infrastructure.

Temples

Our understanding of Angkorian settlement has been connected to the visibility and distribution of temples. Studies have centred on the assumption that temples acted as the focal points of settlement and were likely involved in local and regional activities. The role of temples in the Angkorian power structures will be discussed below. Several important aspects of the temple that should be mentioned are the variety of temple forms, their distribution across the landscape, and the model of temple development.

Temple Form

The inherent politico-religious importance of the Angkorian temple rests in the perception that, although it is likely that temples were initially made of wood or had their preliminary form in this material (Cunin 2006), stone, and likely brick, were reserved as building materials for the homes of gods and not for people (Foucher 1903:178-179; Claude Jacques, pers. comm. July 2006). The corpus of temple architecture shows a marked diversity in both plan and profile that can be roughly divided into local and state-level types. Local temples are characterized by single *prasats* (towers) often surrounded by a horseshoe shaped moat and fronted by a *trapeang* (see Figure 6.2a). State level temples are more diverse and can be roughly divided into concentric (i.e., Pre Rup, Angkor Wat) and axial (i.e., Vat Phu, Preah Vihear) plans (Figure 6.3a-b). These plans are compeimented by the construction of one or more walls, a moat, or a *baray*. The size of these temples also ranges from small enclosures to the largest single *pura* (enclosed city) in Southeast Asia at Preah Khan KS, whose walls enclose an area of 25km^2 (Figure 6.4).

In profile, a distinction is made between temples built on one level and those built as a ‘temple mountain’ (Figure 6.5a-b), which reflects an artificial construction of the Mount Meru concept (see Filliozat 1954). Position and number of *prasats* is another dimension of temple profile with single, triple, quintuple and quincunx (four axial and raised central tower) arrangements found within the central enclosure (Figure 6.6a-b).

Temple orientation is another important aspect of architectural form. The main axis of most temples is cardinally oriented toward the east-west line. Prasats normally face to the east which has the Buddhist and Hindu importance of the rising sun[3]. This orientation is most adhered in the major temples of Angkor as well as many outside the capital. Primary exceptions are Phimai and Preah Khan KS, and the *Rahal* (reservoir) of Koh Ker. Explanations for these divergences have been attributed to geographic and hydraulic factors (Jacques and Lafond 2004:265).

Temple Distribution

Angkorian temples were distributed over vast areas of mainland Southeast Asia. Figure 6.7 shows the recent survey of Angkorian temples in Cambodia completed by the Ministry of Culture and the EFEO. It is apparent that the area surrounding the Tonle Sap Lake acts as a primary building ground. In defining the maximal limit of Angkorian temples, however, Groslier argued that it is easier to show where they did not settle: seacoast, swampy plains, edge of Mekong, thick forest, mountains or hills (1986:70). What remain are locations with favourable land for rice agriculture or religious connection (Ibid.:71). As discussed in Chapter 5, Groslier argues correctly that the

[3] The fact that Angkor Wat opens to the west, the direction of the dead, has raised the issue of whether the monument is actually a mausoleum for Suryavarman II (see Coedès 1992[1933]). For a recent investigation of the archaeoastronomical alignment of Khmer temples in Thailand see Mollerup (2005).

Angkorian Khmer felt most ‘comfortable’ between the Tonle Sap and Mun River on the Khorat Plateau (1986:39). Although there are examples of sites outside this ‘comfort zone’ such as Muang Singh on the Myanmar border and Prasat Narai Jaeng Waeng in Nakhon Sakhon, northeast Thailand, these sites likely represent enclaves rather than evidence of direct Angkorian territorial control.

Development of State Temples around the Empire

By integrating air photos and ground survey B-P Groslier identified the basic elements of temple history and created a typology of the way in which the Khmer used and exploited physical space (Groslier 1997[1980]:189). Expanding on the hydraulic and architectural characteristics of Angkor and large regional centres sites such as Beng Melea, Preah Khan KS, and Banteay Chhmar, the state temple requires the following features: a large enclosure near flowing water, an equally large water reservoir, and associated water infrastructure initiatives such as dikes (roads) and water tanks (see Groslier 1979; Pottier 1999; Evans 2002). Villages then formed around the temples on mounds and also along the embankments created by the dikes. In addition to providing high ground for habitation, embankments also facilitated collection of water that could be channelled into rice paddies (Groslier 1997[1974]:118). A fundamental part of this scenario not discussed in Groslier’s model is the specific reason for selecting the particular location for a site. This question will be evaluated in Chapter 10 during the analysis of the role of cultural resources in the development of settlement and transportation.

Tanks (Water Reservoirs)

Tanks, commonly referred to as *trapeang*, represent perhaps the only vestige of architecture that truly crosses the domain between sacred and mundane in the Angkorian world. Although considerable debate has taken place about the agricultural role and/or political importance of the enormous *barays* around Angkor (see Groslier 1979; Van Liere 1980; Stott 1992; Acker 1998; Evans 2007), the role of their smaller cousins, referred to generally by the Khmer as *trapeang*, (also *srah*, *roluh*, *rolum*, *rohal)* (Khieu 2006), is much clearer. *Trapeang* in ethnographic contexts are identified as tanks spaced further from villages that receive good amounts of water and play an important role in local agriculture (Ebihara 1968:226). They also serve as places to water cattle and are used today to raise fish. Overall, however, there has been little study of the distribution or role of tanks in the Angkorian context.

Dynamics in the Angkorian Period

Having defined the types of material remains used to identify Angkor's extent across the landscape, we can now turn to the second characteristic of global empires which is the recognition of internal spatial and temporal dynamics. In Chapter 4, the concepts of expansion, consolidation and collapse were raised as important benchmarks in the life cycle of an empire. With the exception of the twenty-year sojourn to Koh Ker, Angkor remained the capital until 1431 CE when it was moved to southern Cambodia (Dagens 2003:42). During this time, however, the empire experienced internal fluctuations in regional control and interaction that Stark has equated with repeated episodes of regeneration (see Stark 2006). For the study of transportation it is important to clearly build on the idea of dynamic growth and understand that Angkor was in a state of perpetual 'motion', both spatially and politically. To illustrate this point it is useful to highlight periods of expansion and consolidation between the 9th to 13th centuries.

Expansion

Periods of actual expansion are defined as those times when control moved beyond the existing territories and into new regions that were often occupied by an independent state or ethnic group. Notable points of expansion for particular Angkorian kings include:

- Rajendravarman (mid 10th century) – made forays to towards Luovo (Lopburi) in the west and also attacked and conquered the capital of Champa (Hall 1975:324).
- Suryavarman I (early-mid 11th century) – expansion into territories of Luovo and Tambralinga in central and peninsular Thailand (de Mestier du Bourg 1970:296-297).
- Suryavarman II (early-mid 12th century) – repeated attacks on the east coast of Vietnam against the Cham and Dai Viet (Briggs 1951:192); extended his control to the Myanmar border, down the peninsula toward Grahi (part of Tambralinga) and the Bay of Bandon (Hall 1976:307; Mabbett 1978:6).
- Jayavarman VII (late 12th-early 13th century) – pushed the borders of Angkorian influence further into the Malay Peninsula (Briggs 1951:237-238) and continued attacks on the east coast particularly against the Cham and Dai Viet (Michael Vickery, pers. comm. November 2006); Groslier, however, noted that Jayavarman VII essentially mapped onto the pre-existing empire held by Suryavarman II, perhaps with the addition of Khon Kaen (1997[1980]:201).

Expansion also took place within Angkor's core territory (i.e., Jayavarman II, Yasovarman I) however it is difficult to distinguish whether this is movement into new territory versus consolidation of regions that merely lacked a state temple.

Consolidation

Kings that are able to maintain power over an extended time have managed to keep hold of their provincial territories through the act of consolidation. Consolidation equates to a king's ability to solidify ties with pre-existing or newly acquired regional polities. It is possible therefore to make a direct correlation between the length of a king's reign and his ability to consolidate his territories.

Angkorian kings frequently had a penchant for remodelling pre-existing temples or erection of inscriptions telling of the association of the king to that location. Stark argues rightly that the pre- and Angkorian periods experienced cycles of consolidation alternating with periods of political fragmentation (2006:162). The kings who successfully integrated the provincial centres were:

- Jayavarman II (early 9th century) – in addition to bringing together several individual polities (see Wolters 1973), the first king of Angkor may also be associated with introducing the concept of the ruler as a godly being. This concept of the *devaraja* (or its Khmer language equivalent *kamraten jagat*) would serve as the binding political force for all subsequent rulers.
- Yasovarman I (late 9th century) – built 100 ashramas around the capital and empire which act as markers of his beneficence and control.
- Rajendravarman and Jayavarman V (mid-late 10th century) – re-established Angkor as the capital after the brief movement to Koh Ker, and began extensive remodelling of temples to the northeast of Angkor.
- Suryavarman I (early-mid 11th century) – viewed as the first imperial king of Angkor (Kulke 1986:12); he constructed and or modified numerous temples in the Angkorian region, made his provincial elite swear fealty by taking an oath, and distributed the four linga, the *Surahvaramecvara*, at each of the cardinal points of this empire (Jacques and Lafond 2004:203-204).
- Suryavarman II (early-mid 12th century) – officially shifted his familial power

base from the Khorat Plateau to Angkor; he reintegrated the old territories of Suryavarman I by modifying existing temples and was responsible for significant parts of Beng Melea and Preah Khan KS.

- Jayavarman VII (late 12^{th}-early 13^{th} century) – is responsible for the construction of numerous structures in Angkor (e.g., Bayon, Ta Prohm, Angkor Thom) and in provinces (e.g., Banteay Chhmar, Vat Nokor, Ta Prohm Bati); also built hospital chapels near main settlements and resthouses along the roadways.

An overall trend associated with territorial consolidation was the construction or modification of temples. By building or renovating these structures the king or the local elite in the region were able to incorporate the temple and surrounding settlements into the broader bureaucratic system.

This review of expansion and consolidation episodes within the Angkorian period demonstrates that Angkor was not a homogeneous entity but experienced fluctuations in the size of its territory through time. While this is rather obvious, it is a vital consideration for the development of transport and communication that will be addressed in detail in subsequent chapters.

Angkorian Mechanisms of Control

The kings of Angkor managed to maintain their position over their territories through the control of military, political, economic and religious aspects of society. This section will outline the operational characteristics of Angkorian society and set the groundwork to determine the transportation and communication requirements of the Angkorian Empire.

Military Control

Evidence of the use of military force is commonplace in the historic records throughout the 9^{th} to 13^{th} centuries. Accounts of military force are manifest in the inscriptions as putting down revolts to large-scale attacks on a foreign state. In addition to force, Angkorian kings likely used military threat and influence to gain new allies. Wolters argues that as the great leaders in Southeast Asia were seen as agents of divine power, the ability to provide service to them would result in religious merit for those who acquiesced (1973:838). This is evident from the reign of Jayavarman II, whose victories were so impressive that he gained significant praise and allegiance from those around him (Hall 1985:140).

Physical Representation of Military Control

Evidence of military action is derived largely from epigraphic sources. Since we lack burials or battlefield records, the only visual record of the army in its early 12th and late 12th-early 13th century configuration comes from the bas reliefs of Angkor Wat, the Bayon and at Banteay Chhmar. Georges Groslier (1921) and later Jacq-Hergoualc'h (1979) have examined the practicalities of these representations, describing an army composed of foot soldiers, chariots, cavalry, war elephants, and riverine boats. The only estimation of the size of Angkor's army comes from a record of Suryavarman II which suggests that his expedition against Dai Viet in 1128 apparently involved some 20,000 soliders (Briggs 1951:190). Mabbett argues however that we cannot suppose that there were regular standing armies of many thousand men (1978:37). The composition of the army would therefore have been made up of Khmer farmers serving their corvée duties; many inscriptions refer to *rajakarya*, which is generally associated with tax but may also have involved actual service (Eileen Lustig, pers. comm., April 2007). As indicated earlier, these local forces were supplemented with ethnic militia. Mabbett also states that military expenditure would have been very costly on the ruler's resources (1978:37). The corollary is that a king who initiated several wars had substantial resources available to him. Though there is no record, Lustig suggests that it is possible that armies may have been mobilised by regional rulers on behalf of the Angkorian king (Eileen Lustig, pers. comm., April 2007). In this instance significant funds would have been immediately required to facilitate such mobilisation.

Unlike prehistoric and early pre-Angkorian settlement that features circular moats and walls, the habitation sites of the Angkorian period are largely devoid of any defensive architecture (Welch 1997:76). Welch argues that this pattern in the Khorat is related to consolidation under the hegemony of Angkor and the subsequent decrease in local competition (Ibid.). Evidence of defensive architecture is also not a common feature of Angkorian temples. The only truly defensive walls would have been the 8 m high embankments that surround the city of Angkor Thom.

Military Control and Transportation

The primary requirement of transportation in the context of military power is the recurring movement of troops. Angkor's numerous campaigns directed to put down internal revolts or attack distant states would have resulted in the creation of routes to facilitate this kind of movement. In addition to routes, soldiers, elephants, horses and bullocks would have required support infrastructure such as tanks to water the animals along the way. Armies may also leave visible traces of where they camped, and these locations would be most visible along routes where repeated campaigns were launched. The historical evidence suggests that military activity played an important role in structuring the roads out of Angkor from as early as the 10^{th} century. Both terrestrial and riverine systems were vital to the expeditious dispersal of troops.

Political Control

The king and his capital were the focal points of the Angkorian political world. Terms such as *devaraja* or *kamraten jagat* (god-king) and *cakravartin* (universal ruler) have been used historically to describe the king as the ultimate binding force that connects the earthly world with the celestial (Dagens 2003:87). Two critical dimensions of political control are the accession of the king and the regulatory methods used by the Angkorian rulers to sustain their hegemony.

Gaining Political Control

The process of becoming king at Angkor was achieved through familial succession or bloody coups (see Vickery 1986; Coe 2004:100). Because power was transferred through bilateral descent rules the Angkorian political structure was prone to conflict and instability (Kirsch 1976). Internal conflicts were common during periods of accession with inter-family struggles and enterprising 'foreigners' making attempts at the throne. The attribution of 'foreigners and usurper' status to particular kings however has been questioned in the re-examination of the histories. Vickery's review of the epigraphic evidence shows that the lineage of kings previously associated with usurper status – Yasovarman, Jayavarman IV, Suryavarman I – may be unjustified as they appear to be related within the proper rite of succession (1985:244). If these people were part of the royal lineage it shows that the physical extent of the Angkorian families and communication between them spanned substantial distances outside of Angkor. They were not foreigners but were based in different provinces of the realm and thus were familiar with the internal workings of the capital.

Maintaining Internal Political Control

Once they had established control, Angkorian kings extended their political influence primarily through land grants and marriage alliances, gifts and titles. Ricklefs argues that land would have been the primary source of power during the 10th century (1967:412). Land grants from areas of lesser value or areas that were previously uncultivated served the dual purpose of extending privilege to allies and also expanding the production of rice surpluses for the capital and political integration (Hall 1985:161). Chandler argues that the king begins establishing control by extending networks of patronage and obligations, beginning with close associates and family relations and then working further outwards (1996:48). Once established Wyatt illustrated that the Angkorian Khmer maintained political control by continual movement of people through the landscape including,

- Establishment of supremacy of force of arms coupled with diplomacy
- Governors, and sometimes princes, placed in most important provinces
- Extensive retinue of officials such as inspectors and tax collectors
- Religious parties moving between centres (1984: 25).

While this describes more than strictly political governance it demonstrates the level of the bureaucratic mechanisms used by the Angkorian kings to maintain control over their provincial territories.

Control of specific parts of the empire naturally waxes and wanes during the reign of a single king especially for those who remain in power over extended periods of time. The nature of internal political relations during the Angkorian period were far from calm; inscriptions indicate that land assignments to families and temples show a constant friction between the capital and provincial regions (Hall 1985:157). Since the Angkorian Empire often included territories occupied by ethnic groups (i.e., Cham, Vietnamese, Burmese and Mon) the king would have even greater difficulties in maintaining continuously peaceful or dominant relationships (Dagens 2003:74-76).

Physical Representation of Political Control

At Angkor, the political power of the king is manifest in the construction of monumental architecture. Stern (1954) noted a repeated cycle of building by successive rulers at Angkor that included construction of a large *baray* for the public good, an ancestral temple, and a temple mountain. While the strict adherence to this plan is not universal it is possible to identify this pattern within the reigns of Indravarman, Yasovarman I, Rajendravarman II and Jayavarman VII (Mabbett 1978:9). Outside of Angkor the kings (or their close followers) constructed temples, re-modelled or placed dedicatory inscriptions at existing temples as a common tool for political control.

Political Control and Transportation

Execution and maintenance of Angkor's political mechanisms would have required an extensive internal communication network from the time of Jayavarman II. While it is difficult to assess the location of land associated with marriage alliances or land grants, the distribution of temples and inscriptions offers a more tangible record of a king's political footprint. These nodes represent locations that we know were involved in the workings of the society at that time, and many sites became part of the territory of subsequent kings. Increased or continued communication requirements may have influenced the need for formalized routes in the landscape. For example, Groslier cites a particular event called the 'Anniversary of the King' whereby provincial leaders would come to Angkor, gather around the king and bring precious commodities (1973:133); this event would have necessitated established routes to reach the capital. Groslier also suggests that the roads were used by the king to leave Angkor periodically to visit his provincial territories (Groslier 1986:64-65).

Economic Control

The kings of Angkor required sufficient economic reserves to support their political activities, military expeditions and local populace. Control over both goods and sources of labour were therefore critical in both domestic activities and international exchange.

Domestic Economy

The domestic basis of Angkor's economic power was rice acquired through taxation. Coe describes Angkor as an 'immense revenue-gathering machine' which relied on taxation from its subjects paid in kind (2004:150). While Angkor lacked a formalized monetary system (Groslier 1997[1974]:120; Sahai 1977) rice was likely the primary economic unit. While there is no doubt that rice agriculture – wet, dry and wild varieties – played an important role, it was only part of a wider economic programme (Mabbett and Chandler 1995:141). Khmer language inscriptions describe a vast array of luxury goods and raw materials that were traded using varying exchange 'prices' (Eileen Lustig, pers. comm.

April 2007). Forest resources such as wax, honey, scented woods and resins were among the most highly valued exports (Pelliot 1902:166).

Land transactions were another important mechanism used by Angkor's kings to extend their economic resources. Endowments of land, such as those by Suryavarman I, were directed toward the mobilization, growth, organization, and pooling of economic resources (i.e., capital, land, labour) to support the ritual functions of the regional temple (Hall 1985:160; 178). Labour exchange also played a vital role in rice production and the construction and maintenance of public works (Dagens 2003:134). Human labour, either as 'slaves' or through corvée, ultimately enabled the Angkorian kings to harvest the vast tracts of ricefields and built their temples, hydraulic and transportation infrastructures.

Foreign Trade

Research on the international economy of Angkor was based initially on Chinese records, specifically Zhou Daguan's visit to the capital between 1295-1296 CE (Pelliot 1902). Zhou notes that Cambodia's prime exports were forest products such as kingfisher feathers, wax, elephant tusks, scented woods and resins while Chinese finished products such as fabrics, metal objects, gold and silver were brought into Angkor (Pelliot 1902:167-168). Visual evidence of the Chinese at Angkor is found on the Bayon in the form of Chinese traders in a stall and a junk laden with goods (see Figure 6.8). The distribution of these foreign wares, however, appears to have been limited largely to Angkor. For example, Brown (1981:48) noted a general absence of Chinese ceramics at Angkorian sites in Thailand. Further excavation will assist in determining whether this trend is consistent across the Angkorian territories.

Physical Representation of Economic Control

The local temple is the most obvious marker of economic control as it played an important role in the collection and redistribution of local agricultural input back to the local community and to the capital (Hall 1985: 136). Although temples likely functioned as central collection points, there is little evidence of markets in the vicinity though they would have been constructed perishable materials.

The epigraphic and foreign accounts provide a list of the types of goods that may be found in the archaeological record. Unfortunately, most of these goods have not survived.

The bulk of our archaeological information about trade is therefore based on ceramic and metal-based commodities.

Economic Control and Transportation

Angkor's economic network has several implications for transportation and communication within and without the capital. The requirement to pay tax and tribute to Angkor raises the question of how it was transferred to the capital. Collection and extraction of raw materials from forests and mines would have required knowledge of sources and a means of bringing them into the economic system. Lastly, the presence of foreign goods indicates substantial movement in and out of the Angkorian territory. This trade may have been achieved by land or water-based communication.

Religious Control

Religion is deeply imbedded in all aspects of Angkorian society with the king and Angkor representing the human and geographic centre of its universe. The structure of the elite belief system is formed from a syncretism of Hindu and Buddhist doctrines combined with local animism (Hall 1985: 6). Kings chose to patronize specific aspects of the Hindo-Buddhist pantheon (i.e., Shiva, Vishnu, Buddhist incarnations) yet were often mindful of the beliefs of past kings and often showed respect to temples outside their immediate patronage.

The Angkorian king was supported by a religious administration composed of various officials with Sanskrit titles including *purohita* (royal chaplain), royal *hotar* ('sacrificer') and various *acarya* (learned man) (Vickery 1985:229; Coe 2004:142-143). It is through this hierarchy that religious protocols and ultimately control would have been established and maintained in the capital and provincial territories.

Another important source of religious control would have been contact with the religious homelands in Sri Lanka and India. While this interaction is not well-documented, religious officials from Angkor likely accompanied trade vessels to South Asia, returning with ideals that would be integrated with the Angkorian politico-religious structure. As a form of elite control, religion is an integral part of both political and economic activities during the Angkorian period.

Physical Remains of Religious Control

The temple is the most obvious and visible mechanism of religious control. The capital of Angkor notionally acted as the centre of the kingdom, the abode of divinity and royal power, and, in some instances, the destined royal tomb of the ruler (see Coedès 1992[1933]). Kings erected temples on hills and artificial temple mountains were built to recreate the sacred Mount Mahendra linking earth to the world of the gods. Successive kings also covered their extended territories with a network of religious edifices that served the capital and its institutions (Kulke 1986:16). Iconography on state- down to village-level temples reflects the particular religious orientation of its patron or of the king.

Religious Control and Transportation

Regardless of whether the king or a patron of the king was responsible for its construction, the temple building served the same religious function and participated in a broader communication network. The most common form of religious act that necessitated transportation was pilgrimage. Pilgrims and subject elites would both have been drawn to the capital; conversely, kings appear to have made 'construction and inscription' pilgrimages to visit sacred locales such as Preah Vihear or Vat Phu. Each scenario would have used specific routes to reach these sacred destinations.

Dynamics of Control and the Role of the Temple

Obviously, the mechanisms of Angkorian control over the empire are not isolated but are dynamically linked together. The act of land donation established a reliable political base for the king that would ultimately provide economic return in the form of rice tax. Political relationships with foreign groups were likely spurred by trade or the need for military alliances. Economic decisions to purchase base metals may ultimately have been driven by the need to create religious statuary. The physical remains of the Angkorian Empire similarly show an inherent multiplicity of purpose. For example, the construction of a *baray* served the politico-religious purpose required of a king and also created a body of water that would benefit the economic productivity of adjacent rice fields.

The most obvious example of this multiplicity is the Angkorian temple. The temple integrated the Khmer world in two ways: first, it linked different agricultural regions into a greater economic network and the product from this land fuelled Angkor's ability to expand; second, temples were the pivot point for integrating the upper and lower levels of Angkorian society with the same cultural symbols (Hall 1985:137). Historically, the cultural role of the temple had slowly become more politicized. Kulke suggests that temple construction in Cambodia initially took place at sacred places, specifically natural *phnoms* (hills) which fulfilled the Mount Meru concept of Hindu-Buddhist belief (1986:14). During the Angkorian empire the emphasis shifted away from hills to constructing temples in low-lying locations (Ibid.). Like its contemporaries in India, the Angkorian temple may have played a role in all aspects of control serving as centres of investment, repositories of technological knowledge, and acting as supervisory agencies that involved agricultural labour (Hall 1985:161). The importance of the temple is further attested by the fact that by the end of the 12th century the core area of Angkor was covered by between 3000-3500 temples (Kulke 1986:16). It would only seem logical that such a capital investment would have served more than just religious purposes. Temples would have also played an important part in structuring the political and economic aspects of the Angkorian empire.

Summary

This chapter has framed Angkor within a broader picture of the global operational characteristics of a pre-industrial empire. For the study of transportation, the first four centuries of the Angkorian period were marked by considerable spatio-temporal fluctuations. Peaks in the expansion and consolidation of the empire were reached during the early 11th century under Suryavarman I and again in the 12th century by Suryavarman II and finally Jayavarman VII in the late 12th and early 13th centuries. The oscillations are manifest in the landscape by the construction of temples which acted as localized political centres. These temples served as primary nodes through which communication occurred, either at the regional or local level. Further, the methods that Angkorian rulers used to maintain their position and the societal status quo illustrates a marked diversity of cultural impulses that would have required intensive communication systems. Overall, the Angkorian Empire had considerable transport requirements that would have included military actions, political alliances, extensive movement of goods, and passage of pilgrims to the sacred centres of the empire. We must now turn our attention to the remnants of Angkorian transport and develop a set of research parameters to investigate this system within the operational approach.

Chapter 7. The Angkorian Transport System

The Angkorian Empire created an extensive transport system based primarily on the roads radiating out from the capital of Angkor. This chapter is directed toward establishing the basic characteristics of this transport system and is divided into two sections. The first section focuses on describing each of the transport components (e.g., routes, infrastructure) of the Angkorian Empire. For each component (e.g., bridge, resthouse) a brief review of its history, types, and important characteristics are presented. By looking at the history of each component we can identify the range of questions that have been addressed and also identify the seminal points that have solidified our preconceptions of the transport system. More positively, this review also enables us to mine the historical data for important ideas that have not been consistently included in modern investigations. Where relevant this section is also directed towards dispelling some of the longstanding assumptions about specific component characteristics (e.g., road paving). The second section situates the Angkorian transport components within the operational approach and outlines the investigation for subsequent chapters. Emphasis is placed on synthesizing the existing data through a GIS platform and will address issues within each of the stages of archaeological analysis listed in Chapter 3 (e.g., Location, Description and Analysis). At each stage a set of research questions is posited that relate directly to the concepts of transportation listed in Chapter 2 (e.g., development, maintenance, access, disuse).

Components of Angkorian Transport

The Angkorian transport system comprises two types of links (roads, rivers) and three different types of nodes (bridges, resthouses, and tanks). In addition to these links and nodes there is also considerable information about the modes of transport that used this system (e.g., elephants, ox carts, foot traffic). For each component of the transport system a brief history of past research and a description of the basic physical characteristics are outlined. As indicated above the advantage of stripping down the history of each component is that we can identify key points in the development of our current understanding and also outline trends that need to be adapted or improved with future work. In some cases particular issues that have been primary assumptions in the literature on Angkorian transport and/or the history of the Angkorian empire will be examined.

Roads

History of Road Research

The first European accounts of the Angkorian roads were made during the mid 19th century travels of Bastian (2005[1864]:50; 52) and Garnier (1996[1866-1868]:150). Roads connecting Angkor to the west and northwest were described as being in a miserable state of repair, were impassable due to overgrowth and not well-used by local inhabitants (Bastian 2005[1864]:50). Formal French surveys by the Mekong Exploration Commission (1866-1868), Mission Pavie (1879-1895), and individual reports by Delaporte (1880) and Moura (1883) similarly noted the existence of old roads and began to compile basic locations and descriptions of their general characteristics. In addition, these surveys provide information about where Angkorian roads were *not* built. For example, Pavie's voyage between Oudong-Battambang-Angkor-Oudong identified a lack of land transport infrastructure to the south and west of the Tonle Sap Lake, and emphasized that water transport was the preferred means in this region (1901:99).

More detailed summaries of the location and character of the Angkorian roads were first completed during the temple surveys of Étienne Aymonier (1900; 1901; 1904) and Étienne Lunet de Lajonquière (1902; 1907; 1911). While both produced maps of the roads, it is the version produced by Lajonquière that has become the base map for most archaeological publications of the transport network during the last century. His map depicts five roads radiating out from Angkor (Figure 7.1) and describes them according to their direction from this point of origin: Southeast, West, Northwest, Northeast and East (1911:xxi). In addition to these regional roads he adds smaller, secondary roads such as those between Preah Theat Prah Srei and Banteay Prey Nokor and from Phnom Chisor to Prasat Neang Khmau to the corpus of main arteries (Ibid.:lix). Lunet de Lajonquière provides the first comparison of the regional roads, identifying differences in their geographic position, and variable placement of infrastructure (i.e., bridges and rest houses) (1911:xxviii). Lajonquière also suggested that the regional roads were linked to agricultural practices, using the example that the roads parallel to the lake would have acted to also regulate water during the rainy season (Ibid).

Interest in the 'ancient' roads led to Albrecht's (1905; 1906) survey of the bridges and water courses along the southeast road between the Damdeck and Kompong Thom. Upon completing his survey, Albrecht made the following conclusions:

- the road provided a communication route connecting Angkor to several important centres
- the road is situated at the limit of the floodzone
- the road crosses a deserted country, poorly inhabited, or inhabited by people in floating villages
- the road is bisected in many places by streams which are crossed by wooden and stone bridges
- the road appears to have been in use for a long time
- the road would be an excellent means of communication above the flood zone with the proviso that further work be completed on it (Ibid.:14).

In juxtaposition to Albrecht's report which highlights the road as a terrestrial route, Jully's '*Notes sur les anciennes digues du Cambodge*' (1913) emphasized the hydraulic nature of these structures and concluded that the primary function of these embankments was to retain water during the dry season (Ibid.:41). His travels included the road between Preah Khan KS and Angkor and the route along the lake appears to be south of the one marked by Albrecht between Angkor and Kompong Thom (Figure 7.2). Jully's study appears to be the first recognition in the literature of the lower route which departs Angkor south of Roluos.

Direct interest in the Angkorian roads drops dramatically as the translation of inscriptions becomes the major focus of research (Coedès 1937-1966). Besides Malraux's fictional account of the ancient roads in '*La Voie Royale'* (1989[1930]), the first published synthesis of Cambodian society by Georges Groslier (1921) included a section on Angkorian transportation based on the bas-relief depictions and the surveys undertaken in the 19th century. While Groslier's review largely rehashes the summaries of Lunet de Lajonquière he calculates the total distance of Angkorian roads to be 800 km (Ibid.:95).

The discovery of the Preah Khan inscription by Glaize in 1939 was to become, for better or worse, the benchmark for research on the Angkorian transport system. Translated by Coedès (1941), this inscription dates to 1191 CE and documents three roads lined with 'houses with fire' or resthouses:

- Angkor to Champa (57 resthouses)
- Angkor to Phimai (17 resthouses)
- A circuitous route from Angkor - Jayavatî - Jayasimhavatî - Jayavîravatî - Jayarâjagiri - Çri Suvîrapurî - Angkor (44 resthouses) (Ibid.:160-161).

As will be discussed below, only the road to Phimai can be identified by the presence of resthouses along its length. The two other roads have not been identified. Coedès notes that the route to Champa could have connected to two capitals at this time - Panduranga (Phanrang) and Vijaya (Binh-dinh) (1940:348). Regardless of the endpoint he argues that this route must have travelled through Preah Khan KS (Ibid.). The circuitous road has not been identified either, as the Sanskrit names listed in the text have not been connected to temples in the landscape.

While Preah Khan text refers directly to the resthouse buildings specifically, the temporal association with Jayavarman VII was further extended to date the roads and other infrastructure. Parmentier's (1948) examination of the evolution of Khmer architecture was one of the first to cement the association of Jayavarman VII with the road system on a broad level,

> *Et de plus Jayavarman VII établit, développant les travaux antérieurs, un réseau considerable de routes remontées au dessus du niveau de l'inondation par des levées formidables pour lancer au besoin ses troupes en tout point du pays* (1948:120).

This description would become generally accepted as part of Angkorian studies to the present day. Summaries by Briggs (1951:233), Higham (1989:337), (Freeman 1996:154), Bruguier (2000:542), and Stark (2004:109) have all presented this temporal association in their discussion of Angkorian society. There is no mention or inquiry into the nature of earlier works on which Jayavarman VII built this elaborate system.

Contrary to Parmentier's claim, the corpus of inscriptions has produced two other references to roads that pre-date the Preah Khan inscription. The Phnom Sres (1022 CE) inscription found in the Battambang region makes reference to the construction of reservoirs along roads and a wooden bridge across a river (Jacques 1968:616-617).

Vickery has suggested, however, that the mention of wooden bridges is from a ‘philosophical passage’ and may not refer to any actual construction (Michael Vickery, pers. comm. May 2007). The inscription from Sdok Kok Thom (K235), arguably one of the most important stelae for outlining Angkor’s political history, includes the following verse:

> *Il fit des maisons et des étangs le long des routes pour favoriser les caravanes de voyageurs* (Coedès and Dupont 1992[1943]:213).

Dated to 1052 CE this indicates that both resthouses and tanks were built for the use of traders/travellers by the end of the reign of Suryavarman I.

Advances in aerial reconnaissance in the mid 20th century led to a period of interest in mapping the extent of Angkorian features. During Goloubew’s (1937) aerial survey he identified local roads around the site of Banteay Prei Nokor in south central Cambodia as well as numerous linear embankments scattered between Angkor and the Kulen Hills (Ibid.:468; 469). The use of aerial reconnaissance to locate roads appears again in Déricourt’s (1962) survey of eastern Cambodia. While the aim of Déricourt’s mission was to rectify maps of the region he noted several ‘ancient’ roads including:

- a grand route connecting Sambor to Vientiane, running parallel to the Mekong
- Vat Phu to Neak Buos
- roads in southern Laos
- small roads around Sambor Prei Kuk

Déricourt suggests that the road along the Mekong is older than the others as it appeared to be less well built (Ibid.:524). No efforts were made to ground-truth the features identified from his surveys.

Direct investigations of roads again declined in part due to the inability to undertake new research during the unstable period in Cambodia from the late 60’s to the early 90’s. Instead, studies of state development and revisions of the histories of Angkor dominated research and subsequent publications. Insight into Angkorian transportation during this time comes from the archaeo-historical syntheses of BP Groslier. Groslier’s assessment of Angkorian settlement and agriculture (1974; 1979) and in particular the inscriptions of Jayavarman VII (1973) produced new interepretations of the role of the Angkorian transport system. For instance, he suggests that the emphasis of roads in the northern half of the empire reflects the density of settlement and local political structure (Groslier 1973:117). The lone exception is the southeast road which he viewed as serving the military campaigns against Champa (Ibid.). Groslier also suggests that the roads served pilgrimage and political purposes such as bringing provincial governors to celebrate/honour the 'anniversary of the king' (Ibid.:133). Unfortunately, these hypotheses have not been tested with material data.

The common description of roads in historical works published between the 1970's and 1990's is often limited to a summary statement, such this presented by Kulke,

> …the core area and the provinces were linked through imperial roads.
> Along these roads the imperial kings constructed resthouses for pilgrims, traders, and officers, and at nodal points of this infrastructure temples functioned as royal resthouses and temporary imperial palaces (Kulke 1986:16).

Mention of roads is often made only in relation to Jayavarman VII, either directly stating that he built roads (i.e., Coedès 1968:173) or indirectly through the association of resthouses attributed to this king (i.e., Mabbett 1978:7; Kulke 1986:16; Chandler 1996:61). The regional roads are never mentioned independently by historians outside of this association.

A further aspect of roads presented in the histories is the identification of trade routes which would have served to facilitate economic movement at particular times, particularly the 10th and 11th century as in descriptions by Hall (1975; 1976; 1985). While many of Hall's ideas are disputed (see Vickery 1987) the importance of this study is his proposal of secondary routes away from the main roads identified around Angkor. It suggests, sensibly, that there was considerable communication all over the Angkorian territory.

The fact that roads were not part of regular academic discourse was acknowledged by Claude Jacques who stated that,

> I am not sure whether any special study on the roads in ancient Cambodia has been carried out, although roads have been noted from the very beginning of Khmer studies (1986:332).

Over the past decade, considerable advances have been made to fill the void in the study of Angkorian transport. The introduction of new remote sensing imagery has provided new methods for mapping the roads at a regional (i.e., Parry 1996) and site-based level, specifically around Angkor (i.e, (Moore 1989, 1998; Pottier 1999; Evans 2003; Greater Angkor Project 2003; Evans 2007) and Banteay Chhmar (Pottier 2004). Lack of ground-truthing or background knowledge has, unfortunately, led to some erroneous interpretations of roads (i.e., Parry 1996, see paving discussion below). The emphasis of these studies, however, has been oriented toward identifying broader landscape features and not specifically to the roads.

The first direct investigation of the Angkorian roads was completed by Im (1998). Im's work represents the first summary of the inscription and archaeological data on the entire Angkorian transport system. In compiling these data he adds several routes to the body of information including a second northeast route connecting Angkor through the Kulen Gap to Vat Phu (Ibid.:21-22). An updated version was recently published (2004) that includes roads identified originally by Aymonier, specifically the link between the site of Phnom Srok and Spean Toeup along the Phimai road.

Another important study focussed directly on roads is Ittaratana's (1998) thesis which focussed on identifying the physical location of the Angkorian road between the Dangrek and Phimai in Thailand. Following Groslier's lead, she attempted to use the spatial arrangement and alignment of the resthouses around Angkor as well as remote sensing, epigraphic, and toponymic data to identify this track in northeast Thailand (Ibid.:1). Ittarattana's conclusion was that the only remnant of the Angkor-Phimai route in Thailand is that laid out by the orientation of rest houses. She offers three potential reasons that the road was not visible between these structures: 1) the road did not pass through the area of the resthouses; 2) the road was totally and suddenly destroyed; or 3) traffic travellers used a different route between Phimai and Phnom Rung that may be buried beneath an existing road (Ibid.:89). Overall, her research suggests that the Phimai road was never fully completed across its entire distance of 245 km to Angkor (1998:159).

A third major contributor to the study of roads and its infrastructure is Bruno Bruguier of École Française d'Extreme Orient. His landmark paper on the Angkorian bridges (discussed in greater detail below) specifically identifies the important military function of the road system, which is reflected in the military processions on the bas-reliefs of the Bayon (2000:541-542). His surveys of Angkorian sites within Cambodia, in association with the Cambodian Ministry of Culture, also verified sections of the road between between Koh Ker and Vat Phu (Seelow 2005:10). It should be noted that Bruguier's verification is actually a re-discovery of sections originally identified by Aymonier a century earlier (1901:229).

Over the past five years, there has been a steady increase in the number of studies on the Angkorian roads. In Laos, the Lerici Foundation and UNESCO have used aerial photography and ground truthing to map the extent and associated settlements of the road connecting Vat Phu to Angkor within Laos (Patrizia Zolese, pers. comm. Nov. 2005). The Angkor Living Road project, a joint Cambodian-Thai venture, is completing a similar project surveying sites and structures along the length of the Angkor to Phimai road (Im Sokrithy, pers. comm., January 2006). The regional survey completed by the Eastern Cambodian Archaeological Project (ECAP) in Kampong Cham and Kratie, while not specifically directed toward the study of transportation, has also identified numerous embankments along the Mekong river (Pon and Davis 2004; Mam et al. in preparation). This fieldwork is the first potential corroboration of the linear embankments observed by Déricourt. At present there is no known temporal association of these embankment features, which could realistically pre- or post-date the Angkorian period.

The Angkorian transport system is commonly referenced in general texts published on Angkor. For the most part, however, these publications simply reiterate the basic descriptions and temporal assocations of the roads with Jayavarman VII (see Higham 1989:337; Freeman 1996:154; Bruguier 2000:542; Stark 2004:109). These summaries often reproduce an idealized picture of the distribution and character of the Angkorian roads. Ishizawa and Tamura's 'Along the Royal Roads to Angkor' (1999) makes several erroneous claims such as the Angkorian roads were paved with stone and that the site of

Banteay Chhmar was located along a ‘royal road’ (Ibid.:167, 177). As will be demonstrated later on, there is no evidence to support either of these claims. Perhaps the most misleading aspect of this publication is the map of the Angkorian transport system (Figure 7.3) which depicts an idealized network that extends far beyond the visible extent of features on the ground.

Other publications, however, have provided useful contributions to the perception of roads. Freeman’s (1996) tourist guide of temples in Thailand and Laos includes the Angkor-Phimai road as a potential stop on one’s itinerary. Dagens (2003) and Coe (2004) both summarise the combined knowledge of EFEO research on the Angkorian roads over the past 100 years. Coe includes an interesting comment that Thai farmers constantly run into the roads and that they avoid them at all costs to prevent disturbing angry spirits (Ibid.:152). Unfortunately the locations of these roads are not presented in the text. Recent ground surveys by the Angkor Living Road Project have identified traces of this road in Thailand (Surat Lertlum, pers. comm., April 2007).

One of the most important works on the nature of Angkorian roads is presented in Claude Jacques’ ‘*L’Empire Khmer*’ (Jacques and Lafond 2004). This survey of major sites outside of Angkor raises some key issues regarding the relationship between roads, infrastructure and sites. In addition to identifying the secondary road around the site of Phnom Chisor (Ibid.:212) he spends considerable time discussing the importance of the road connecting Angkor to Preah Khan KS, specifically in relation to the latter’s role in iron production. Contrary to the Preah Khan (of Angkor) inscription, which suggests Preah Khan KS was on the road to Champa, Jacques argues that this route likely ended at this ‘industrial city’ (Ibid.:286). The evidence for this is based on the lack of resthouses to the east of the site, but more importantly on Preah Khan KS’s substantial number of iron smelting sites and its proximity to both the local iron workers and the ‘Iron Mountain’ of Phnom Dek to the east (Ibid.:259). This point is particularly important as it emphasizes looking at the practical concern of access to agricultural or mineral resources in relation to settlement and transportation. More recently, Jacques (2006) argued that the roads were formalized by Jayavarman VII and his successor, Indravarman II.

Regional Roads

Regional road are defined as the axial or ‘trunk’ routes that connect Angkor to its provincial centres. Five regional roads have been identified through past studies: West, Northwest, East, Northeast, and Southeast road (see Figure 7.2). With the exception of the Lower Southeast road, situated close to the Tonle Sap Lake, these are the same roads named in Lunet de Lajonquiére's report (1911:xxii-xxvi). Since the publication of Lajonquière's benchmark work, only Im (1998; 2004) and Bruguier (2005) have sought to enhance the accuracy of these archaeological features on a map. Many sections of the Angkorian roads are still used today. Highway Route 6 connecting Siem Reap to Phnom Penh actually overlays the old Southeast Upper road and the shortest route link between Beng Melea and Preah Khan KS is the East road. While this latter route may be the most direct road to reach Preah Khan KS it remains largely in its original state and therefore it is often quicker to travel by ox cart than by truck for large sections of the road.

Secondary Roads

Within the framework of the trunk routes, there are secondary roads that connect main Angkorian sites to their surrounding area. Secondary roads served the important role of enabling local traffic to move between villages, to the regional temple, into rice fields, or access specific resource locations. Examples of secondary roads have been identified around Angkor (Pottier 1999; Evans 2002), Banteay Chhmar (Pottier 2004), Phnom Chisor and Neang Khmau (Jacques and Lafond 2004:212), Sambor Prei Kuk (Shimoda 2006) and Banteay Prei Nokor (Goloubew 1937:468). At Angkor these secondary roads are laid out in a grid that serves as a network for land and water movement (see Figure 6.1). Embankments around Banteay Chhmar also appear to serve this dual function as they connect to water sources within the catchment; the road to the east of the *baray* is an exception (Christophe Pottier, pers. comm. January 2006).

Projected Routes

Projected routes are links listed in past surveys but not yet verified or links based on historic or archaeological evidence; in essence these are routes that 'should' be present in the landscape. Examples of those listed in past surveys are found on the maps of Aymonier (Figure 7.4), specifically Phnom Srok and Banteay Chhmar and from Phnom Srok to the Northwest road. These routes have yet to be verified through ground survey.

The second type of projected routes is based on associations with trade routes or connections to important resources. Hall (1985) lists several important routes that would have been necessary for the flow of trade goods in the region. These include:

- the route connecting Sambor to the east to collect forest products
- an east-west route on top of the Dangrek to connect Angkorian sites in the Khorat plateau
- overland route avoiding the Khone Falls between Ban That and Prasat Kantop
- trade route to Vietnam connecting the Mekong and Nghe-An through the Ha-trai pass (Ibid.:176-184).

In addition to these trade-based routes, there are also projected routes that are based on visible nodes in the landscape that must have been connected as part of the greater transport system. The most obvious example is a connection between Preah Khan KS (iron-smelting site) and Phnom Dek (source of iron). Another example is Albrecht's suggestion that the Southeast roads continued from their terminal points at Kompong Thom to the sites of Hanchey and Vat Nokor along the Mekong (1905:10). Both of these are logical assertions however they need to be verified on the ground before they can be included in discussion of regional or secondary roads.

The absence of roads between these locations that should be connected can be explained by two factors: 1) the roads have eroded, or been completely destroyed; or, more likely, 2) roads were not built either in favour of alternate routes (e.g., rivers) or lack of communication in the region.

As indicated at the beginning of this thesis, the emphasis of this study will be placed on examining the regional roads. Unless otherwise stated, the following discussion of roads will be in reference to the regional and not the secondary type.

Road Characteristics

The dimensions of the regional roads vary anywhere from 8 m to 30 m wide and are raised between 1m to 6m above the ground (Figure 7.5a-b) (Moura 1883:243; Aymonier 1900:108; Albrecht 1905:8; Lunet de Lajonquière 1907:xxxiv). Im suggests that the regional roads are on average 10 m to 20 m wide and are raised 2 m to 6 m above the ground (1998:49-50). The road base at the site of Phlau Beng on the East road near Chao Srei Vibol measured 40 m in width (see Appendix 1). It should be noted roads are prone to vary substantially along their length depending on proximity to major settlement or the amount of local flooding. Raised roads also served the double function as dikes and the canals excavated for the construction of the road could be used for water transport during the rainy season. This duality of purpose is an important part of the Angkorian building programme.

All Angkorian roads are constructed by piling up earth from either side of a route, creating a passable land route as well as a canal for water movement. Albrecht's early report on the Angkorian roads indicated that they were made of clay mixed with sand (1905:8). Sections excavated through the East roads within Angkor by the Greater Angkor Project (see Appendix 1) have confirmed Albrecht's description of the construction materials. This should be viewed as a product of constructing the road from adjacent soils rather than a formalized construction technique.

Road Paving

A recurring point of discussion that appears in the literature is whether Angkorian roads were surfaced with stone. Recent literature contains numerous descriptions that the roads were paved with laterite (i.e., Parry 1996:30; Im 1998:49; Stark 2004:109). Ironically, the accounts of early explorers make no mention of surfaced roads at all. Aymonier describes the roads as uncovered banks of earth and suggests that while it is too bad that they were not paved, they still functioned properly (1900:108). Lunet de Lajonquière similarly noted the excellent condition of the earthen embankments and suggested that they would have been a solid platform for stone roads (1911:xxiii). No mention of a stone paving however, appears in Lajonquière's summaries. Excavations through two roads at Angkor by the Greater Angkor Project have recovered no trace of any formalized surfacing (see Appendix 1).

Several lines of reasoning can be put forward to put to resolve the issue of paving on the Angkorian roads. First, if the roads were paved we should find evidence *in situ* or in the construction of new structures from the looted stone. Analogous evidence of reuse was noted in the 16th century construction of Spean Thma, located east of Angkor Thom, from a 13th century sandstone temple (Jacques and Freeman 1997:130). More recently the staircase leading up to the temple of Banon was used to build the citadel in Battambang (Aymonier 1901:287). If indeed the roads were paved, then we would expect remains of paving to be found in one of three places: on the roads, eroding down the banks and into their accompanying canals, or as part of the building materials for structures erected near the roadways. None of these scenarios are visible in the archaeological record.

Second, paving hundreds of kilometres of roadway would require a massive amount of stone which is not abundant in all areas where roads are found. While sandstone is rare, laterite is commonly available in many parts of Angkor's territories and could have been used as a road surfacing material (see Pendleton 1941:201-202). The massive works created by the Angkorian kings suggests that they would have had the manpower to pave the roads; the question is whether they would have been able to maintain them to the standard of their intial construction. Maintenance of a paved road from traffic or seasonal damage would also be far more costly than a tamped earthen surface.

A final consideration is whether paving would have afforded significant benefits to the empire given the practicalities of Angkorian traffic and the effect of the monsoon. Wheeled traffic would certainly benefit from solid surfaces but elephants and foot traffic may be hindered by them. Even the use of laterite gravels would have questionable value for Angkorian traffic. Examples of laterite used as macadam paving in Thailand in the early 20^{th} century broke down rapidly and was not suitable for heavy traffic of any kind (Pendleton 1941:201-202). Repeated movement of vehicles such as chariots, elephants and large armies during the Angkorian period would therefore have caused excessive damage to the roadways, necessitating constant maintenance.

To conclude this issue, we can safely argue that regional roads show no evidence of paving. The use of paving was therefore restricted to ceremonial causeways leading to temples (Figure 7.6a) and the tops of bridges (Figure 7.6b). Regardless of the surfacing type the effort required to build 10 m wide and 4 m high roads would have still required substantial local or state-level organization.

Summary of Road Study

Angkorian roads were among the first transport features re-discovered by European explorers. From the literature we can identify the following characteristics:

- There are regional and secondary roads
- Constructed of dirt piled up from either side of the roadway
- Roads were not paved with laterite blocks
- Implied dual purpose as canal in rainy season

- Temporal association No direct dating of roads has been undertaken. The only temporal evidence is based on the connection to resthouses in the Preah Khan inscription (late 12th century); some scholars have suggested they may be earlier
- Associated with miltary and religious function primarily, with some reference to trade

Overall, the research emphasis has been directed towards identification and description of the basic characteristics. Other than Albrecht's (1905) report and recent initiatives by the Angkor Living Road Project, there has been little direct interest in the roads as archaeological entities.

Rivers and Canals

History of Water Transport

Water communication has played an important role in Cambodia from prehistoric through to modern times. The early explorers saw fluvial routes as the preferred method of transport and locating the most economical routes was the focus of French surveys such as the Mekong Exploratory Commission. While the 'discovery' of the Khone Falls prevented the Mekong from being a direct route for steam travel between Yunnan and the Gulf of Thailand (Carné 1995[1866-68]:55), the network of secondary rivers and the Tonle Sap Lake still afforded an excellent network for regional transport. In particular, Harmand noted the economic importance of the Stung Sen whose banks offered a vast array of materials and products and could be navigated for at least half the year (1876:353). The 19th century accounts recognized the importance of water access to Cambodian settlements and that where natural routes were not sufficient or available, canals were constructed to facilitate access (Pavie 1905:99). Pavie located an old canal, called the Au Dombang or 'Old River', to the east of Battambang which was used to shorten the distance between the region and the Tonle Sap (Ibid.:101).

Following these geographic expeditions there has been intermittent reference to water routes in an Angkorian context. The 200 m wide double embankment known today as the Damdeck canal east of Angkor was noted by Albrecht (1905) during his surveys. Local accounts of this structure suggested that it was excavated to allow Chinese junks to sail up to the Kulen where they exchanged pottery for pepper and lychees (Ibid.:15-16). Jully argued that it must have served as a canal given its depth and lack of vegetation (1913:41). More recently its function has been identified with moving sandstone from the southern part of the Kulen to the Tonle Sap lake (Lunet de Lajonquière 1911:xxiv; Boisselier 1952:224).

Georges Groslier's summary of Angkorian culture acknowledged the importance of the Tonle Sap Lake and the river system as they provided both an important food and transportation locus for Angkorian settlement (Groslier 1921:143). Aerial surveys also began to identify a broader use of man-made canals. Paris (1941) and Malleret (1959) described the extensive network of canals in southern Cambodia connecting pre-Angkorian sites of Angkor Borei to Oc-Eo on the coast. Canals continued to be built for water management and transportation in the Angkorian period especially around Ankgor (see Goloubew 1937; Groslier 1979; Moore 1989; Pottier 1999; Evans 2003; Fletcher et al. 2003). The embankments identified around Banteay Chhmar would have also served as canals (Pottier 2004:135).

While discussion of rivers is largely restricted to their role in feeding canals and urban networks there has been some discussion of their importance to water transportation. Both Groslier (1974:114) and Hall (1985:173) argued that the distribution of archaeological and historic data indicates that rivers must have played a major role in settlement and regional economic communication at least by the end of the 11th century. Hall, like Harmand a century earlier, highlights the Stung Sen as an important economic artery, this time in its ancient context (Ibid.). Im also agrees with this scenario in his summary of the role of rivers during the Angkorian period (1998:58-71).

Rivers and Canals Summary of Study

The discussion of rivers and canals in the context of Angkorian transport is extremely limited. The basic assertions about rivers and canals are:

- Many sites are not connected to the roads, but are near rivers
- Assumed that rivers were vital for economic activities by the end of the 11th century
- Bulk goods (e.g., sandstone, rice) were likely transported along the rivers
- Canals were built at many Angkorian sites (e.g., Angkor, Banteay Chhmar,

Sambor Prei Kuk, Angkor Borei) likely facilitating local movement as well as water flow

Water transport is obviously an important part of Angkorian communication and settlement, but there have been no direct studies of the physical aspects of this system in the literature.

Bridges

History of Bridge Research

Bridges made of stone (Figure 7.7a-b) and wood are frequently mentioned and used by 19th century travellers in Cambodia (stone in Mouhot 2000:251, Bastian 2005:45, 51; Garnier 1996:141, Delaporte 1999:108; wood in Mouhot 2000:159; Albrecht 1905:8; Lunet de Lajonquière 1902:xlv; Aymonier 1900:108; 1902:xlv; 1918:108). The size of some of these great stone structures greatly impressed the European explorers; the largest Angkorian bridge, Spean Toeup, measures some 140 m in length, 15 m wide, 10 m high and has 34 arches (Garnier 1996:141). The first summary of these structures was published by Harmand who also noted that the bridges were adorned with balustrades that terminated with ‘dragons’, today referred to as mutli-headed nagas (Figure 7.8a-b) (1880:226). A total of 30 bridges were located within Cambodia from the temple surveys undertaken by Lunet de Lajonquière (1911:493). During his survey, Lajonquière noted that the Angkorian Khmer did not build bridges across all of the major river crossings (1902:lvii-lviii). For example, he noted the sudden absence of any bridges on the Southeast Upper road past the Spean Praptos on the Stung Chikreng even though the road continues past this point (Ibid.:lviii).

One of the main points from the early discussion of stone bridges is their chronological association. The attribution of the stone bridges to the Angkorian period was based initially on their presence along the Angkorian roads. Moura has suggested that they were constructed before the 12th c. CE (1883:243). After the translation of the Preah Khan inscription however the roads and bridges, by extension, became associated *de facto* with the works of Jayavarman VII. Pamentier explains the construction of the stone bridges as permanent replacements for those structures burned down during the apparent sack of

Angkor by the Cham in 1177 (1948:119-120). He further states the military importance of the roads,

> *Il les munit pour éviter les retards possibles de ponts immenses à la traverse des rivieres importantes, les garnit de ponceaux sur le moindre cours d'eau; cette oeuvre énorme est executée richement, avec des splendides balustrades à naga…*(1948:120).

Boisselier similarly attributed the bridges to Jayavarman VII arguing, that they all follow the same model of construction; he does point out, however, that the inscription does not mention bridges directly (1966:107). Further doubt about the direct association of the bridges with Jayavarman VII was raised by Groslier who argues that only the naga balustrades can be directly associated with this king (1973:note 2,118). Wooden bridges are assumed to have been used before and in conjunction with their permanent stone counterparts. The only temporal association for wooden bridges is based on the reference in the Phnom Sres inscription (Jacques 1968:616-617). Michael Vickery points out, however, that this reference is made in a philosophical passage and may not be discussing the particular location of wooden bridges (pers. comm., April 2007).

The most comprehensive study on stone bridges was completed by Bruguier (2000). Compiled from earlier research and his own surveys across Cambodia he identified sixty-five bridges along five regional roads (Ibid.:533-534). In his discussion he constructs a typology of bridges based on their hydraulic location and suggests that many bridges functioned as culverts to enable water to pass through the roadway to land below (Ibid.:534-537). Bruguier argues that bridges served to ensure year-round communication and integrate the various economic zones connected by the river and road system for the purpose of trade and, more specifically, military activities (535-536). Bruguier’s argument for a military function is based on several points. First, he sees the maximum distribution of bridges from Angkor (approximately 100 km) as representing the core region of the Empire (Ibid.:534). He compares the sudden absence of bridges on these roads to the monumental arches of the Roman Empire, signifying to the traveller that they have entered into or exited the territory of the Angkorian king (Ibid.). Second, he describes the wooden bridge in the bas-reliefs of Banteay Chhmar as a floating bridge likely designed for military purposes (Ibid.:541). Third, Bruguier downplays an idea by

Dumarçay that the bridges were built in the 13th century CE (Dumarçay 1992:134), in favour of Parmentier's assertion that stone bridges were built to replace the wooden versions of Suryavarman I and II destroyed during the Cham sack of Angkor in 1177 CE (Ibid.:541-542). Following the recent review of the Cham histories by Vickery there is some doubt in the validity of this event. Two important points are that Cham history does not describe this monumental event and that Jayavarman VII spent time in Champa and most likely used Cham allies to gain control over Angkor (Michael Vickery, pers. comm., July 2006). A universal burning of all the crossing points, especially those far from Angkor, therefore seems highly unlikely. This point aside, Bruguier's work represents an important step toward applying multiple forms of evidence to directly study individual transport components in the Angkorian transport system.

Over the past five years, there has been a ressurgence in field work on bridges. APSARA, the Cambodian agency in charge of managing Angkor, and the EFEO assisted in the restoration of the bridges located on the Upper Southeast road which has doubled as Cambodia's Route 6. Their efforts were directed toward recording and preserving these stuctures by diverting the highway around these in situ remains (Bruguier 2000:532). An increase in surveys has also located several new bridges in Angkor and along the regional roads. Several bridges have been found by the Greater Angkor Project and APSARA buried along the East and West roads (Chhay and Hendrickson 2005; Im, pers. comm., February 2006). Bruguier's surveys in Preah Vihear province found new bridges along the Northeast road (Seelow 2005). Outside of Cambodia, however, only one Angkorian bridge has been found at Saphan Khom in Sakhon Nakhorn, northeast Thailand (Ittaratana 1998:40). Similarly, work by UNESCO around Vat Phu in southern Laos has failed to locate any bridges along the road connecting the site to Angkor (Patrizia Zolese, pers. comm., Nov. 2005). Jacques recently argued, following Dumarçay that the bridges were built in the 13th century and possibly by Jayavaraman VII's successor, Indravarman II.

Stone Bridges

With the exception of the re-used sandstone used to build the Spean Thma all of the stone bridges are constructed of laterite (Boisselier 1966:107). Stone bridges are constructed using the corbelled arch[4] and vary in size depending on extent of the waterway or their intended function. Large scale bridges such as Spean Praptos and Spean Ta Ong were built to span major waterways and smaller 'culvert' style bridges were likely placed to facilitate movement of water from one side of the road to the other (Figure 7.9a-b). Although Aymonier criticized the use of the corbelled vault saying they are designed as architectural and not engineering works, he does concede that the solid construction would have enabled the bridges to resist dramatic flooding and withstand the shock of trees brought down by these torrents (1902:lxii; 1900:108).

Bridges are built on a laterite skirt that extends beyond the structure up to 8 m on both the up- and downstream sides (Figure 7.10a). Further support is provided from stepped terraces built into river banks on both sides of the bridges (Figure 7.10b). The top of the bridge was paved with laterite and was framed by two sandstone balustrades that terminate in an elaborate multi-headed naga. Parmentier commented that the Buddha images on the naga balustrades appear to have been were removed during the iconoclasm in the 13th century thus eliminating their special character (1948:123). Many of these images were subsequently recarved from the remaining stone (Figure 7.11a-c).

Wooden Bridges

Evidence of wooden bridges built in Angkorian times have long disappeared, however the bas-reliefs and historic accounts provide some idea of the types used in the past. In addition to the depiction of the floating wooden bridge from the bas-relief on the Bayon (Bruguier 2000:REF), Lunet de Lajonquière suggests that wooden bridges were constructed of long planks laid without being fixed on trestles (1902:xlv). We can expect that wooden bridge construction would have changed little and modern examples would reflect those built during the Angkorian period.

Summary of Bridge Study

Bridges, like roads, were noted early in the discussions of Angkorian transport. The general characteristics of bridges are as follows:

- Angkorian bridges were made of stone, and likely wood
- Constructed of laterite, often with naga balustrades of sandstone

[4] Corbel vaulted bridges were commonly built by Hindu princes in Orissa on the east coast of India between the 9th and 14th c. CE (Deloche 1984:10). This is an intriguing coincidence given that the same style of bridge appears in regions that were most likely in contact with one another.

- Corbel vault construction method
- Bridges served different functions depending on their location and size
- Many bridges were buried
- Distributed on five of the Angkorian roads, though not equally between roads or over the same types of river crossings
- No direct dating of roads has been undertaken. Association made with Jayavarman VII through the resthouses in the Preah Khan inscription and number of laterite temples built by him.
- Military function

Bruguier's (2000) study is the most detailed investigation of the location, typology, history and function of the Angkorian bridges. This represents the only example in the literature that combined aspects of location, description and analysis in a synthetic approach.

Resthouses

History of Resthouse Research

The first historic account of an Angkorian resthouse[5] comes from Zhou Daguan who noted the presence of rest stops, or *samnak*, that he compares with the Chinese post halts along the main highways (1902:173). Six centuries later the descriptions of European explorers repeatedly refer to rest stops or *salas* during their travels. For instance, Bastian records staying at wooden salas located beside ponds, rivers, monasteries or outside villages (2005[1864]:33; 45; 54; 101). Mouhot commented on the frequency of 'stations' erected for the king on the route between Kampot and Ubong (2000[1858-60]:142). These large stations consisted of a large hall with a thatched roof made of bamboo and were placed approximately 12 miles (19.3 km) apart with intermediary stops placed between these larger structures (Ibid.:141-142). Albrecht's survey along the Southeast Upper road includes reference from local tradition that the grand routes leading to Angkor had *étapes d'éléphant* (elephant stops) that were marked by a monument (1905:7). Sadly the locals informed Albrecht that the Thai destroyed these edifices during their control over the region (Ibid.). Remnants of both the *étapes* and the *salas* used by

[5] There is considerable debate about the function of these strucures. The use of the term resthouse is used as general descriptor as these buildings would have served, regardless of their primary function, as way stations for travellers seeking shelter along the roadways.

European travellers have disappeared or their footprints have not been identified by surveys.

Evidence of Angkorian resthouses was first recognized by Lunet de Lajonquière based on the recurrence of sites modelled after Prasat Teap Chei (Figure 7.12) (1902:296). Lajonquière identified ten Teap Chei along the East and Northwest roads and a further three placed within temple enclosures (1911:xxix). Unlike the majority of Angkorian temples the orientation of the Teap Chei did not follow the east-west cardinality but seemed to follow the orientation of the Angkorian roads (Ibid.). Lunet de Lajonquière was therefore lead to associate these buildings with humble origins and refers to them as ‘palais ou habitations’ that are regularly found along the roadways (Ibid.:xxviii-xxx). He also introduced the need to get a better understanding of Hindu practices, particularly if the resthouses were used as rest stops for pilgrims. Based on the number of Teap Chei structures located at the time, he suggested that the distance between them (up to 37 km) was too great for anyone to travel comfortably; he then adds that this may be related to individual construction rather than a component of state level planning (Ibid.:xxx).

Lunet de Lajonquière’s comments about the function of these Teap Chei fuelled an immense amount of discussion that has continued to the present day. In response to Lajonquière’s association of Teap Chei with palaces or habitations, Foucher pointed out that these are religious structures intended for the gods and not for human habitation (1903:180). In keeping with this association and the fact that similar structures are found in India, Foucher suggests that these structures are better referred to using the Sanskrit term *dharmaçalas* (Ibid.).

Finot published the first summary of the *dharmaçalas*, which he says are unique among Angkorian architecture as they seem to fit both civil and religious purposes (1925:417). Of the 15 structures found at that time, he noted that the examples on the Northwest road were made of laterite while those on the East road and in temple enclosures were constructed of sandstone (Ibid.:420). As part of a transport route, Finot suggests that while the average distance between the road rest houses is 15 km those with greater distances between them would likely have had smaller wooden structures in between them (Ibid.:420-421). The explanation for why these buildings appear only on two roads is based on the idea that important pilgrimages took place between Phimai, Preah Khan

KS and Angkor (Ibid.:421). The other roads were therefore not important enough to merit the construction of these buildings. After considering the proximity and distribution along roads, their orientation and decoration, Finot concludes that these buildings are best viewed as *dharmaçalas* or *maisons de charité* (Ibid.:422). The presence of the *Lokeçvara*, the Buddhist healer of maladies, on the fronton of these buildings is seen to justify this explanation,

> *…car il protège les hommes contre tous les dangers, notamment contre ceux qui menacent les voyageurs: brigands, éléphants, serpents, bêtes fauves* (Ibid.).

Finot therefore provides a more broad-ranging and practical perspective on the role of these resthouses in the Angkorian transport system.

Coedès's (1941) translation of the Preah Khan inscription provided the first direct connection between the *dharmaçalas* and Angkorian history. Of the 121 *dharmaçalas*, or directly translated *maisons du feu*, listed along three routes it was possible to link the seventeen listed as being on the route to Phimai with the laterite buildings found along the visible road. Unfortunately, the *dharmaçalas* along the route to Champa (57) and the circuitous road connecting numerous unknown sites (44) could not be located. Coedès attempted to locate the other roads by multiplying the number of resthouses in the inscription by an average distance between these resthouses derived from the Northwest road (13.2 km). He was unable to come to any decisive conclusions and posits that the East road and its four buildings are part of the route to Champa and that the buildings along the circuitous route were either made of wood or were never completed (1940:348-349).

In Lajonquière's discussion of the orientation of the Teap Chei on the East road he also makes passing reference to a second set of neighboring monuments that do follow the east-west direction of most Angkorian temples. This is likely the first mention of the second type of resthouse structure, the *temples d'étape* (Lunet de Lajonquière 1911:xxix-xxx). This was verified by Trouvé who stated that three other temples, Prasat Sup Tiep B, Prasat Pram and Prasat Ta En, all follow the same architectural layout and notes that these structures would have served as resting places for pilgrims on the ancient route to Preah Khan KS (Ibid.:524-525). Parmentier (1948:112-113) briefly discusses these buildings by linking them to Suryavarman II based on similarities they share with Thommanon, which itself shares architectural characteristics of the Angkor Wat Style (1948:112-113). He further adds that Banteay Ampil and Banteay Samre also fall within this same group (Ibid.:113). Boisselier, however, raised the issue that the attribution of these buildings to Suryavarman II is less than certain given that the Angkor Wat style itself is not dated directly to an inscription (1952:222-223).

Several decades later, Groslier was the first to refer to these '*temples d'etape*' as being the first set of resthouses built along the road between Angkor and Preah Khan KS (1973:118). He suggests that Chau Sey Tevoda, not Thommanon, is the first structure on the East road while Prasat Chambok, located just outside the west side of Preah Khan KS, is the last (Ibid.). Groslier argues that the distribution of the *temples d'étapes*, placed on the south side of the road during the early 12th century, provided a template on which Jayavarman VII built his own resthouses on the north side of the road half a century later (Ibid.). With the exception of Prasat Teap Chei the *dharmaçalas* are placed on the north side of the road nearby a *temple d'étape*.

Little direct study of either type of resthouse has been undertaken over the past two decades. Welch (1998) argued the resthouses were not restricted to pilgrimage and must have served a trade purpose given their location on the route between Phimai and Angkor. He cites the presence of kilns along the route in Thailand and also the likely salt–fish trade between these centres (Ibid.:214). The only excavation to take place around one of these resthouse structures is being currently undertaken by the Chinese team responsible for restoring Chau Sey Tevoda. A final report of their findings remains to be published.

The major contributor on the subject of resthouses is Claude Jacques who has raised several important issues. For the *temples d'étapes* buildings he argues that Chao Srei Vibol, which was built by Suryavarman I, and Chau Sey Tevoda, built during a later part of Suryavarman II or by his successor, were not part of the plan that laid out the four *temples d'étape* between Beng Melea and Preah Khan KS (Jacques and Lafond 2004:286). He also suggests that we use the term *maisons du feu* instead of *dharmaçala* (Ibid.:387-388). *Maisons du feu* more accurately reflects the term used in the inscription and possibly points to its role in housing the sacred fire, an image depicted on the walls of Angkor Wat, Banteay Chhmar and the Bayon (Ibid.:388). While he agrees that they would have served as religious rest stops he rejects past assertions that they functioned as *gîtes d'étapes*, or lodging stations, for travellers. He asserts that these mundane structures would have been made of wood and thatch (Ibid.). Regardless of this terminological debate, Jacques makes the important point that we need to identify the function of these buildings in order to better understand the role of the Angkorian roads (Ibid.:286). In Jacques' (2006) recent presentation on the events and constructions of the 13th century he suggested that the resthouses may pre-date Jayavarman VII, but these conclusions without reference to specific data sets or methodologies.

Gîtes d'étape

For the purposes of this study, the term *gîtes d'étape* will be used to describe the resthouses built on the Northwest and East roads. This decision is based on the idea that regardless of the religious importance of the actual building, it would still act as a focal point around which people would rest. In this way, the name is an operational term that is not biased by the historical data sets on which past interpretations have been made.

The *gîtes d'étape* consists of a single structure comprised of a long hall, or *mandapa*, ending with a tower on the west end with an average dimension of 14-15 m long and 4-5 m wide (Figure 7.13) (Finot 1925:420). Windows on the south side of the building are open, while those on the north are covered over; presumably this related to the position of the road as the *gîtes d'étape* are normally positioned to the north of the route. Based on recent surveys by the Angkor Living Road Project, all seventeen resthouses cited in the Preah Khan inscription have now been located on the Northwest road (Im, pers. comm., March 2007). Four *gîtes d'étape* are found on the East road between Preah Khan KS and Beng Melea and a further seven are built within temple enclosures (Table 7.1). As indicated earlier the primary difference between the *gîtes d'étape* resthouses is that the buildings on the Northwest road are made of laterite, while those on the East road and all but one in the temple enclosures are made of sandstone (Figure 7.14a-b). Overall, the laterite *gîtes d'étape* are more coarsely built and have little decoration. The sandstone examples are often highly carved and all are adorned with the Lokecvara motif.

Further study of the *gîtes d'étape* resthouses has investigated the spacing between them along the roads and differences in building orientation. The spacing of the resthouses has been described largely using straight-line measures between sites (15 km) or by dividing the distance between known sites by the projected number of resthouses from the inscription (13.2 km). No measurement of their spacing along the roads has yet been completed. Variation in building orientation away from the generally held east-west focus of Angkorian building was identified by Finot (1925:419). This variation is particularly evident along the Northwest road and subsequent investigations by Ittaratana (1998) and Mollerup (2004) have attributed this variation to follow the alignment of the the road.

The temporal and functional association of the *gîtes d'étapes* has been largely guided by the textual reference in the Preah Khan inscription. They are currently associated with the reign of Jayavarman VII through the correlation with the buildings on the road to Phimai. A second fact is that all but one of the temple enclosures (Beng Melea) in which the *gîtes* are built date to this same period (Boisselier 1954:218).

Before the translation of the Preah Khan inscription the *gîtes* were given the dual purpose of serving both civic and religious purposes. The association between stone constructions and temples clearly emphasized the relgious nature of the buildings, but the fact that they would have acted as refuges for travellers and pilgrims was equally recognized. After the translation, these buildings became almost exclusively discussed in context with the term *maisons du feu* used in the text and thus could have only served the purpose of housing the sacred fire. No actual analysis of the *gîtes d'étapes* has been undertaken to demonstrate that there is no secondary habitation around them. Recent work by the EFEO on the Jayavarman VII hospitals has shown that there was much more activity than is visibly evident from the stone structures.

The idea that these buildings served multiple purposes is an important step in identifying their role in Angkorian society. Before the issue of terminology raised from the inscriptions I would argue that Lunet de Lajonquière and Finot were on the right track: the *gîtes d'étapes* were socio-religious locations that functioned for pilgrimage and potentially for the placement of rest of the sacred fire or idol between Angkor, Phimai and Preah Khan KS. It is highly unlikely that they did not also serve as places for human travellers to rest for the night, with the structures for both the monks keeping watch over the building temple and travellers. The considerable investment in their construction would have acted to draw people within its immediate vicinity.

Temples d'étape

The resthouses referred to as *temples d'étape* are substantially larger than the *gîtes d'étape.* Consisting of an enclosure open to four directions, a central tower and one or two libraries, these sandstone buildings are much more recognizable as temples (Figure 7.15, 7.16). The actual number of these structures along the East road is a matter of great conjecture. The architectural plan described by the *temples d'étape*, referred to as a *mandapa*, is commonly found in temples and off the East road and these temples also vary in construction date from the 11th through to the early 13th century (Cunin 2004:444). It is therefore possible to identify five *temples d'étapes* between Beng Melea and Preah Khan KS (Prasat Chrei, Prasat Teap Chey II, Prasat Pram, Prasat Sup Tiep B, Prasat Chambok). Groslier further connected these buildings back to Angkor via Banteay Ampil, Chao Srei Vibol, Banteay Samre and Chau Sey Tevoda or Thommanon. As indicated above, Jacques suggests that many of these additions pre- or post-date the buildings on the eastern part of the East road. While Jacques' argument is valid the fact remains that these buildings are located on a route that connects Angkor through to Preah Khan KS. For the purposes of this study Groslier's model of the *temples d'étapes* is adopted as an initial investigation on these structures. The only comparison between these buildings lists the average distance of 18 km (Jacques and Lafond 2004:286).

Ashramas and Salas

Evidence supporting the construction of wooden resthouses is limited for the Angkorian period. The most famous examples are the diagraphic inscriptions of Yasovarman I that list 100 *Yasodharasramas* (*ashramas*) around his territories (Briggs 1951:106-107); recent work by Pottier (2003) has identified the inscription and footprint of an *asrama* south of the East Baray. While the relationship between the *asramas* and the roads is not certain, the Sdok Kak Thom inscription identifies the construction of houses to shelter traders and travellers along the roads (Coedès 1992[1943]:213). Zhou Daguan's description in the 13th century of rest stops similar to Chinese post stops is likely referring to wooden and not stone structures. Travellers' records in the 19th century, such as Bastian (2005), frequently mention staying at wooden *salas* positioned along roads and rivers. While there is little visible evidence for these structures it seems highly unlikely that the Angkorian Khmer would not have incorporated wooden resthouses as an integral part of their transport system.

Summary of Resthouse Study

Resthouses are perhaps the best described component of Angkorian transport. Of the three different types of resthouses we can summarize them as follows:

Gîtes d'étape

- Single stone building of particular plan
- Made of stone, either laterite or sandstone
- Found on the Northwest road (17, laterite) East road (4, sandstone) and in temple enclosures (7, sandstone and one laterite)
- Regularly spaced apart (13-15 km)
- Associated with Jayavarman VII (late 12th century)based on direct association with the Preah Khan inscription
- Religious and or state function; general belief is that they did not serve to house travellers

Temples d'étape

- Temple consisting of multiple buildings and enclosure wall
- Made of sandstone and laterite
- Found on the East road (5 to 8 buildings depending on interpretation)
- Associated with Suryavarman II (early 12th century) based on Angkor Wat style architecture.
- No function has been associated with these buildings, though they likely served as religious stopover points on the East road

Wooden

- No direct evidence of wooden resthouses, based solely on inscriptions and bas-reliefs
- Likely used throughout the Angkorian period

As component there has been considerable description of the resthouses individually as well as basic comparisons of their orientation and material type. The actual distance travelled by road has not been measured. Discussion of their function has varied from being quasi-religious to strictly domiciles of the gods.

Tanks

History of Tanks

Discussion of water tanks built near roads dates back to the early European visitors who frequently used them on their travels into Cambodia (i.e., Bastian 2005[1863]:19, 24, 35). The importance of these structures was noted by Delaporte as they were vital for conserving water in the dry season; without such infrastructure animal traffic would not be effective transportation (1999[1880]:266). Aymonier regularly came across tanks of various sizes dug 'to refresh men and beasts' along the Angkorian roads (1900:106). Lunet de Lajonquière similarly describes rectangular water tanks dug by hand found near resting places along these communication routes (1902:lxiii, xlv). An important point raised by Lajonquière was that in places where the roads were not visible, pools such as Trapeang Chuuk and Trapeang Prah, were used to mark the ancient route (1902:lvi). In this situation the 'boundary lakes' were also placed further apart (Ibid.:lvii-lviii). Like Delaporte, Lajonquière emphasized the role of these tanks in sustaining animals in the dry season and also indicated that they played a direct role in agricultural management (Lunet de Lajonquière 1907:xxxiv).

The most detailed survey of the rectilinear tanks was published by Albrecht (1905; 1906) during his survey of the Southeast Upper road. His report (1906) provides a list of all the major tanks and their dimensions between the Damdeck Canal and Kompong Thom. Albrecht describes the *trapeang* as being found on either side of the road (1905:12).

The historical association of the tanks remained largely undiscussed until Parmentier included them in his discussion of Jayavarman VII's architectural feats (1948:120). Interestingly, these structures were not mentioned in the Preah Khan inscription but do appear in both the Sdok Kak Thom and Phnom Sres texts which date to the 11th century (Coedès 1980:213; Jacques 1968:616-617).

In recent times, the study of tanks has emphasized role of their larger cousins, the *baray* found around Angkor and at many of the regional centres (i.e., Groslier 1979; Van Liere 1980; Dumarçay 1994; Bernon 1997; Acker 1998; see review in Evans 2007). Detailed mapping of tanks around Angkor using remote sensing imagery has been completed by Pottier (1999) and Evans (2002; 2007). Pottier identified numerous examples of tanks situated in direct proximity to major embankments around the site (1999:129-131). These studies, however, were not directly interested in the potential role of tanks as part of the transport system. Preliminary analysis of the relationships between the tanks and roads across Cambodia was presented by the author and indicated that consistent distance of 3-5 km between tanks (Hendrickson 2004). Unfortunately the resolution of the remote sensing data set was fairly coarse (15 m) and many of the smaller tanks were not visible in the survey. Another approach to the study of tanks by Khieu (2006) has sought to develop a typology of these structures based on the various Sankrit and Khmer terms used to describe them (e.g., *trapeang*, *rolum*, *rahal*, *baray*, *tataka*, *srah*).

Tank Construction

Tanks are normally rectangular structures that range in size from the massive *barays*, built in conjunction with main temples (Figure 7.17), to the small temple and household examples found today. Tanks are constructed of earthen embankments by excavating of the interior of the tank or by creating embankments so that the tank is above ground level. In certain examples tanks are lined and terraced with laterite or sandstone though these are normally found only within temple enclosures (Figure 7.18). No tanks with stepped stone linings have been identified in association with roads. Generally tanks are oriented with their long axis aligned east-west, however, important exceptions to this are found at the *barays* of Preah Khan KS (NE-SW), Phimai and the *Rahal* at Koh Ker (SE-NW). Since this rule is not adhered to in all cases for state-level tanks we could therefore expect comparable variations to be found within the smaller versions.

Summary of Tank Study

From the basic descriptions of tanks in the Angkorian context we can identify the following:

- Tanks are often found along roadways, and often mark the route when the roadway is not visible or built-up
- Rectilinear shape
- Often oriented east-west
- Excavated or walls of tank built up around body of water
- No temporal association, tanks appear to have been built from pre-Angkorian through to the present day
- Served to water beasts of burden and as sacred pond

These basic characteristics emphasize the overall integration within the Angkorian transport system. Albrecht's survey of tanks on the Southeast Upper road is the only direct investigation of these structures in this context. Other studies by Pottier (1998) and Evans (2002) identified their relationship near embankments in Angkor but did not consider their logistical importance for furthering communication.

Traffic

History of Modes Research

Zhou Daguan is the first to mention the types of traffic used on the Angkorian roads. He describes vehicles such as palanquins and chariots and the use of animals such as horses and elephants for longer trips (1902:172). Foot traffic would have been the major form of transport as the Angkorian army was comprised largely of unclothed and barefoot soldiers (Ibid.:175). Water transport was undertaken using oar-propelled boats constructed of hardwood boards held together with iron nails and covered in a grease made from fish and lime (Ibid.:172). Importantly, he noted that they did not use sails.

Indirectly, the accounts of the European explorers in the 19th century provide considerable information about the logistics of different forms of traffic and also the difficulties of travelling by land and on the river system through Angkor's former territories. Many of these accounts provide important information about the limitations of animals and the distances that they could travel in a day. For example Mouhot describes a journey using elephants and wagons travelling at 3 miles (4.8 km) per hour (2000:159). Another journey taken by Mouhot involving oxen and buffaloes took eight days to travel 135 miles (217 km), which equates to 27 km per day (Ibid.:139). He adds that this distance would be accomplished in half the time using elephants, but these animals were strictly used by the king and wealthy individuals (Ibid.). Louis de Carné's (1995) travels up the Mekong include several references of the size of canoes used by local Khmer. He describes boats as narrow canoes often made of a single tree with some of the larger ones being manned by a crew of fifty-three people (Ibid.:48; 59).

Clovis Thorel (2001[1866-68]), a scientist tasked with examining the agricultural and botanical resources for the Mission Pavie, outlined the various abilities of the main beasts of burden in the region. Oxen were the most common form of travel and a double-harnessed cart could travel ten to fifteen leagues (42-63 km) in a day (Ibid.:35). Similar carts are found on the bas-reliefs of the temples and in fields of Cambodia today (Figure 7.19). Buffalo were also used to cart heavy goods but had greater requirements for bathing and drinking (Ibid.:32). The most important animal, from a hierarchical perspective, was the elephant. From a practical point of view, Thorel suggested that horses and oxen can replace an elephant 75 per cent of the time (2001:43). The limitations of the elephant is that they can barely hold two riders, travel six to ten leagues (25-43 km) and require immense amounts of water to bathe and drink. A direct result is the regular placement of rest stops with wells along the roads (Ibid.). Other than their symbolic and military benefit, Thorel points out that the elephant's true advantage is that it can cross swampy areas easier than other beasts during the rainy season (Ibid.).

G Groslier's (1921) study of the bas-reliefs of Angkor Wat, Bayon and Banteay Chhmar was the first foray into defining the types of Angkorian transport . Most of the description is of military units (Figure 7.20a-b) such as foot soldiers, elephants, cavalry, chariots, and water craft, and also includes royal transport in the form of the palanquins as originally identified by Zhou. Groslier's discussion also argues for the importance of water transportation and the necessity of access to the Tonle Sap. He suggests that that Tonle Sap was a primary means of transportation and that the lake is one of the prime forces for the rapid fortune of Angkor in the 9th century (Ibid.:143).

Subsequent work by Paris (1942) and Jacq-Hergoualc'h (1979) added more detail to Groslier's initial study. Paris provided a more detailed examination of the water craft depicted on the Bayon and Banteay Chhmar (Figure 7.21), and made the important comment that that the Angkorian boats would not have been sea-worthy (1942:356). The focus of Jacq-Hergoualc'h's investigation of the bas-reliefs was to identify the military organization of the 12th and 13th centuries CE. This detailed description identified the organization of the army, its composition, armament and different ethnic groups (i.e., Chinese, Thai, Cham) within the reliefs (Figure 7.22). Among the units and their respective beasts of burden in the Angkorian army were included infantry (foot travel), elephantiers (elephant), charioteers (cart traffic), cavalry (horseback), supplies (attendants on foot carrying yokes, cooking food), and the navy (boats). While the processions are not direct evidence of travel along the Angkorian roads they do present a range of probable traffic. With the exception of horseback and litters, these forms of transport are all visible today. In his conclusion, Jacq-Herguoalc'h suggests that the imagery of horses shows the importance of these animals which is explained by the fact that they were imported to the region (Ibid.:228).

The inscriptions provide a few hints about the nature of traffic, including a few mentions of water traffic. Hall mentions the appearance of barges used on the Mekong from the Ban That inscription associated with Jayavarman VI (1080-1107 CE) (1985:173). Vietnamese sources also suggest that Suryavarman II sent a fleet of 700 ships to attack positions on the Vietnamese coast (see Briggs 1951:190).

Traffic Types

The different types of transport available to the Angkorian Khmer included beasts of burden (oxen, elephants, buffalo, horses) and different types of vehicles (palanquin, chariots, boats). B-P Groslier argued that conditions and way of life in Cambodia have not changed much since the Angkorian period due in part to the nature of agrarian activity; the continued use of the ox cart is an excellent example (1997[1980]:204). The evidence from the 19th century accounts therefore allows us to understand some basic limitations in the speed and, in the case of beasts of burden, weight of material transported during the Angkorian period. He also points out that Angkorian sites are regularly spaced in the landscape (about 24 km) which he equates with a common stopover in the past (Ibid.).

Summary of Traffic Study

From this review we can identify the following characteristics of the types of transportation that used the Angkorian roads:

- Foot and animal traffic commonly used
- Evidence for riverine traffic
- Traffic served both military and economic functions
- General continuity with many traffic forms used today

The discussion of traffic in the Angkorian literature has therefore heavily focussed on describing the bas-reliefs. There has been no summary of the logistical requirements of animals.

Angkorian Transport and the Operational Approach

This summary has outlined the relatively small amount of research undertaken on the Angkorian transport components over the past 150 years. By contrast with studies of temples and inscriptions the subject of roads has not been largely ignored. From this information, however, we can identify some key points. Angkor's transport system consisted of terrestrial and riverine routes punctuated by several types of infrastructure that enabled a wide range of different traffic modes to move around the landscape. Among the many potential research directions that could be identified from this review, three issues stand out as critical in a broader evaluation of the transport system. First is the need for a synthesis of the transport components. Syntheses in the past provide us with detailed descriptions of the types of components (Groslier 1921; Im 1998) or have outlined the basic differences between the roads (i.e., Lunet de Lajonquière 1911:xxi-xxviii). These data has not been pulled together and evaluated using a consistent methodological procedure.

Second is the fact that many of the presumptions of the transport system have not been tested using other types of information. Groslier and Jacques have contributed substantial interpretations of the temporal and functional nature of the transport system. Again, these ideas need to be examined through a more investigation of both the historical and archaeological data. By introducing an operational approach to transport the historic biases will be examined within the more pragmatic concerns of geography and requirements for communication.

A final issue is the overwhelming impact of the Preah Khan inscription on defining the chronology and function of the road system. Interpretation of any aspect of the road system is linked to this sudden florescence of communication during the late 12th century. The reason for this association is simple: the Preah Khan inscription is the only document that we can connect directly to the Angkorian road system. Roads are lined with stone buildings which were used as pilgrimage routes. By connecting the roads and resthouses to Jayavarman VII the baggage of his militaristic rise to power is further laid upon the transport system. This system has not been examined in a holistic manner and has not considered the information of movement from hundreds of inscriptions before his reign.

A single platform needs to be established whereby we can make detailed assessments of these issues. This involves collating all of the transport components in a single database, evaluating their spatial relationships, testing the chronological associations and trying to outline reasons for the construction of the roads. The operational approach requires the inclusion of archaeological, historical, and geographic data within a GIS platform. In order to invest the results with a broader cultural meaning, the investigation of these phases is situated within a research question derived from the transport concepts outlined in Chapter 2.

Location: Mapping and Collation

The first maps of the Angkorian transport system were included in the site surveys of Aymonier (1902-1904) and Lunet de Lajonquière (1911). Subsequent publications have relied heavily on these maps which are more schematic than accurate. Recent maps by Im (2004) and Bruguier (Seelow 2005) have incorporated the use of remote sensing data (i.e., Landsat satellite imagery, aerial photography) to identify the perambulations of the roads but a map of the entire system has not been produced. Creation of an accurate basemap with all the known transportation components is the first step in this study. Information for this map is derived from mapping structures visible (e.g., roads, tanks, major sites) from remote sensing imagery (ASTER, air photographs), ground surveys and existing literature (e.g., coordinates for resthouse buildings and bridges), and also modern topographic and cultural databases (e.g., rivers, catchments, mineralogical zones). It should be pointed out that the emphasis is on the mapping regional roads; while secondary roads may be identified during the broader surveys they will not feature prominently in the overall analysis. The objective is to investigate the significance of what can be readily seen; this will set the platform for future research.

Description: Spatial Relationships

The majority of research on the Angkorian transport components has focussed on description. Each component has been discussed in terms of its general dimensions, materials, construction technique, and art historic and architectural style (i.e., Lunet de Lajonquière 1911:xxi-xxxi; Finot 1925; Bruguier 2000). Detailed examination of specific attributes of a component is much less common and comments are rarely backed up with methodologically rigorous approaches. A more significant gap in these descriptions is the lack of inquiry into the spatial relationships of the transport components. A single example is the spacing of *gîtes d'étapes* undertaken by Finot (1925:419) and Coedès

(1940:348-349), however, these were derived from straight-line distances between buildings or mathematics based on historical data. The distances were not based on the actual routes on which they were situated.

An important point that arises from the discussion of spatial distribution is the degree to which the Angkorian transportation system was planned. The average distances between the *gîtes d'étapes* outlined by straight-line distances (12 to 15 km) indicates that they were part of a regular plan enacted across the roadway. By contrast, Lajonquière (1902:lvii-lviii), and later Bruguier (2000:532), noted that the placement of bridges was not univeral across the Angkorian roads. By framing the study of spatial relationships within the concept of planning the following questions will be evaluated:

- What is the spatial distribution of each transport component?
- What is the relationship between the components of the Angkorian transport?
- What is the relationship between each of the roads (and their components)?
- Was there an Imperial road plan? And was it regularly applied across the roads?

This study will therefore clarify whether the Angkorian transport system represents a single or unified plan whereby all of the parts are laid out in an identifiable manner. An investigation of the spatial relationships within and between the individual transport components (i.e., roads, major sites, resthouses, bridges, tanks) and to geographic features (i.e., rivers) is undertaken in GIS. An important part of this analysis will be the introduction of the Linear Referencing function in GIS, which calculates point locations along a route and is commonly used in transport applications today. No cultural considerations are included in this discussion, just the structural relationships of the Angkorian components. Topography is also not included in the analysis as the landscape in Cambodia offers little vertical challenges besides scattered hills.

Description: History versus Histories

The Preah Khan inscription has become the only temporal association generally accepted by Angkorian scholars for the road system. Resthouses (and by association) other infrastructure are seen as part of the late 12th century floresence of architecture built by Jayavarman VII. This assumption, however, has ignored the fact that Angkor was the seat of an empire that was intensely active across most of mainland Southeast Asia for several centuries before him. Historical texts are the anchor on which all Angkorian art and architectural temporal associations have been derived. These texts also detail specific events that took kings or their retinues around their territories. The issue is that a single piece of history has upstaged a far greater corpus of histories that can be used to examine how active Angkor was across its landscape.

By contrast with the relational characteristics above, the aim of this section is focussed on a solitary question:

- What evidence is there to support that Jayavarman VII was responsible for the Angkorian transport system?

The approaches used are based on the architectural construction and renovation of temples around the empire and also the direction of historic events (i.e., conquests, trade missions) attributed to the reign of each king. As part of this investigation we can integrate the results from the spatial analysis to determine whether we can align the plan(s) with temporal phase(s) in the construction of the system. An important part of this discussion is recognizing the difference between dating the road versus the route. For this investigation we are interested in identifying the time when the route became part of regular communications in the Angkorian Empire.

Analysis: Imperial Resources

Analytical investigations about the function and role of roads in Angkorian society are the least explored in the literature. These studies have raised the fact that religious, political (often military), and economic functions were part of the transport system. Religious pilgrimage, military expeditions and trade routes have all been raised by scholars in relation to this system. Military activities appear to be supported by the limited extent of bridges (100 km) away from Angkor and also frequent depictions of armies on the temple bas-reliefs. Bruguier’s interpretation of why the formalized transport system was built, however, rests largely on the Groslier’s (1973) historic assumption that Angkor was sacked and its territorial infrastructure was razed. Roads were improved and stone bridges built as a knee-jerk reaction to facilitate year-round movement and maintain control of Angkor's immediate territory. Military functions have been cited by Chandler (1996:59) as a means of responding to uprisings and invasions.

The transport system also functioned as trade routes. Numerous finished products and raw materials such as pottery (Groslier 1981; Welch 1998:213-216), iron (Groslier 1986:72; Jacques and Lafond 2004:259), salt (Nitta 1997), and sandstone (Lunet de Lajonquière 1911:xxiv) have been identified as being moved around the landscape. Unlike the other functions, evidence for this activity is often based on the archaeological remains of the objects, or obvious resource locations (e.g., salt domes near Phimai; Phnom Dek iron reserves near Preah Khan KS). Two clear limitations of these studies are the emphasis on one transport component and the general lack of recognition of the functional plurality of the transport system.

The proposed solution is to look at the transport system in a broader perspective and consider the location of major settlements, roads and the location of important geographic resources (i.e., goods, passes, mountains) in the landscape. Jacques made the important point that we need to evaluate the location of resources, particularly metals, and determine the function of the terminal sites before making any conclusion about the function of a roadway itself (Jacques and Lafond 2004:156). The fundamental point to be made is that sites are situated in the landscape to meet an operational requirement, either locally in the form of food, or more broadly in the extraction of precious resources.

The final part of this operational discussion of Angkorian transport is to examine the spatial relationship between major Angkorian sites, resources that would be operationally required, and the transport system. By contrasting the location of these features it will be possible to address the following questions:

- What kinds of resources were sought after during Angkorian times?
- Are Angkorian sites situated near culturally important resources?
- Are these sites connected to the road system?
- Are these sites connected to the river system?
- Does the placement of the road network relate to the need to control specific resources?

The range of resources included in this study is based on the operational requirements of control described for the Angkorian Empire in Chapter 6. The concepts of access and distance are extremely important to this discussion. Proximity of major sites to geographic resources is evaluated based on direct distances, gauged within the ability to reach the desired locale within a single day of travel (25km). A broader impact of this study is that it will demonstrate whether Angkorian settlement was laid out to take advantage of particular resources over time.

Summary

This chapter has outlined the historiography, methods and issues in the study of Angkorian transport components. Though the volume of work on Angkorian transport is substantially smaller compared to other subjects in the Angkorian civilisation, the results have produced an excellent basis for future investigation. By summarizing this work three issues are identified that need to be addressed: 1) the lack of synthesis; 2) the lack of rigorous investigation to support material interpretations; and 3) reliance on historic data, particularly the Preah Khan inscription. This last issue is particularly important as translation of the Preah Khan inscription has underpinned not only the temporal but the functional interpretation of the transport system irrespective of other data sets. The proposed solution to these issues is the introduction of the previously outlined operational approach to the Angkorian transport system. The goal of the operational approach is to synthesize the available data on varied elements of the system and its context and the relationship between them and examine its parts using a series of archaeological methods couched in theoretical concepts of transportation. By using multiple data sets in a complementary fashion a more holistic perspective of Angkorian transport will be produced that is supported through a rigorous and integrated methodology. It will also address the issue of plurality of development and function of Angkorian transport at a regional level.

By compiling the transport components within a GIS four basic elements of the operational study are established for the Angkorian transportation system: 1) creating a base map of the extent of transport components using multiple data sets; 2) examining the spatial relational within and between the transport components within the context of planning; 3) testing the chronology of the transport system using a range of historic and architectural data sets; 4) examining the function of the transport system through the identification of operational resource requirements (i.e., economic, military, religious) of the Angkorian empire and examine the spatial relationships between settlement and roads to these resources.

Chapter 8. Location, Description and Spatial Relationships of the Angkorian Transport System

The first stage in the operational analysis of the Angkorian transport system is to locate and describe its physical characteristics. This process involves accurately mapping, collecting, and integrating the data into a single framework for analysis. In addition to mapping these structures, this chapter will also outline the spatial relationships within and between the transport components. The goal of this discussion is to identify the structural aspects of the Angkorian system before it is laden with its historic and cultural properties. Through this synthesis it will be possible to assess whether the Angkorian system is planned and whether this plan was consistently applied throughout its extent. The analysis is based on a comment by Lunet de Lajonquière (1911:xxi-xxviii) who identified that, while each of the regional roads connected to Angkor, their construction and composition of infrastructure were often markedly different. This insight deserves more attention and has not been rigorously examined (see Bruguier 2000).

The chapter begins by integrating the information on Angkorian transport within a single GIS database. This involves mapping components (e.g., roads, tanks, main Angkorian settlement) using remote sensing imagery, ground surveys and publications (e.g., resthouses, bridges) as well as digital data sets (e.g., rivers, catchment boundaries). A review of the total number and characteristics of each component is also provided. The second section is an investigation of the spatial relationships within and between the transport components. This approach is based on the methods used by transport geographers to study networks described in Chapter 2 focussing on the structural characteristics of the system. A series of questions will be raised during the evaluation of each component before comparing the composition of the regional roads to see if there is evidence for single or multiple patterning.

The Study Area and Data Sources

The study area (Figure 8.1) is based primarily on the locations of roads identified in the maps of Aymonier and Lunet de Lajonquière and also the distribution of main Angkorian centres within Cambodia. The reason for including areas away from the road system is to test whether there are traces of roads that have not been identified within the core region of the Angkorian empire. This scale of investigation also allows an assessment of rivers within the overall transport system. For the purposes of this survey the urban area within the confines of Angkor is excluded from analysis. Two reasons for this are: 1) the objective is to identify regional patterns of transportation; and 2) the palimpsest nature of occupation within the Angkor area makes it extremely difficult to determine what is and what is not related to the road network. The boundaries of Angkor for this study are set at Banteay Srah, Chao Srei Vibol, the Roluos group and Prasat Srah or Number 100114 (Evans 2007) near the Northwest road (Figure 8.2). Embankments continue from these locations into Angkor but the number of potential routes and problem of where they finally terminate suggests that these periphery locations are appropriate as the inner edge of the study area.

This study area is populated with transport information from three different data sets in the GIS. The first set is derived from the mapping of regional level or large-scale structures (e.g., roads, tanks, main sites) from remote sensing imagery (e.g., satellite, aerial photographs). The second are points (e.g., resthouses, bridges) collected from ground surveys and existing publications of site-level features not visible in the remote sensing data. The final data set incorporated in this investigation is digital layers of topographic features (e.g., rivers, catchment boundaries).

ASTER and Aerial Photographs

Two types of remote sensing imagery were used to map the transport components within the GIS. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery was initially selected to assess the pattern of the Angkorian road across the entire region of interest (Figure 8.3). Given the resolution limitations of the bands of ASTER imagery used (15 m pixel resolution) a second survey of the immediate areas around the roadway was completed using 1992 B/W Finnmap aerial photographs. Air photographs were not available to evaluate the roads within Thailand and Laos so the ASTER survey provides the primary data set for these sections. The benefit of using two different imagery types is that they act as a primary test of their accuracy (Figure 8.4). Comparison of objects identified in ASTER with the aerial photos showed that it was a reliable source for mapping archaeological features. Where available other data sets were used to check the results of the main data sets including SPOT, Landsat, AirSAR, and Ikonos. Further discussion of the remote sensing mapping process and comparability of these data sets is presented in Appendix 2.

Ground and Ultralight Surveys

Verification of features identified from remote sensing is a critical component to any mapping project. Generally, ground truthing is the primary means of verifying features. However the process is complicated for surveying roads and is particularly problematic for the Angkorian roads. An initial problem with road surveys is the extent of the road network and gaining access to remote locations on land. Many of Cambodia's secondary roads are poorly maintained and the Angkorian road often stretches across abandoned regions. A more serious issue in Cambodia that prevents comprehensive survey is the presence of unexploded ordinance and land mines.

The solution to these problems was to undertake surveys using an ultralight plane (Figure 8.5) which avoided the issue of mines and allowed the survey to be completed quickly. Flights were undertaken over sections of four Angkorian main roads during three different field seasons (Figure 8.6). Ground surveys were also undertaken at several locations (Figure 8.7a-b) which added a further level of verification. It should be pointed out that both methods of survey have their benefits and drawbacks. The ultralight does not allow detailed examination of resthouse features, for example, however it can fly low enough to pick the building out of the trees and also enables recognition of large-scale structures such as roads and large tanks. On the ground, these features often appear as a bank of trees with no indication that they line a road or the edge of a tank.

Description of Angkorian Transport Components

The main components identified through the remote sensing imagery are regional and secondary roads, tanks, and main Angkorian temples. In addition to mapping the location of these items, several secondary characteristics were recorded that may assist in identifying important patterns in the overall structure of the transport network.

Roads

The regional roads correspond to the main arteries identified in the early maps of the Angkorian Empire (Figure 8.8). Five roads leave directly from Angkor with a sixth connecting to Vat Phu at a juncture north of Beng Melea. The most obvious characteristic of these roads is their relative straightness which is assisted by the lack of topography around the Tonle Sap floodplain and across northern Cambodia in general. Discussion of the orientation of the road and water system is presented below. A more informative feature of the mapping process is the degree of visibility of each of the roads along their entire length. Visibility is derived from the ASTER, aerial photographs and ultralight surveys with sections of road classified as visible, partially visible and non visible[6].

Regional Road Visibility

Bruguier's surveys around Cambodia suggested that the roads represented in the early maps are idealized versions and are actually quite heterogeneous in visibility (2000:540). The results of the remote sensing survey (Table 8.1) similarly show that the roads are not uniformly visible across their length. From Angkor the roads remain clearly visible for considerable distances (see Figure 8.8) but especially the traces of the West and Southeast Upper roads. While the latter road reappears a few kilometres after this point the West road remains largely almost untraceable past Phnom Srok. A more detailed examination of each road is worthwhile, proceeding from the most visible road to the least visible.

The East road is the most visible road in the survey, a fact that is aided by its current use as the most direct route between Beng Melea and Preah Khan KS (Figure 8.9). The only section of this road that is not clearly visible leads up to the western side of Beng Melea. A secondary route to the north of the main road is also identified and will be discussed with the secondary roads.

The two Southeast roads are both very visible as they pass through the treeless floodplain on the north side of the lake. The Southeast Upper road, classified by its 'upstream' location in the catchment, is overlayed by National Route 6 for most of its length (Figure 8.10) and is well documented in the literature (see Chapter 7). The Southeast Lower road is closer to the lake edge; it should be pointed out that this road has not been directly studied although it appears to correspond with the route taken by Jully in the early 20th century (see Figure 7.2). This Lower road appears to connect to the embankment/canal within the urban area of Angkor where it is variously referred to as the Southeast canal (Pottier 1999:129; Fletcher et al. 2003) or West Baray canal (Coe 2004:147). These roads are unique as they run parallel to one another, approximately 4 km apart for the first part of their journey, and then join twice near the villages of Neang Sa Lngeach and Pradet. It

[6] Ground surveys of roads in Cambodia are often less successful in identifying roads than remote reconnaissance. Roads lined with trees are often impossible to distinguish from the surrounding forest on the ground and many roads have extremely low relief.

appears that the Southeast Upper road branches off to Sambor Prei Kuk while the Lower road continues toward Kampong Thom.

Lunet de Lajonquière had indicated that the Southeast Upper road split at Senko (San Kor village) with one branch continuing Sambor Prei Kuk and another toward Kompong Thom (1911:xxiii). The only traceable road connects east-north-east toward Sambor Prei Kuk and there is no direct evidence of the Angkorian road continuing to Kompong Thom. This connection is based on a route that crosses south of Russei Cheah, which today lacks any remnant of a bridge. Locals informed Lunet de Lajonquière, who quickly dismissed the notion, that there was a road connecting the region through Prah Theat Prah Srei to Banteay Prei Nokor (1902:liv). Albrecht also suggested that the road continued on to Vat Nokor though he could find no direct trace (1905:10). While communications obviously continued past this point there is no direct evidence to suggest that the road continues up to or past the Stung Sen.

The West road is extremely visible up to Phnom Srok (Figure 8.11), a few kilometres west of the Stung Sreng, then suddenly disappears shortly afterwards. This corresponds with the initial reports by Lunet de Lajonquière who noted a similar absence in the plain of Veal Chok as it continued on toward Sdok Kok Thom (1911:xxvi-xxvii). He suggested that this sudden change corresponds with the edge of the cultivable and savannah lands (Ibid.:xxvii).

The Northeast road is the longest of all the regional roads, and as such has the longest section of visible road (Figure 8.12). However, its actual visibility is quite limited particularly between Beng Melea and Koh Ker. Unlike the East road which is remarkably visible through dense forest, this section of the road is based on linear features found along the line of bridges and tanks located in the area. Once the road reaches the vicinity of Koh Ker it becomes extremely clear for most of the journey toward Vat Phu. A logical explanation for this gap would be that the road did not actually connect Angkor to Koh Ker via Beng Melea, but instead travelled through the break in the Kulen Hills. The remote sensing survey did not show any trace of this latter route.

The Northwest road is extremely visible from Angkor to the Stung Sreng (Figure 8.13), however, once it passes this river it becomes extremely difficult to follow up the

Dangrek. Past the Dangrek the trace of the road relies on the pattern of tanks and resthouses that line the way to Phimai. Ittaratana's study of the Northwest road in Thailand concluded that the road was destroyed, not built in association with the line of the resthouses, or was not formally constructed in the first place (1998:176). A similar situation may have occurred in Cambodia between the Stung Sreng and the Dangrek. One important contrast that must be pointed out is the lack of the extensive landscape remodelling in Cambodia that took place in Thailand during the Green Revolution in the 1960s. Given the fact the Northwest road travels through much less forested areas than either the Northeast and East roads the fact that the road is not visible is somewhat remarkable.

Secondary and Projected Roads

Traces of secondary roads are surprisingly infrequent across the study area. Three locations that have secondary roads are found around the sites of Banteay Chhmar and Preah Khan KS (Figure 8.14a-b) and another communication route connecting Beng Melea with Angkor. Pottier (2004) had previously identified several canal/embankments around Banteay Chhmar extending out into its immediate vicinity. The routes mapped in the ASTER data (Figure 8.14a) include one extending from the *baray* of Banteay Chhmar to the east which may have been the route taken to reach the Northwest road. However, this secondary road becomes difficult to follow about 5 km past from the *baray*. It should be noted that any eastern link to the Northwest road would have had to cross the Stung Srong and Stung Sreng.

The remote sensing imagery also identified secondary roads at Preah Khan KS (Figure 8.14b). A second road on the west side connects Preah Khan KS to the East road running north of the main route into the site. This road also doubles as the modern route for accessing the main enclosure and is likely the same one recorded on Delaporte's travel to the site (Delaporte 1999:107). Aerial photographs indicated other roads leading to the southeast, northeast and northwest of the enclosure. This southeastern road appears to connect Preah Khan KS to the site of Phnom Dek, the main source of iron in Cambodia (see Chapter 10). The presence of tanks in proximity to this road suggests that it may be Angkorian in origin (Figure 8.15). An important point to consider is that if the road was used to bring iron to Angkor, why wasn't the road more formalized? Further ground surveys need to be completed to evaluate the nature of this important linkage. The other roads around Preah Khan KS were not visible from the ultralight.

After the field season, a road was identified from aerial photographs starting past near the bridge the Spean Stung Kassang and directing eastwards into the forest. While the road has not been verified the existence of the bridge suggests that some communication, however far from the site, would have taken place. It would not be surprising to find further traces extending out from Preah Khan KS, as it was one of the largest enclosure sites in mainland Southeast Asia along with Sriksetra, Sukhothai and Angkor.

Another secondary route was also identified connecting Beng Melea to Angkor to north of Chao Srei Vibol (Figure 8.16). This route is actually a heavily embanked canal that would have served as both a water and land transport route. It was first reported by Aymonier (1901:401) and more recently by Evans (2007). Whether the route connects to Chao Srei Vibol or continues on to the Phnom Bok and the East Baray cannot be distinguished.

Attempts to locate the projected roads identified by Hall (see Chapter 6) were not substantiated from the ASTER data. Again the issue with finding roads in Thailand is complicated by the massive alteration of the landscape over the past 50 years. Routes indicated by Im (2004:58-59) are based on Aymonier's records and today are often marked by modern roads (e.g., between Phnom Srok and Stung Spean Toeup) and it was not possible to discern whether they were Angkorian in origin from the remote sensing pattern. Further remote sensing analysis and ground survey are needed to verify the physical evidence of these traces.

Tanks

Tanks were recorded initially across all the ASTER data to assess the regional distribution and then along the Cambodian portion of the roadways through aerial photographs. Each tank was mapped as a rectilinear polygon using the internal edges of the tank as the border. A total of 3626 tanks were identified from the ASTER coverage which spans an area of 134,000km^2 (Figure 8.17). The spatial distribution of these structures shows their general ubiquity across the study area, with particularly higher density along the north side of the Tonle Sap between the Mekong on the southeast and the Dangrek on the Northwest. The pattern also extends across into the Khorat in Thailand. The aerial photographic survey was restricted to following the roads within

Cambodia and recorded 2610 tanks covering an area of 3431km^2 (see Figure 8.18). The greater number of tanks per area is directly linked to the finer resolution of this data set.

From the polygons mapped in GIS it was possible to measure the perimeter and orientation for each tank. The difference in the mean perimeters (Table 8.2) between the two data sets is directly related to the resolution of the remote sensing imagery; ASTER-derived tanks have a mean average of 525 m while those mapped using air photographs include smaller tanks, with the mean being 273 m in perimeter. Since this study is directed largely toward examining the distribution of tanks along the road system a subset of this sample is also highlighted. The selection of tanks that are found within 1000 m and 100 m on either side of the roadway is directly linked to the logistics of road transportation. A tank situated closer to the road is more likely to have been used by travellers. The majority of this investigation will focus therefore on the 100 m buffer zone. Interestingly, the mean size of the tanks presented in Table 8.2 indicates that tanks become larger closer to the roadway. The 1000 m buffer is chosen to test whether there is a dramatic fall off of tanks further away from the road.

Overall, the survey found that ASTER data was a useful data set for mapping structures with a minimum of 150 m perimeter but is better at identifying structures with perimeters of 500 m or more. As we have seen around Angkor larger tanks are often associated with state-level construction, either directly with temples or as a major water management feature in the immediate vicinity. State- or local-level investment may have been a factor in the patterning of tank size.

Another characteristic measured directly for each tank is orientation. Using the azimuth of the long axis is it possible to compare the mapped angles of the tanks. The orientation of tanks across the study area (see Table 8.2) derived from the ASTER data shows the remarkable tendency to an east-west orientation, with a mean average of 88.5 degrees. An entire thesis could be directed solely to study the differences in orientation; however the importance of this characteristic here is whether road alignment can draw tanks away from the east-west cardinality that dominates the mapped sample.

Main Angkorian Sites

Including Angkor, 20 sites were mapped from the ASTER data (see Figure 8.8). At each of these sites a nodal point was placed in the main enclosure and polygons were drawn to demarcate the perimeters of the largest enclosure and, if present, an associated reservoir. These will be referred to as *baray* to differentiate them from local tanks found across the study area. Table 8.3 shows the variation in perimeter size of enclosures and *baray* measured from the remote sensing data. As with the description of tanks, the orientation of the long axis of the enclosures and *baray* were calculated. The differences between these two features will be discussed below.

Spatial Description

Transport geographers rely on the study of networks to understand the character of a transport system. Network analysis varies according to the kind of attributes being used. The researcher can consider locational (e.g., geographic setting, size, form, number of nodes and links), modal (e.g., the infrastructure and kind, volume and direction of traffic that uses it), or structural attributes (e.g., overall layout of a network) in their analysis of the network (Rodrigue et al. 2005:2:11). The review of Angkorian transport in Chapter 7 identified an apparent plan in the position of the resthouse buildings that are 13-15 km apart. In order to assess whether there is a broader pattern of transport planning we need to investigate the distribution and spatial relationship for each of the Angkorian transport components both individually and in comparison with each other. Within this discussion it is possible to identify specific questions of the Angkorian components, specifically:

- What is their distribution of bridges? Are they consistently built over specific kinds of river types (e.g., permanent, intermittent, artificial canals/levees)? How many bridges could we expect within the maximum distance?
- What are the distances between the known resthouses along the road network? Is there a difference between the two types of resthouses?
- Is there a comparable pattern among the tanks along roadways as is found for the resthouses along the roadways? What kinds of attributes can we use to identify this pattern?
- Are main Angkorian sites situated closer to rivers than roads?

Figure 8.19 outlines the range of characteristics that are examined for each of the transport components and also the range of comparison between the components. A primary tool that will be used in these GIS analyses is the application of Linear Referencing, which acts to measure both the spacing of objects along a route and also the distance that the objects are away from the route. Linear Referencing is commonly used in modern transport planning and is therefore an appropriate tool for measuring the distances between objects in the Angkorian context. The decision to not incorporate Least-Cost Surface analysis is based on the low relief of the Tonle Sap plain. The straightness of roads in Cambodia is directly related to the lack of obstacles in the landscape; the only consideration appears to be proximity to the lake and avoidance of the inundated zone.

After a brief description of the main types of routes, the analysis examine the distribution of previously recorded transport infrastructure – bridges and resthouses – and then turns to the spatial patterning of tanks and main Angkorian sites. The use of statistical methods is restricted to simple calculations as the intent is to outline basic visible patterns within the corpus of Angkorian transport data. Further investigation using more detailed statistical tools should be applied with the development of specific research questions.

Rivers and Roads

The general location of the roads acts to cut perpendicularly to the flow of the main rivers (see Figure 8.8). Lunet de Lajonquière noted this fact in his discussion of the difference between the East and Northwest roads and the Southeast Upper and West roads; the former are cardinally oriented while the latter follow the line of the Tonle Sap floodplain (1911: xxviii). The placement of roads in this manner raises the key point of complementary difference between the terrestrial and fluvial routes. In essence the roads are serving to facilitate communication in areas that cannot be reached, or at least reached easily, by the river system.

Bridges

Stone bridges were constructed to cross natural water courses. The spatial questions we need to ask of bridges can be examined in relation to roads and rivers: 1) number of bridges and 2) maximum distance of bridges from Angkor; 3) type of water crossings; and 4) potential locations of new bridges. The primary assumption is that bridges are largely independent of the regular infrastructure regime which is aimed to meet the physical demands of the traveller. However, construction of a bridge at a location was an important investment in resource capital and also improved year-round communication.

Bridges and Roads: Distribution and Spacing

Stone bridges have been found on five of the regional roads (Figure 8.20). The Southeast Upper, East and initial parts of the Northwest road have the most bridges along their lengths. The lack of bridges on the Northeast and Southeast Lower roads may be a consequence of the lack of survey along their length. With respect to distance from Angkor, Bruguier's original survey of bridges indicated that they lay within a maximum radius of 100 km radius of the capital (2000:534). Two bridges are found just outside this range on the Stung Sen northeast of Koh Ker and east of Preah Khan KS (Spean Stung Krasan). Following Bruguier's re-discovery of the Spean Khmeng along the Northeast road (see Seelow 2005), the maximum distance of bridges increases to 141 km direct line distance from Angkor. The fact that bridges suddenly stop, and that many are substantial structures such as Spean Praptos on the Southeast Upper road, has interesting implications for what this maximum distance means in its cultural context.

Bridges and Rivers: Types of Crossings and Prediction

The distribution of bridges is related primarily to facilitating crossing bodies of water. Lunet de Lajonquière noted that bridges were often constructed on less important crossing locations while major flows nearby lacked a comparable structure (1902:lv). By breaking down the hydrology network into its natural (e.g., main, permanent, intermittent/streams) and cultural types (e.g., levee/embankment) we can evaluate the types of water courses that are fitted with Angkorian bridges. The results (Table 8.4) show that, with the exception of the Southeast Lower road, that nearly all main and permanent rivers along the Angkorian roads are crossed by a stone bridge. Intermittent streams and levees are less consistently fitted with bridges, especially along the Northeast road and western section of the East road (see Figure 8.20).

The crossing points of water courses and the Angkorian road also provides a predictive model for where bridges could be found within and beyond the last visible bridge found along the Angkorian roads (Figure 8.20; Table 8.5). This data should be used to complement future regional surveys especially given the recent discoveries of several bridges buried within road embankments.

With the exception of the Southeast Lower road, the distribution of bridges along the Angkorian roads is similar in two ways. First, following Bruguier, bridges are generally distributed at a maximum distance of 100 km radius from Angkor. Second, is that while the primary rivers (i.e., main, permanent) are regularly fitted with bridges, there is considerable variation in the placement of bridges over intermittent courses. Potential explanations for this are that the bridges are buried, have been washed away, or were only ever constructed of wood.

Resthouses

The resthouse buildings, specifically the *gîtes d'étape* associated with Jayavarman VII, are among the most famous markers of Angkorian transportation. With the exclusion of the resthouses found in temple enclosures, these structures are only distributed on two roads (Figure 8.21, 8.22a-b).

Gîtes d'Étape: Distribution

The sandstone *gîtes d'étape* along the East road are consistently spaced between Beng Melea and Preah Khan KS (14.8 km), however, there is a significant gap from Kuk Top Thom to Angkor. The distance between these two sites (45.6 km) suggests that the resthouses were not meant to service transport all the way to Angkor. A second possibility is that a resthouse (or two) have not been located or properly identified.

The laterite examples built on the Northwest road do appear to connect directly to Angkor but are generally further distance apart (17.7 km) based on the fourteen structures known at the time of this study (Table 8.6b). If we accept the Preah Khan inscription that 17 of these buildings were built along this road, the predicted mean average distance between Angkor and Phimai would be reduced to 14.6 km. This corresponds with the distances laid out by Coedès (1940) who divided the number of resthouses by the distance between Angkor and Phimai. New *gîtes d'étape* have been identified in the gap between Prohm Kel and Ta Muan by the Angkor Living Road Project, however the locations were in still *in press* and are not included in this study (Im, pers. comm. January 2007).

Temples d'Étape: Distribution

The difficulty with examining the distribution between the second set of resthouses on the East road is that there is varied opinion about what constitutes a *temple d'étape* (see Chapter 7). Using the different opinions about this issue, three different starting points on the East road – Prasat Teap Chei (SII), Chao Srei Vibol, and Chau Sey Tevoda – were measured connecting to Prasat Chambok (see Figure 8.22b). At its most limited, Jacques indicated that the distance between the four *temples d'étape* between Beng Melea and Preah Khan KS was approximately 18 km (Jacques and Lafond 2004:286). The measured distance from this study suggests however that they are spaced much closer, with a mean average of 13.4 km (Table 8.6c). Extending the connection to Chao Srei Vibol, at the formal beginning of the East road, the distance actually remains the same. If we link these buildings back through Banteay Samre to the 'prototype' *temple d'étape* of Chau Sey Tevoda, the distance drops only to 12.1 km. It should be noted that the road connection within Angkor is based solely on the most direct route using embankments within Angkor. A different route may have been taken to reach the Royal Palace in Angkor if, indeed, it was the ultimate destination or starting point for travellers.

Resthouses, Rivers and Bridges

A potential explanation for the variation in resthouse spacing may be explained by the distribution of rivers along the route. Looking at the frequency of resthouses at distances ranging from 100 m to 500 m from the nearest water source (Table 8.6a-c) twenty (67%) of the resthouses are found within 500m of a flowing water source. On closer inspection about half of the laterite *gîtes* and *temples d'étape* structures are found within 200 m. The type of river varies along the Northwest road, while the East road buildings are exclusively found near intermittent streams. The question of whether these buildings are situated near tanks as a source of permanent water for travellers will be examined below.

Of the resthouses that are within 500 m of a water course, only seven of these courses have bridges built across them (Table 8.6a-c). Excluding the Spean Thma, which post-dates the construction of Chau Sey Tevoda and Thommanon by several centuries, the correlation of resthouses and bridge crossings appears most often on permanent river types. Generally, the resthouses on the Northwest road are most often found near intermittent water sources while both types of resthouses on the East road are placed much further away. The infrequent appearance of these two structures along these roads suggests that their construction is not directly related to each other.

Overall, the spacing between the *gîtes d'étape* and *temples d'étape* is fairly regular. These distances largely conform to those based on straight-line distances published by Finot (1925:419) and Coedès (1940). When the position of these resthouses is examined in relation to rivers and bridge construction it shows that while they are close to water sources, there is no direct correlation between them. It appears that the distance between the resthouse buildings had a logistical consideration that outweighed or was unrelated to construction of bridges as we rarely find these two structures near one another. A potentially important aspect for understanding the relationship between resthouses and roads is the orientation of the temples, both of which have been discussed specifically in relation to the Northwest road (see Ittaratana 1998; Mollerup 2004). Further discussion of orientation of resthouses is beyond the immediate scope of this study.

Tanks

Tanks represent a relatively unknown element in the context of Angkorian transportation studies. The basic logistical argument is that tanks would be built within a limited distance of the roadways to make them worthwhile as rest stops. A regularly repeated transport plan, hinted at through the resthouses, would likely be repeated for the construction of tanks. An important caveat that must be raised is the lack of chronological control over when tanks were built. Many continue to be used to the present day. Because of the lack of temporal association the analysis of tanks relative to roads in this study is restricted to general patterning along the regional roads and to the other nodal points of bridges and nodes. In order to enhance our understanding of these structures we can compare them according to their spacing distance along the road, perimeter size, orientation, alignment to the road and relative position between the road and local hydrology (see Figure 8.19). Since the object is to identify tanks that are in direct association with the transportation system a limit of 100m distance away from the road was specified. Beyond this point it is suggested that tanks would not serve the direct purpose of assisting travellers with water and or shade.

The inability to use aerial photos for the tanks in the Thai and Lao sections of the roads requires that a distinction be made in the interpretation between tanks mapped using ASTER data and those identified using aerials. Because the spatial resolution of the imagery is better within Cambodia, an emphasis is placed on the results derived from both methods.

Tanks and Roads: Distribution and Spacing

A total of 369 tanks were identified within the 100m buffer zone of the six mapped roads (Figure 8.23). Table 8.7a shows the total number of tanks and compares the number mapped from each of the remote sensing data sets. Overall, the Southeast Upper, Lower and Northeast roads have the greatest number of tanks in their immediate vicinity, while the West road has significantly fewer tanks. Looking at the results from each remote sensing type we find, not surprisingly, that the number of tanks found in the ASTER data decreases dramatically.

An examination of the spacing between tanks from the aerial survey (Table 8.7b) shows a clustering of tanks among the East, Southeast Upper and Lower roads (1.3-1.4 km apart) and between the West, Northwest, and Northeast (2.3-2.4 km apart) roads. At a coarser resolution the tanks mapped from the ASTER data show a similar spacing along the Northwest, Northeast, and Southeast Upper roads (6.0-6.9 km apart). There is considerably more variation between the roads based on the maximum distance between tanks along their length. This difference is not restricted to each remote data set, as the Northeast and Southeast Lower roads mapped from aerials have similar sized gaps to those derived from ASTER imagery.

Tank Perimeter

The mean tank perimeter mapped from the aerials is tightly clustered for each of the roads, though a slight difference can be identified in the larger tanks found on West and Northwest roads (Table 8.8). In fact, the perimeters for the tanks along the Northeast, East and Southeast Lower roads are extremely similar. From the sections mapped with the ASTER data, the only similarity is found between the Northeast road in Laos and the small section of the Southeast Upper road connecting Sambor Prei Kuk.

Orientation

Within 100 m of the Angkorian roads, only half of the tanks mapped were found with their long-axis oriented east-west (Table 8.9a). This suggests that, contrary to the general rules of Angkorian cardinality, tanks are built to suit specific conditions. Only the East road has a greater number of cardinal tanks, however this is can be attributed to the east-west orientation of the road (see Figure 8.8). Tanks mapped in the ASTER data are more regularly associated with east-west cardinality, except the section of the Southeast road that connects to Sambor Prei Kuk, which has only one example oriented in this direction.

An important question therefore is whether tanks are aligned to match the angle of the road.

Road Alignment

An aspect of tank placement that, at least physically, may indicate a direct connection with the road is alignment of the long axis to the roadway. This relationship was noted during the ultralight surveys around Cambodia (Figure 8.24). Within the aerial survey a total of 123 tanks were found with either their long or short axes aligned to the roadway (Table 8.9b). Given that long stretches of the East and Northeast roads are aligned roughly east-west, it is not surprising that they show the largest number of road-aligned tanks. Interestingly, both the Southeast roads have many tanks aligned with the route. This may be explained by the angle of these roads relative to the floodplain. These tanks may have served the same purpose as the long u-shaped embankments called *tnub* in the floodplain south of Angkor; the physical differences between these two features suggests, however, that they were made for different purposes. Very few tanks are ever aligned with their short axis to the roadway. The fact that there are seven on the Northwest road is explained by its general northern alignment.

Catchment Position

Since the road embankments cross-cut the watersheds of major catchments, it is possible to describe tank position as being either upstream or downstream. Table 8.9c shows that tanks are generally found on both sides of the roads, however they are more commonly found on the downstream side along the Southeast Lower, Northeast and, to a lesser degree, West roads from the aerial survey. From the ASTER survey, tanks are slightly more frequent on the downstream side. These patterns largely reflect those derived from the aerials.

Tank and Road Summary

Tanks are a common feature on all the regional roads, though they tend to be more densely fitted along roads to the east of Angkor. Some similarities exist between the Southeast roads and the East in number of tanks, spacing and perimeter however, the placement characteristics of these roads are much more variable. While other individual associations can be identified from this data set this initial survey of the spatial relationship of tanks suggests that there is no single plan of tank placement along the Angkorian roads.

Tanks and Bridges

In addition to evaluating the regular spacing of tanks near roads, we can also look at whether tanks are found in the proximity of bridges and resthouses. Since the pragmatic function of these tanks is to store water, their absence around bridges is a logical outcome as the bridges are situated, of course, on sources of flowing water. The comparison of tanks and bridges is best viewed from the position of the bridge and from this we can identify several variables. First is the presence of tanks within the immediate vicinity of the bridge, measured at 100 m, 200 m, and 500 m increments. Second is the number of tanks found around each bridge within these buffer zones. A third variable is the type of river on which the bridge was built to cross; this is an important consideration as it may determine whether an artificial store of water is needed at the location.

From the sample, 36 bridges were found with tanks within 500 m of their position (Table 8.10). In comparison with the total number of bridges on each road, the bridges on the Southeast Upper (74%) and East (59%) roads are most frequently found within proximity to a tank (or vice versa). A comparison of crossing type shows that the majority of bridges with tanks nearby are situated on artificial levees (21) or intermittent streams (11). This fact suggests that the tanks would provide a source of water along the route.

Looking at the spatial distance between these tanks and bridges, we find that tanks are normally located quite a distance away from the stone crossing points, most often between 300-500 m away. The East and Southeast Upper roads also have the only bridges with tanks within 100 m. Between one to five tanks are found within these buffer zones around the bridges, and the majority of cases (21) have only a single bridge nearby. Three or more tanks are found only on the Southeast Upper and East roads.

Tanks and Bridge Summary

Tanks appear in relatively close proximity to about half of the Angkorian bridges and the majority of these examples are at crossing of an intermittent or irregular water flow. These similarities become less clear when we include the spatial relationship between these structures. There is no readily identifiable distance between a bridge and its tank or tanks and the majority of these tanks are found some distance away. Another factor that suggests there is no central cohesion is that the visible association is largely influenced by the pattern from the East and Southeast Upper roads. While this could be argued for a shared plan of tank building between these two roads, the remaining three roads are markedly different. Further investigation of the size of bridges relative to the distribution of tanks is merited. The biggest problem in extending the analysis at this stage is that we do not know if the tanks were built as a reaction to the construction of bridges or, more significantly, if they were related at all to the needs of transportation.

Tanks and Resthouses

Working from the idea that a source of water was needed to supply the people stopping at resthouses we need to investigate whether water tanks were fitted close to these way points. Of the total number of resthouses along the Northwest and East roads we find that there are eleven are within 500 m of a tank (see Table 8.6a-c). This generally occurs in the 500 m buffer away from the building. Only two examples, Prohm Kel on the Northwest road and Kuk Top Thom in the enclosure of Beng Melea have tanks within 100m. These sites have two tanks within the 500 m buffer, while Prasat Chrei, also at Beng Melea, has three.

It has already been shown that most resthouses are found within 500 m of flowing water sources (see Table 8.6a-c). A total of seven resthouses are actually found within 500 m of a water source and a tank. A key difference appears to be the type of river near the resthouse. The examples on the East road are situated near intermittent rivers, while those on the Northwest road are distributed near each river type. Since the idea of placing a tank near a resthouse is to serve as a source of water for the local visitors/inhabitants, we must also look to see how far away these rivers are. For resthouses that are near a tank, there are only three examples which are within 500 m of a river. These resthouses are found on both the Northwest and East roads. This suggests that some resthouses may have been placed near tanks or vice versa when a permanent river was not available. The fact that most tanks are more than 200 m away, however, makes a direct association difficult to verify without further evidence.

A second query of the relationship between tanks and resthouses is whether tanks are spaced at specific intervals along the roads. Using the resthouses as starting and stopping points demarcating route sections, we can test whether tanks of specific characteristics were placed as intermediary points between each resthouse. The first test was to look at the relationship between the total number of tanks found between the resthouses identified on the East and Northwest roads (Figure 8.25). Table 8.11 shows that that there is no immediate consistency in the distribution of tanks on either in the number between each resthouse or in their secondary characteristics (e.g., perimeter, orientation, alignments). Generally, it appears that the Northwest tanks are further apart, are larger and are less densely spaced than on the East road.

A closer examination of the distribution of tanks between resthouses on visible roads is undertaken to see if this broader pattern is masked by limitations in the mapped data, especially along the Northwest road. Two sections were chosen, on the Northwest road between Sampoeu and Prohm Kel (see Figure 8.21), and on the East road from Banteay Ampil to Prasat Chambok (see Figure 8.22b). Excluding the last stop, the results for the Northwest road (Table 8.12a) show a similarity in distance, size and side of the road. Oddly, only one tank was found between the second and third resthouse.

The results for the East road (Table 8.12b) show a marked difference in spacing between the first two (2.7-3.0 km) and last three resthouses (0.9-1.1 km). Other than a slight difference in size and bearing, however, there is little further evidence to separate these two sets of *temples d'étapes*. The characteristics between stops are not immediately indicative of a definite plan.

Tanks and Resthouse Summary

None of the characteristics evaluated here provide clear evidence that roads and tanks are laid in accordance to specific plan. Without knowing what constitutes a 'road tank' the most that can be said from this discussion of tanks and resthouses is that tanks on Northwest road are spaced slightly further and are larger than their counterparts on the East road.

The association of tanks with religious and agricultural functions further complicates the identification of specifically transport-based locations. An immediate problem that must be solved is the chronology of these structures. By establishing a temporal stamp it will be possible to discuss whether the tank was built in conjunction with the road or whether it pre- or post-dates the construction of the route.

An important point that must be made is that this distribution of the resthouses conforms to the area surveyed using aerial photographs in Cambodia. A further survey using air photos around the resthouses on the Thai side of the border needs to be undertaken to see if smaller tanks not visible in the ASTER data can be identified.

Main Angkorian Sites

The last aspect of this analysis is to assess the relationship between main temples identified in the sample with the road and river routes. The focus is on identifying distances between the main sites; a second characteristic that to be investigated is the impact that the road has on reducing the distance between provincial centres and capital.

Roads and Sites

Following the original maps of the Angkorian network and the remote sensing surveys presented here, only 12 main sites are directly accessible to the road network (Figure 8.8). Most of the regional roads end at a final destination point; a potential exception to this is the West road, which disappears past Phnom Srok as it heads toward Sdok Kok Thom and the sites of central Thailand. This system acts to connect sites found on the north side of the Tonle Sap Lake and there is no evidence of a road on the south and west sides in Battambang nor toward the sites past the Stung Sen toward the Mekong Delta.

Putting aside geographic location, we can look at the physical size of these sites (e.g., enclosure, *baray*) as a secondary indicator for why they were incorporated in the terrestrial system. This follows the argument that larger sites were more likely involved in the machinations of Angkorian imperial communication. Table 8.3 shows the comparative size of enclosures and *barays* for sites both connected and not connected to the Angkorian road system. There is considerable variability between the individual sizes of both structures regardless of their road connectivity. Enclosure size ranges dramatically from 140 m to 18000 m perimeter; the size of the *barays* is less variable ranging from 1152 m to 7017 m. An obvious anomaly in this group is the size of both structures at Preah Khan KS. Removing it from consideration, the mean difference between the connected (enclosure – 1900 m, *baray* – 2600 m) and not connected (enclosure – 1600 m, *baray* – 3100 m) are quite similar. From a rank order perspective it is interesting to note that four of the largest enclosure sites are connected to the road system, however, there is no obvious relationship among the rest of the sample. A similar heterogeneity between sites connected and not connected to the road system is evident for the *baray*.

Overall, there does not appear to be a direct correlation between site size and connectivity to the road system. Many sites such as Banteay Chhmar and Ta Prohm Bati are as large, or larger, than some placed on the roads. These results may demonstrate Sinopoli and Morrison's suggestion that the monumental architecture is not a straightforward indicator of power, but may be statements made by local rulers about their position in the region (1995:84).

Rivers and Sites

The importance of rivers has long been assumed in relation to Angkorian settlement (see Chapter 7). In this study emphasis is on measuring the distance from main sites to the river network and also to examine the relative position of the site within the river catchment. A primary assumption is that the rivers would be navigable for at least part of the time. The question of navigability is not addressed here but new data on to be released by the Mekong River Commission will assist our understanding of fluvial communication. For the purposes of this examination we can use the base river network as an initial model for testing whether access to rivers for transport was a guiding factor.

The distribution of sites and rivers is presented in Figure 8.26. Generally we find that sites are situated within 2 km of any water source (Table 8.13). The distance to the main river of the catchment, however, is considerably different with a mean average distance of 22.5 km. In fact, only four sites are found within 5 km of the primary fluvial route. Connection to the Mekong was not an important part of the Angkorian settlement as only one main Angkorian site, Vat Nokor, is situated next to this river. Overall, it appears that Angkorian builders had a preference for locations sites along secondary rivers.

The decision to build on a secondary river has several implications. Many of the larger rivers, such as the Stung Sreng, meander dramatically; the impact of seasonal flooding along these routes on settlement would therefore be potentially disastrous. A second reason is that these types of rivers would be difficult to control and therefore would be less useful for localized irrigation or water management. Another explanation is that, while main rivers provide easier regional communication, they also provide easy access to a site. From a defensive perspective these locations would not be ideal. A secondary river, though perhaps only navigable for part of the year, would be more reliable for settlement and safety.

Lack of river access does not appear to be a defining factor in the connectivity of a site to the road system as all are within 5 km of the water system. There is no readily identifiable pattern in the access to the catchment river or tributaries. It is interesting to note that many of the sites not connected to the road system, such as those west and south of the lake (Battambang group, Prasat Don An) and more isolated sites (Preah Vihear, Ta Prohm Bati) are within a kilometre of a potential water route. Other sites such as Banteay Chhmar, are not connected to the road system directly nor are they within a short distance to the river system. Since we know that these sites were part of the Angkorian territory the placement of these sites suggests that water transport or secondary road systems, not visible with the current data sets, played important roles in regional communication away from the main road network.

Rivers versus Roads: Distances to Angkor

The last relationship to examine is the impact that the road system had on reducing the total distance from provincial sites to Angkor. The primary assumption here is that the river system and the Tonle Sap Lake would have been the primary communication system for the lowland region. As such only those sites situated on the roads are included in this discussion. The direct correlation of distance between river and road distances ignores important factors of each transport type such as river speed and topography; it is argued, however, that a basic comparison of distances will outline the basic nature of this relationship that can be examined with the addition of specific traffic and fluvial data sets.

(Table 8.14 summarizes the location and distances of the shortest riverine routes between road connected sites and the capital. The greatest shift in distance appears between sites of the Khorat Plateau, Phimai, Phnom Rung, and Muang Tam, and Angkor (see Figure 8.8). The construction of a road between these sites reduces the distance by up to 10 times. The formalization of a road to this region is hardly surprising; the distance required to travel to Angkor and the difficulties of crossing the Khone Falls and up into the Tonle Sap Lake suggests that this route was extremely impractical to reach the capital. Within the Tonle Sap basin the sites along the Northeast road (Koh Ker, Neak Buos) show the most significant change in travellable distance. With the exception of Prasat Andet the road system served to reduce connections between most of the sites in Cambodia to at least half their original distance.

From this evaluation of river and road distances, it is possible to conclude that the road system would have had its greatest effect on reducing travel distance to Angkor from Thailand and sites placed within the Sen river catchment.

The Angkorian Transport Plan

From the analysis of the spatial relationships between the infrastructure and routes it is possible to address the degree to which the Angkorian state built a single or unified plan. Patterns derived from individual components, comparison across components and by road are presented. This last section will touch on the relative importance of each road based on the amount of transport infrastructure within the overall system.

Individual Infrastructure

Roads

Each of the roads connects to Angkor, either directly or through the junction with another regional road. Each of these roads is equally visible as they leave the immediate vicinity of the capital. It is at this point where some important variations can be identified. While the Southeast and East roads are largely visible across their entire length, the others show marked differences. The West road is extremely visible until it passes the Stung Sreng where it then disappears into the landscape, discretely linking up to Sdok Kok Thom. The Northwest road shows a similar pattern past the Stung Sreng and is particularly the case once the ‘road’ passes over the Dangrek Range into Thailand. Excluding the impact of post-Angkorian landscape modification in Thailand and remote sensing errors, the investment in building up the Northwest road appears to suddenly stop at the Stung Sreng. The Northeast road is somewhat different in that the trace can be identified to its ‘terminal’ at Vat Phu but it has several important gaps along its length between Neak Buos-Koh Ker and Koh Ker-Beng Melea. A unifying attribute within this pattern is that the regional road is often most visible in the vicinity of main sites. This is a logical association as roads are often best maintained around population centres that would have relied on them for regional access. This information shows, as both Lunet de Lajonquière and Bruguier pointed out, that the roads are much less homogeneous than has been previously depicted on maps of the Angkorian roads.

Bridges

As Bruguier originally pointed out, the extent of bridges along four of the roads away from Angkor is relatively standardized at approximately 100 km. The discovery of the bridge on the Northeast road extends this road distance to nearly twice as far. Within this maximum extent the selection of the type of water course on which bridges are placed is somewhat more varied. This may be the result of planned burial to prevent water from passing from through the embankment or construction in non-durable materials. Lunet de Lajonquière suggests a third possibility that this gap is the result of an incomplete set of architectural works (1902:lvi).

The fact that bridges suddenly stop while the road continues is an important issue. The best example of this is on the Southeast Upper and Northeast roads, with the former ending at the impressive Spean Praptos (see Figure 7.7b). Currently it is unclear whether this is part of a plan laid out by the capital or if these further structures were established by local rulers to improve access along the roadways. If the placement of these structures is part of a state-level programme the 100 km distance could relate to the area under direct rule from Angkor. The distance of corresponds with the association of military control extending to about a week's travel from the capital. Further discussion of the importance of this distance is not possible without more detailed information about the sites (i.e., masonry construction, size of the bridge, proximity to local centres) and with the detailed information on the location of officials and functions that will derive from the work of Lusting (n.d.) and the current reappraisals of the Angkorian inscriptions by Vickery and the EFEO.

Looking at the overall distribution of bridges it is important to note the impact of bridge construction on river transportation. Three of the rivers closest to Angkor, the Stung Chikreng, Stung Staung and Stung Sreng are each fitted with several stone Angkorian bridges. The Chikreng, which is crossed by the Spean Ta Ong on the East road and Spean Praptos on the Southeast Upper, may not have been a viable route as the narrow bridge arches would have been unsuitable to travel through. Its arches would only permit small canoes, but the force of current during the rainy season through these passages would have made the trip extremely difficult. One possibility is that the terraced embankments (see Figure 7.10b) were used as a means of transferring goods from one side of the bridge to the other. Again, the steepness of these terraces would have been difficult to climb in the rainy season.

Resthouses

The fact that resthouses are restricted to the Northwest and East roads and are placed at regularly spaced intervals has already been identified in past studies (see Lunet de Lajonquière 1911:xxviii; Finot 1925). From the GIS analysis, the measurements along the roads have not changed dramatically from these original distances. An important difference is that the *temples d'étape* are actually much closer to each other than the 18 km suggested in the past (see Chapter 7). Overall, the mean distance of 13-15 km suggests that they were placed to meet the specific requirement of Angkorian traffic.

Three important points can be raised that suggest these buildings were not part of the same plan. First is the construction material of the *gîtes d'étape* on the Northwest (laterite) and East (sandstone) roads. The sandstone examples are also similar to those found within temple enclosures (e.g., Ta Prohm, Preah Khan, Preah Khan KS, Ta Prohm Bati, Banteay Chhmar). Second is that the *gîtes d'étape* on the East road appear to stop at Beng Melea and do not continue on to Angkor. Third, is that the while the distance between *temples d'étapes* is remarkably similar we are still unsure if those connecting Beng Melea to Angkor were part of the structures erected on the eastern half toward Preah Khan KS.

Tanks

Ultimately, the search for tanks along the roads is a focussed toward identifying evidence of caravanserai. In other contexts routes are often demarcated by the presence of repeating tanks rather than being raised or formalized as roads. Each of the Angkorian roads is fitted with numerous tanks and the distribution along them suggests that a tank would be accessible within a relatively short distance (1.3-2.4 km) along any roadway. The question, however, is whether they were built for the purpose of aiding travellers along the road or as part of a settlement system that appeared before or after the route was established. Developing a method for obtaining chronological control over these structures is a vital part of future research. The comparison of traits such as size and orientation and alignment provide no obvious clues about whether a tank is affiliated with the road. Even when tanks are aligned to the road, there is the possibility that they were built to be in line with the watershed. The biggest issue in using tanks is that they are built to serve purposes other than transport, in Angkorian agriculture and religious practices.

Comparison of Infrastructure

A list of general specifications can be identified from the spatial relationships of the transport components. Positive associations that appear are:

- resthouses are found within 500 m of rivers
- tanks are often found within 500 m of resthouses
- bridges and tanks cluster around main Angkorian sites
- main Angkorian sites not connected to the road system are normally found near a river suitable for transportation

Negative associations are also identifiable:

- resthouses are not placed near bridges

The bulk of this evidence suggests that Angkorian transport infrastructure may have been placed in a wide-ranging plan. Two issues can be raised that suggest otherwise. First, while the tanks, bridges, and resthouses are may be found within 300-500 m of each other this distance is actually substantial enough to argue that they were too far to be directly related. Second, the roads are often passing through areas, such as the northern plains of the Tonle Sap Lake, which were heavily populated in the past. The relationship of tanks to resthouses and bridges becomes less clear when we consider the palimpsest nature of settlement in the region.

Comparison of Roads

We can discuss the overall content of the Angkorian roads in quantitative and qualitative terms. From a purely quantitative perspective the length of roads and their visibility and associated nodes provides a very heterogeneous pattern. With the exception of the Southeast Lower road, which lacks any bridges, it is the distribution of resthouses that immediately separates the roads into different categories. Looking at the relative ordering of each component by direct or relative frequency it is possible to create a rank order of importance based on:

- Visibility Rank - percentage visibility along road length

- Bridge Rank - total number of bridges
- Bridge Road Rank - proportion of number of bridges to road length (visible road length divided by number of bridges)
- Resthouse Rank – total number of resthouses
- Tank Road Rank – proportion of number of tanks (visible road length divided by number of tanks)
- Site Rank – total number of main Angkorian sites along road

The results of these rank categories are presented in Table 8.15. According to this basic ranking, the East and Southeast Upper roads are fitted with the most transport infrastructure. The West and Northwest roads would be considered the least important. The fact that the Northwest road is ranked so low is ironic given its assumed importance from the presence of resthouses. A further fact that needs to be pointed out is that, with the exception of the West road, each of the Angkorian roads was ranked first in at least one of the categories.

The qualitative comparison of the Angkorian roads shows a similar heterogeneity. Tanks appear to be a regular feature across the roads it is the extent and spacing of resthouses and bridges that mark the most significant differences. The East road is far better fitted than any other road; the Northwest road has resthouses but bridges do not appear on the Thai side of the border. The distribution of bridges is also interesting for the Southeast Upper road which suddenly ends at one of the most elaborate examples, Spean Praptos. The West and Northeast roads have fewer bridges but the West road is significantly shorter and does not have significant gaps along its visible section. By contrast the Northeast road, in its current state, has numerous crossings that lack stone bridges. The most curious road is the Southeast Lower which has the greatest number of tanks. As indicated above the position of this road within the floodplain of the Tonle Sap Lake suggests that it may have played a primarily agricultural role. Tanks aligned along the downstream edge, like the *tnub* in the south of Angkor, and the lack of any other infrastructure may be further indications of a different purpose.

The Question of Importance

An important issue that arises from this discussion is whether the amount of infrastructure on a road is directly connected to its relative importance within the region. Following this logic the East road is the best supplied route in the entire system, a fact that has already been suggested by Jacques (Jacques and Lafond 2004:261). The importance of Northwest road lies largely in the presence of numerous large bridges and, of course, the laterite *gîtes d'étape* built between Angkor and Phimai. Lunet de Lajonquière mentioned these two points during his surveys and added further credence to them by identifying that the road crossed densely populated regions (1911:xxiv-xxv). The lack of visibility of the Northwest road in northern Cambodia and throughout Thailand suggests that it may have been an important route, rather than a formalized road. That the Northwest and East roads connect directly to two of the largest sites, Phimai and Preah Khan KS, is another indicator of their relative importance in the Angkorian world.

The presence of bridges alone is still an important aspect of regional integration. The Southeast Upper and West roads are the best fitted along their lengths. However, it is striking that bridge construction suddenly stops halfway along the length of the Southeast Upper road. Lunet de Lajonquière suggested that the location of the West and Southeast Upper roads, both of which run parallel to the edge of the floodplain, make them less important than those which connect directly to main temples (1911:xxviii). The Northeast road has fewer bridges but the fact that its furthest bridge is double the distance of a bridge on any other road is potentially significant.

Plan versus Plans

The heterogeneity measured from the spatial relationships suggests that there is no single plan for the Angkorian transport network. Instead of a single plan we can argue that the evidence supports multiple phases. For instance, the distribution of bridges does not correspond with the extent of resthouses on the Northwest road. Similarly, the excavation of tanks is not connected to the construction of resthouses. As such we can posit the following phases in the sequence and the potential that they span a single or multiple event:

- Construction of six roads (multiple events)
- Construction of bridges (along five roads) (single event?)
- Construction of sandstone *temples d'étape* along East road (Suryavarman II) (single event)
- Construction of sandstone *gîtes d'étape* along East road (single event)

- Construction of laterite *gîtes d'étape* along Northwest road (single event)
- Construction of tanks in proximity to roads (multiple events)

This model of multiple plans will be tested directly in the discussion of chronology in Chapter 9 and indirectly within the examination of geographic resources and road function in Chapter 10. The division of the system into separate phases also outlines the need for more intensive archaeological work directed at each of the transport components. An important counterpoint to the overall heterogeneity between the types of infrastructure is an underlying homogeneity within several types. The similarity in construction of bridges and resthouses is indicative of a state-level plan which is related to a specific cultural association, such as trade connections or military access.

Summary

This chapter located and described the spatial relationships of the Angkorian transport components. In addition to creating an accurate map of the regional roads, the location of tanks and main sites across the study area strongly supports the existence of a less visible secondary road system and, perhaps more importantly, the integration of river transport. An underlying issue of this discussion is whether the transport components represent a unified plan or a series of different constructions. While there is some evidence of individual homogeneity (e.g., spacing of resthouses, maximum extent of bridges, ubiquity of tanks) there is little direct evidence to link the placement of these structures in relation to each other in a regular method. A discussion of the amount of transport infrastructure on each road similarly shows an inherent heterogeneity between each of the roads. This supports the conclusion by Lunet de Lajonquière that the system is markedly different across the roads. From this starting point, we must now add the element of history to test the chronological association of the roads with Jayavarman VII and also whether the spatial differences represent phases of Angkorian transport construction.

Chapter 9. Historical Analysis of Angkorian Transport

The second stage in the operational approach to transport is to evaluate the chronological issues of the Angkorian road system from the integrated database. Our current understanding of the temporal association of Angkorian transport is based primarily on relationships established through historic information, in particular the Preah Khan inscription (1191 CE) and the role of Jayavarman VII. Jacques (2006) recently presented a slightly different view of this chronology suggesting that the road system was likely formalized by Jayavarman VII (1181 to 1220 CE) and Indravarman II (1220 to 1270 CE). Jacques also argued that the resthouses are pre-Jayavarman VII and the bridges are post-Jayavarman VII constructions. The purpose of this study is to systematically assess the evidence and its implications using archaeologically-based methods not pursued by Jacques.

As illustrated in Chapter 4, roads are notoriously difficult features to date since, more often than not, they continue in use long after their initial construction. Following a review of the evidence for and against the assertion that Jayavarman VII was responsible for the transport system we see today, the examination of the chronological issue is divided into two sections. The first section deals solely with models for evaluating the date of the Angkorian roads by incorporating a broader sample of historical sources and evaluating them within their spatial context in GIS. A core emphasis is on identifying the existence/use of a route rather than the formal construction of a road. Three temporal models based on main sites, communication zones, and events (specifically military campaigns) are presented to evaluate the location of regional and supra-regional communication routes in the Angkorian period. Temple construction along the roadways and the shifting extent of each king's influence are also assessed temporally to identify spatial patterns of communication between Angkor and its territories. Outside of Angkor, inscriptional evidence of military excursions undertaken by Angkorian rulers is used to identify directions of communication based on the intended destinations.

The second section looks at the potential for dating the transport infrastructure. An inherent implication of recognizing several 'plans' of infrastructure development from

Chapter 8 is that the components came together at different times. Whether this occurred over a short or long space of time is subject to further discussion as is the issue of whether each component had one or more developmental phases.

The Temporal Backdrop

The evidence for and against associating Jayavarman VII with the road network is the starting point for this investigation. The main issue is whether the evidence from a single text that specifically discusses transport outweighs the bulk historical evidence and archaeological sources that indirectly deal with transport and communication during the Angkorian period.

Evidence For JVII: Preah Khan Inscription and Archaeological Data

The Preah Khan inscription underpins the association of the Angkorian road network with Jayavarman VII. As illustrated earlier, this text discusses the placement of a specific number of resthouses along three roads. With the addition of the new structures discovered by the Angkor Living Road project the number of *gîtes d'étape* on the Northwest road now corresponds directly to the number in the text between Angkor and Phimai. The correspondence between the inscription and these buildings provides us with an absolute date of 1191 CE. Excluding the two brief references to transport infrastructure in the Phnom Sres and Sdok Kok Thom inscriptions attributed to the early to mid-11th centuries, Jayavarman VII is the only king to have written about the subject. Another aspect of his reign that suggests he was capable of undertaking such a massive enterprise is his reputation for expanding the empire demonstrated by the distribution of large enclosure and secondary sites (e.g., hospital chapels) attributed to him in Angkor and across mainland Southeast Asia. Groslier argues that the position of the road system and density of Jayavarman VII's architectural works on the north side of the lake is a direct response to the political situation in the 12th century which saw repeated conflict with the Cham to the south (1973:117). In this light the road to Prasat Andet served to take military campaigns to Champa (Ibid.).

Evidence Against JVII: Preah Khan Inscription and Archaeological Data

Looking more closely at the details of the Preah Khan inscription, the temporal association is much less clear-cut. The most obvious issue is that the text refers only to the construction of resthouses, what we now call *gîtes d'étape,* on three roads.

Currently, we can only identify one of the roads (Northwest) by association with the number of resthouses listed in the inscription. It does not say that Jayavarman VII built or improved these lines of communication, nor does it say that he built bridges or tanks. To date there has been no direct dating technique applied independently for each of the associated transport infrastructure.

The number of resthouses also poses a problem. Beyond the seventeen identified along the Northwest road, the inscription lists fifty-seven to the Cham capital and forty-four lining a circuitous route connecting to Angkor. The only other road with recognizable *gîtes d'étape* is the East road, however there are only four buildings and they are found between Beng Melea and Preah Khan KS. They do not continue past Preah Khan KS and, more importantly, they do not connect directly to Angkor. While further surveys along the secondary road to the east of Preah Khan KS identified in Chapter 7 may change our perception, the road is clearly not as well built as other regional roads. Though Coedès' use of the average distance between resthouses (13.2 km) demonstrates that the roads could have reached Champa or wound around the Tonle Sap Lake, there is no archaeological evidence to support this claim. The date of the Angkorian roads is therefore based on an inference from the Preah Khan inscription of resthouses being built along roads.

Another issue that has recently been raised is whether Jayavarman VII was responsible for all of the building attributed to his reign. The evidence raised by Jacques (2004:345,388; 2006) and Cunin (2004) places an increased importance on Jayavarman VII's son and successor, Indravarman II, in the modification or completion of numerous buildings. Through a recent retranslation of the Mangalartha inscription, Jacques (2006) has argued that the reign of Indravarman II originally dated to 1220 to 1243 CE should be extended to 1270 CE. During this fifty-year period, Indravarman II Jacques suggests that he was probably responsible for finishing many of Jayavarman VII's temples, including the famous face towers on many temples that were begun in Jayavarman VII's reign (Jacques and Lafond 2004:294,351). Cunin's thesis also points out the issue of architectural similarities between many of Jayavarman VII's temples and earlier constructions attributed to Suryavarman II, such as Chau Sey Tevoda and Thommanon (2004:460). The importance of this research is that it tempers the importance of

Jayavarman VII and more importantly, these results were achieved from the examination of multiple sets of historic and material evidence.

Evidence Against JVII: Broader Angkorian History

Evidence that transportation was an important state-level concern before Jayavarman VII was demonstrated in Chapter 7 in the description of transport infrastructure in the Phnom Sres and Sdok Kok Thom inscriptions. A more significant argument against a Jayavarman VII-derived transport system is the corpus of historical events spanning over 300 years that lead up to his reign. The distribution of over a thousand inscriptions and several thousand temples across mainland Southeast Asia demonstrates that the Angkorian Khmer state was active across vast parts of this region. The contents of these histories further shows to what degree and when these activities took place. A summary of this information is therefore vital to our understanding of the construction of both routes and roads in the Angkorian past.

In discussing the continuity of communication it is important to recognize that the actions of Angkorian kings may have been based on or influenced by the pre- Angkorian period. A prime example of this is that three sites (Sambor Prei Kuk, Vat Phu, Prasat Andet) along the road network have their origins in the pre-Angkorian period. While it is possible to include these sites within the analysis, it is beyond the scope of this document to investigate comparable communication events from pre-Angkorian inscriptions. An examination of the spatial movements within these two periods would no doubt provide interesting perspectives on the conclusions derived from the Angkorian period alone.

Temporal Models of Angkorian Transport Components

The preceding discussion has identified the primary issues in the dating of the Angkorian transport system. Working from the perspective that Jayavarman VII was not responsible for all of the visible remains we see today, a set of archaeologically-derived approaches are outlined. The objective of this section is to summarize the chronological information for the individual transport components (i.e., roads and resthouses) to come up with a more holistic approach for dating regional communication. Our starting point is to identify whether the different spatial patterns identified for the transport components in Chapter 8 represent particular phases of building. The following sections will evaluate the temporal characteristics of each of these transport components (roads, resthouses, bridges) through a combination of multiple historic and archaeological data sets. The construction/modification events and appearance of inscriptions relating a site to Angkor is based on information from a variety of different surveys of Angkorian provincial sites (e.g., Lunet de Lajonquière 1902-1911; Parmentier 1948; Briggs 1951, Jacques and Lafond 2004, Snellgrove 2004; Lustig 2006) (see Appendix 3).

Road Chronology

The evaluation of whether previous kings of Angkor played a role in the development of the Angkorian roads is based on two sets of information. The first is the architectural and dedicatory inscription evidence that a king was involved or held sway over a particular site. The second is the inscription-based accounts of military expeditions undertaken by Angkorian kings to quash regional rebellions or attack distant states.

Architectural style provides the other critical evidence of a king's involvement at a site. Dates for the temples in Cambodia and throughout the Angkorian empire are derived from a combination of the original art historical chronologies (i.e., Stern 1927, Parmentier 1939, Coral Rémusat 1940, Briggs 1951, Boisselier 1952; 1966) and more recent summaries of the temples of the Khmer empire by Snellgrove (2004) and Jacques (Jacques and Lafond 2004). The dates of these buildings are actually reliant on the inscriptions carved into their walls or on stele found in their enclosures. Subsequent plans and styles are therefore attributed to the 'type site' established by the historic comparison. The architectural modifications are included for the Angkorian period, even though many locations (Sambor Prei Kuk, Vat Phu) have their origins in pre-Angkorian times.

Three different assessments (Figure 9.1a-c) are undertaken through GIS that will provide a picture of when transportation would have been needed and where it went:

- Main Sites and Roads – diachronic examination of construction and modification episodes at main Angkorian sites
- 'Communication Zones' - comparison of changes in regional extent of a king's influence at main sites
- Historical Events - mapping of the direction of military actions

Each of these models are evaluated individually and then compared collectively to assess the role of Jayavarman VII on the roads and also identifying potential phases of roads individually. Further discussion of the methodology used to create the communication zones is presented in Appendix 3.

An important point of this discussion is that the chronology is aimed at identifying the age of the route, and not a road per se. The data sets being used in this study cannot tell us when the road was physically raised, modified or destroyed; instead it allows us to ascertain when the area in which roads were eventually built became part of the Angkorian communication landscape. The following discussion therefore uses the term route to refer to predictions and the term road in reference to the visible trace of these components.

Main Sites and Roads

The main sites selected in this study represent the largest, and arguably most significant regional centres in the Angkorian world. Compiling the historical activities associated with each site we find that many had multiple phases of construction, occupation or political involvement with the capital. The objective of this test is to map the temporal distribution of sites connected to the roads to determine when the route connecting them to Angkor could have been in use (see Figure 9.1a). An important point that must be considered is that in the construction of main sites and roads it is difficult to determine which came first; roads can be built to connect sites and/or sites may be built along the length of roads. This test will therefore attempt to break down the order in which sites appeared along the known Angkorian roads.

Sites and Roads by King

The construction phases of the main sites are presented in Figure 9.2. Between the 7th and 9th centuries, main temples are found at the end and mid points of Northeast and Southeast roads (e.g., Vat Phu, Prasat Andet, Sambor Prei Kuk, Neak Buos) or along them. In the 10th century the Northeast road has the only construction which corresponds with the shift of the capital to Koh Ker. A single movement toward the west appears in the late 10th century at the enclosure of Phnom Srok, represented by a Khleang style lintel at the temple of Prasat Srok (Ang Chetra, pers. comm. May 2007). The most dramatic florescence of sites occurs in 11th century to the west of Angkor. These include multiple constructions in the Khorat Plateau and in Battambang, and possibly additions to the site of Phnom Srok. Another important addition is the initial construction at Preah Khan KS on the East road and the appearance of Phnom Chisor in the far south. From the second half of the 11th century there is a continued emphasis on construction/modification in the northwest part of the empire. This fits with Im's (1998:26) assertion that communication to the west and northwest was the primary focus between the 10th and 11th centuries. Moving into the early 12th century, Beng Melea is the last site to appear along the road sometime during the reign of Suryavarman II or his immediate successor. The distribution of sites for Jayavarman VII shows a comparable footprint to that laid out by Suryavarman I. None of the new temples that are attributed to him are found near the regional road network.

Main Sites: Discussion

Following the proposition that kings, either directly or indirectly, influenced temple construction or modification, it seems highly unlikely that Jayavarman VII could have been responsible for the totality or even much of the road system. Two immediate pieces of evidence are: 1) that all of his road-associated temples were previously built or modified up to two centuries before his reign; and 2) none of the new constructions for which he is given credit are found anywhere near the visible road network.

Instead, the evidence of the 11th century suggests a fairly important shift in the regional focus of Angkor which may have been a catalyst for the road system as we see it today. A point made by Van der Leeuw can be used to support this assumption,

> Where the rapid increases in growth occur we are likely to see similar developments in communications and formalization of channels to deal with specific kinds of information or commodities. This often leads to the development of long-distance, state-supported and -controlled road systems, messenger services, state information-gathering networks (1981:28).

Presuming that these routes are associated with the main sites we can make an initial temporal association for each of the routes. The earliest date for each route/road can be summarized as follows:

- Southeast route(s) – 7th to 9th centuries

- Northeast route – 7th to 10th centuries
- West route – late 10th – early 11th century
- East route – early 11th century
- Northwest route – early 11th century

This information also illustrates the amount of time that a route would have been incorporated within the greater communication system. Following the construction of their ‘terminal’ points, the Northeast, East and Northwest routes would appear to have been almost continuously used. The West road was intermittently used, but the end point defined here (Sdok Kok Thom) was not an important location for most the Angkorian kings. Both of the Southeast roads are linked to sites that had their greatest significance in the pre-Angkorian period (Sambor Prei Kuk, Prasat Andet), and therefore appear to have factored into regional communication in the Angkorian period least of all.

While the sites connected to the road system provide evidence for when the routes may have become part of the regional communication network, nearly half of the main sites lack any evidence of a terrestrial connection to Angkor. Two important points of discussion need to be raised. First is the dichotomy between Vat Phu and Preah Vihear. These two sites are among the most consistently built upon locations throughout the Angkorian period. However, only Vat Phu is connected directly to the road system. It appears that Vat Phu was connected to Angkor by the Northeast route from at least the 9th century and was continually involved to the mid 12th century. The geographic importance of Vat Phu is further attested to by its location near the Mekong, which would have served, to some degree, as an important regional artery. By contrast, Preah Vihear has no visible road connecting it at all. As Jacques suggested, Preah Vihear was a goal of destination unto itself and not a stop on in the generalized communication system (Jacques 2004:235). In trying to explain the absence of a formalized road to this important site we are presented with several options: 1) a road was not built to Preah Vihear; 2) as a pilgrimage site it was accessed by a secondary path established by repeated foot traffic; 3) it was accessed from on top of the Dangrek; or 4) it was accessed by boat up the Stung Sen. Regardless of how it was accessed it shows a duality in the importance of providing direct access to important sites in the empire.

A second issue to consider is why roads do not appear in the territories to the southwest and southeast of Angkor. The history of main Angkorian sites in both regions begins in the early 11th century; thus we cannot say there was insufficient time to build roads to these regions. The more likely explanation is that they did not need roads and relied on water transport through the Tonle Sap Lake and the Mekong. As discussed in Chapter 8, the proximity of many sites to the edge of the floodplain shows that they would have had direct access to the river system and Angkor for at least part of the year. This shows clearly that both roads and rivers would have been used to integrate the provincial sites with Angkor.

Main Sites and Catchments

The same information for main sites can be used to evaluate their distribution across the catchments. While only a small proportion of these sites are placed along the catchment river, the main sites are almost universally located within a short distance of a secondary channel that leads to the main river. If we consider that the rivers are part of a greater catchment system, the placement of provincial centres may be related not only to river access but also to establish a regional outpost within a greater hydraulic network defined by local topography. By looking at the distribution of main sites through time we can test to see if catchment control was an important consideration of the Angkorian settlement/transport plan.

Sites and Catchments through Time

Figure 9.3 shows the distribution of sites across the catchments from the pre-9th through to the early 13th centuries. After at least two centuries of focus on the northeast, the 11th century sees a dramatic increase in the appearance of main sites in the catchments to the west of Angkor. The regional emphasis then moves from the northwest back to the northeast and finally, with Jayavarman VII, we see the widest range of sites across the region's catchments. This king may therefore be credited with integrating the transport system but that does not mean he created it; indeed it specifies that he did not.

Sites and Catchments: Discussion

The temple constructions of Jayavarman VII locate a main provincial centre in each of the catchments to the north side of the Tonle Sap as well as outposts to the south (Vat Nokor, Ta Prohm Bati) and modifications to integrate the west (Vat Baset, possibly Banon). Many of these sites, however, represent modifications to existing temple complexes (Phimai, Muang Tam). The most consistently occupied catchments are found to the northeast of Angkor in the Sen and Huai Khamouan drainages. From the second half of the 11th century Angkorian construction activity in the Mun catchment shows a continual need to integrate a second major river system in the empire. This is directly related to the idea that the kings of the Mahidhapura dynasty (Jayavarman VI-Suryavarman II) had their power base in this region above the Dangrek Range.

Positioning sites in the centre of the catchment is common throughout the pre-9th to 11th centuries as seen in such sites as Sambor Prei Kuk, Angkor, Phimai, and Preah Khan KS. The sites in Battambang could also be included in this group given that the width of the Battambang catchment is so narrow near Vat Ek and Vat Baset. Other sites such as Koh Ker and Sdok Kok Thom, while not directly on the main river in their catchment, are also situated toward the centre of the greater catchment.

In contrast to this practice, the 12th century sees the positioning of several temples directly on the catchment (Beng Melea and Banteay Chhmar) or within a short distance of this topographic boundary (Ta Prohm Bati). Vat Nokor sits in an interesting position as it is on the boundary of the Siem Bok catchment and has direct access to the Mekong River. The position of Preah Vihear and Neak Buos suggests that this practice occurred earlier than the 12th century, however, the catchment boundaries are attributable to the location of the Dangrek Range and not the rivers running on either side of the escarpment. Whether these sites were placed at these locations as to take advantage of both catchments is a subject for further investigation.

In summary, it appears the placement of main Angkorian sites is directed not only by the presence of a water course, but also to its position within the broader hydrological network defined by the catchment. There is a general trend for main sites to be situated within the middle of the catchment prior to the 12th century; during the 12th century there appears to be a shift toward placing sites on catchment boundaries (Beng Melea, Banteay Chhmar, Vat Nokor).

Communication Zones

A second application of data derived from main sites is to map the maximum extent of influence for each king and compare the locations that were repeatedly held through time.

Generally, mapping the extent of control during the Angkorian period has focussed on the distribution of dated inscriptions (e.g., Parmentier 1916; Stark 2006). The study of extent here differs in two ways. First, by selecting temples which are within the 'heartland' of the Angkorian Khmer represent the 'administrative or core interaction boundary' (see Marquardt and Crumley 1987:9). The second difference, following Smith (2005) who demonstrated the need to identify internal workings and not just formalized boundaries, is that these extents are viewed as maximal areas of administrative communication, but not necessarily complete control, for each king. These areal extents are referred to as communication zones.

Mapping Communication Zones

Internal communication zones are based on the notion that kings sought to maintain contact with their provincial centres. Measurement of this influence is derived from evidence of architectural construction/modification in addition to recorded historic contact (i.e., inscription mentioning the king or his deeds) at the site. The extent of a king's reign is therefore measured by the area described by his most distant contacts in the landscape (Figure 9.1b). The process of identifying shared areas in the Angkorian territory held through time involves overlaying the extents of each king and 'cutting' out shared locations in space. A more detailed description of the method used in GIS is outlined in Appendix 3.

Zones are examined in relation to the transport network using two interrelated approaches. The first approach is a comparison of the size and location of each king's reign, or communication zone. This provides the amount of space for each reign that could have communicated across as well as identifying the geographic focus of a king's architectural and inscription activities. By overlaying the Angkorian roads on top of this data we can compare when the communication zones of each king included the location of the known road system. The second approach is to identify communication zones shared by multiple kings (see Figure 9.1b). The value of investigating shared communication zones is to identify the regions in the Angkorian territory that would have been most and least incorporated. From this investigation we can identify whether kings before Jayavarman VII would have had regular communication within the area of the known road system.

Area of Communication Zones by Reign

The sizes of the communication zones (Figure 9.4) remain relatively small until the beginning of the 11th century with the accession of power by Suryavarman I. The areal extent established by this king is only surpassed by the area associated with the constructions of Jayavarman VII. The fact that the areas, outside that of Jayavarman VI, remain fairly consistent suggests that communication between sites was well established from at least the mid-11th century.

Communication Zones and Roads

The spatial distribution of each king's communication zone is presented in Figure 9.4. Prior to the 9th to 10th centuries, kings tend to focus their attention northeast from Angkor until the reign of Suryavarman I. The extent of the communication zone of each subsequent king largely copies this same area, while after the death of Jayavarman VII the area ascribed to Indravarman II shows a dramatic decrease in size. In relation to the Angkorian roads, we find that the earlier kings would have communicated over the Northeast and Northwest routes. Not surprisingly, the zones defined by Suryavarman I, Udayadityavarman II, Suryavarman II, and Jayavarman VII include all or the majority of the road system.

Shared Communication Zones and Roads

By overlapping the communication zones it is possible to show where the majority of Angkorian kings focussed their attention. Figure 9.5 shows the distribution of shared zones for categories divided into 1-3, 4-6, 7-9 and 10-12 kings. The 1-3 king category, which includes the Battambang sites and slices along the Mekong River, corresponds with the pre-eminent rulers of the 11th to 12th centuries (e.g., Suryavarman I, Udayadityavarman II, Suryavarman II, Jayavarman VII). The area defined by 4-6 kings is the largest shared communication zone and includes large parts of the Khorat Plateau as well as sections further south along the Tonle Sap and toward the Mekong Delta. The following category of 7-9 kings shows a definite, and logical, shift toward the region around Angkor and the northeast. The emphasis on the northeast in the category of 10-12 kings further demonstrates the importance of this region to the rulers of Angkor. While this region experienced the greatest concentration of communication activity the periphery of the Angkorian 'heartland' shows that it was important only to a few of its kings.

The contrast between the location of the Angkorian roads and shared communication corridors raises several important points (see Figure 9.5). The most obvious is that the majority of Angkorian roads (e.g., Southeast Upper, Southeast Lower, Northwest, parts of West and Northeast) fit within the communication zone of 4-6 kings. Perhaps more interesting is that the East and majority of the Northeast fit within the zone held by 7-9 different rulers. Only the distant edges of the West and Northwest roads are found within the zone shared by 1-3 kings. Overall this suggests that the roads, or at least the routes, would have been part of the operational realm of several kings, and not just those who are attributed with great expansions of territory. Interestingly, the zone shared by the majority of Angkorian kings – that connected Angkor to the region of Preah Vihear – did not overlap with any roads.

Communication Zones: Discussion

The changing distribution of zones shows two patterns of communication that pre-date the reign of Jayavarman VII. During the first two centuries of the Angkorian period there is continual emphasis on the northeast part of their territory. The importance of this region has long been recognized by Angkorian scholars,

> Champassak (southern Laos), was to remain the mystical source of Angkorian power, the place erected by the Angkor kings for their pilgrimage, more important in a sense than the former patronage of the Fou-nan… (Groslier 1986[1973]:39).

The second pattern is the dramatic increase in size and location of zones in the 11th century with the works of Suryavarman I. Spatially, this new region includes considerable expansion west and southeast of the Tonle Sap Lake and also across the Dangrek into the Mun River catchment. This pattern appears to be the footprint for Suryavarman I's major successors, including Jayavarman VII.

By comparing the individual and shared zones with the location of the road system it is possible to evaluate the relative temporal sequence and also the importance of each of the regional roads. The chronology of the roads based on the individual communication zones can be summarized by the following ranges,

- Northeast route – 9th to 13th centuries

- East route – 9th to 13th centuries
- Northwest route – 10th to 13th centuries
- West route – 11th to 13th centuries
- Southeast route – 11th to 12th centuries

This data supports the notion that routes could have been incorporated into the Angkorian transport realm at different times. It also shows that each of the visible roads would have been part of Angkor's realm for at least a century prior to the arrival of Jayavarman VII.

Historical Events

Ispahani (1989:6) argues that the history of routes illustrates the impact of war and trade on regional evolution. Conversely, if we use the evidence of foreign actions such as war or political relationships we should be able to identify the history of routes. The third approach utilizes the historical evidence of Angkorian conflict internally to quash rebellion and externally to attack foreign states to identify directions of imperial transportation routes. By comparing the straight-line connections between Angkor and the intended destination with the road network we can provide a range of dates for when certain routes may have been taken (Figure 9.1c). Since military expansion requires considerable logistics to mount and move we can expect that they either established or followed an existing route. A sample of 17 historic records (Table 9.1) of Angkorian activity from Khmer, Vietnamese, Cham and Chinese sources are chosen as they commonly appear in the literature and each has an identifiable end point or region. The directions are based on an 'as-the-crow-flies' principle and are compared with the location of the roads. If the event could have taken more than one route (e.g., Vijaya could be reached by East or Southeast) both roads are included in the discussion.

Events

The events are divided into four maps for the 10th, 11th, early 12th and late 12th-early 13th centuries (Figure 9.6). The earliest events from the 10th century show communication toward the east, including the movement of the capital from to Koh Ker by Jayavaraman IV in 922 and back to Angkor by Rajendravarman in the 940s. During the 11th century there is a marked expansion of the number of imperial forays and a much greater diversity in their destinations. By contrast with the two earlier centuries which were largely restricted to regional interactions, the activities of the 12th century kings Suryavarman II and Jayavarman VII show a deliberate and substantial focus on military activity involving foreign territories. For both kings the coastal states of Champa and Dai Viet were their primary target as evidenced by the repeated incursions into these areas (Michael Vickery, pers. comm., November 2006).

Events and Roads

Several important points can be raised from the distribution of events and the regional Angkorian roads. Beginning in the 10th century, the movement of power to Koh Ker strongly suggests that part of the Northeast and sections of the East roads were in use. The scale of this action, from a transport perspective, would likely have involved at least a partial movement of the population who would be required to assist with temple construction and agricultural activities. At this time we also see the first incursion towards the Cham capital of Vijaya. The route taken to reach that city may have followed the same line as either the East or Southeast roads, however, neither of these roads extend past the Mekong River. BP Groslier suggested that the Southeast road (Upper) was the route taken by Jayavarman VII to reach Champa (1973:117).

The 11th century map (Figure 9.6) shows a clear overlap of the projected historical directions and each of the mapped Angkorian roads. While direction alone suggests that the routes were developed at this time, the argument is strengthened by the majority of these events being rebellions whose proposed terminus is within the administrative core of later Angkorian kings. The establishment of Preah Khan KS as an outpost on the frontier with Champa, suggested by BP Groslier in the 12th century (1986[1973]:40), fits with the historical developments presented here. The absence of a formalized road leading out of Preah Khan KS is perhaps the best argument that a different route (i.e., Northeast, Southeast roads) was used to reach the eastern territories.

The reigns of Suryavarman II and Jayavarman VII see a marked increase in attacks on foreign states mostly toward the east. Both kings focussed efforts against the Cham and Dai Viet and may have taken any or all of the Northeast, East, and Southeast roads to reach their destinations. The naval assault on Dai Viet by Suryavarman II recorded in the Vietnamese histories suggests that water transport may have played an important role in supra-regional (and possibly regional) transport at this time. Michael Vickery (pers. comm. November 2006) has suggested that the details of this inscription must be reviewed to assess the degree to which Angkor utilized sea-craft and identify the starting point of the assault. This event is therefore divided into two potential routes, one travelling to the southeast and a second heading east from Angkor.

Events and Roads: Discussion

Comparison of the historic events with the regional roads shows that Jayavarman VII's primary interests abroad were directed eastward. The fact that he and Suryavarman II were able to mount so many attacks on foreign states suggests that the infrastructure was already in place or was established locally during the early 12th century. The historic data show us that the Angkorian roads may have been most active during the following periods:

- West route – 11th century
- Northwest route – 11th century; early 12th century
- Northeast route – 10th century; 11th century; late 12th century
- East route – 10th century; 11th century; early 12th century; late 12th century
- Southeast route – 11th century, early 12th century

Overall, it appears that the regional roads would have been established as routes by the 11th century and continued in use in subsequent centuries.

Summary of Road Chronology

Combining the three approaches to road chronology together (Figure 9.7) we can assess to what degree the transport system may have been in place before Jayavarman VII and identify phases of development for the routes. Several key features support a pre-Jayavarman VII development of this system. The first indication is that sites appear on the West, Northwest and East routes during the early 11th century; the temples on the Northeast and Southeast actually have their beginnings in pre-Angkorian times. Perhaps more importantly, the Northeast and Southeast roads are associated with sites that are pre-Angkorian in origin. Moving into the 12th century there is a repeated appearance of site modifications and a dramatic increase in historic events that would have relied on the eastern communication corridors. This pattern is repeated during the time of Jayavarman VII. Overall, Figure 9.7 shows that most site construction and events occurred before Jayavarman VII. The key implication is that Jayavarman VII was continuing the trends of previous kings and expanding/exploiting the established network. We should therefore be largely attributing the development of the maximum extent of the routes used by the 11th and 12th century kings to Suryavarman I with potential additions or embellishments made by Suryavarman II and Jayavarman VII.

While the overall pattern suggests that the majority of Angkorian communication corridors have their systematic beginnings in the period of Suryavarman I, the evidence of activity derived from site construction and events is far from homogeneous. An initial difference is that construction of temples along the western routes appears to coincide with events, most of which represent rebellions. Other than a single event in the 12th century the focus is on recurring modification of sites along the Northwest road. The eastern routes, however, show substantial variation in site modification and a significant increase in historic movements during the 12th century, particularly during the reign of Suryavarman II. Another important divergence is found along the Southeast route(s). By contrast with the other roads which have several episodes of construction or modification as well as historic events, the Southeast road is largely devoid of any building activity after the 10th century. If we follow Groslier's argument that the southeast route was taken to Champa then the road would have been regularly used during the 11th to 13th centuries. It is also likely that only one of these roads – towards Prasat Andet or Sambor Prei Kuk – was in use during this later time.

These differences merit discussion in relation to the smaller sites and re-investigation of the inscription data to bolster the historic events of the Angkorian period. The outcome of this analysis is that the provisional chronology of road/routes is as follows:

- West road – early 11th century established as route
- Northwest road – early 11th century established as route, definitely present by early 12th century
- Northeast road – possible route from pre-Angkorian period, Angkorian use begins in the early 10th and is consistently, but not excessively used to the early 13th century
- East road – early 11th century first established route to Angkor, but becomes more important during the 12th century
- Southeast road – possible route from pre-Angkorian period and is used largely as a transport system to reach other territories from mid 11th century.

The benefit of this approach is that it examines the temporal sequence of the roads independent of the information derived from the other transport infrastructure. We can now look at the data for resthouses and bridges within the newly derived ideas for the road chronology.

Resthouse Chronology

Within the current literature the resthouses represent the best-dated components in the Angkorian transport system. Broadly, the *temples d'étapes* are associated with Suryavarman II while the *gîtes d'étapes* are connected to Jayavarman VII. That being said, the majority of these structures have been dated by one or both of the following methods: association with an inscription or architectural/artistic style.

Temples d'étape Chronology

The temples d'étapes are dated to Suryavarman II based on stylistic similarities to the 'type' sites of Thommanon and Chau Sey Tevoda (Figure 9.8). Both of these sites are associated within the Angkor Wat style based on obvious architectural and decorative similarities with the temple of the same name (Parmentier 1948:112-113; see Boisselier 1952). However, neither they nor any of the other temple d'étapes have an inscription to support this association (Boisselier 1952:225). In his treatise on the dating Beng Melea, Boisselier argues that only Angkor Wat can be truly connected to this king (Ibid.:225). Part of the problem with dating these structures is their similarity in form to Suryavarman I and also Jayavarman VII core plans. The dating of the resthouse structures is further complicated by the fact that they share a similar architectural plan to the central enclosures of Ta Prohm and Banteay Kdei, which are linked to Jayavarman VII (Boisselier 1952:188; Cunin 2004:457-458). A recent paper by Southworth (2003) has argued that this chronology is incorrect and has gone as far as to say that Jayavarman VII might have built Angkor Wat. At present we must take Southworth's conclusion as conjecture, but it does raise the significant issue that the temple d'étapes (and most of the structures attached to Suryavarman II) have not been directly dated.

Gîtes d'étape Chronology

The *gîtes d'étape* found on the Northwest and East roads and in temple enclosures share a similar plan and have a 'direct' temporal connection through the Preah Khan inscription. This stele indicates that resthouses were built along three routes, with the route to Phimai being fitted with 17 resthouses. The *gîtes d'étapes* built on the Northwest road were connected by Coedès (1941) with these structures, even though the remaining resthouses have only been discovered in the past year (Im, pers. comm. January 2006). Unfortunately, the level of direct association ends here. The other roads fitted with resthouses listed in the inscription – 57 to Champa and 44 on a circuitous route – have not been identified, though Cunin suggests that the laterite *gîtes d'étape* found at Ta Prohm Bati may be part of the circuitous route (2004:352). The assumption is that the buildings on the East road correspond to those connecting to Champa (Jacques and Lafond 2004:289). This is problematic in two ways; first, is that it contradicts BP Groslier's suggestion (1973:117) that the Southeast road was used to reach Champa; perhaps more importantly, there is no evidence of a further 53 buildings past the last structure at Preah Khan KS. Also, the buildings listed in the inscription do not correspond to the sites where they are found today (i.e, Ta Prohm, Ta Prohm Bati, Preah Khan of Angkor, Preah Khan KS, Banteay Chhmar). While this may be attributed to the inability to correlate the Sanskrit names with temples, the fact remains that we have not been able to identify the location of these resthouses in the landscape.

The physical evidence that binds the *gîtes d'étapes* together are their plan and, in two instances, an association with roads. Two important differences are immediately identifiable from an archaeological perspective, which suggests multiple phases of construction. The most obvious difference is that the Northwest buildings are all made of laterite, while the East and enclosure *gîtes*, with the exception of Ta Prohm Bati (Cunin 2004:174), are made of sandstone. A second difference is that the sandstone examples are more finely constructed and have significantly more decoration – specifically the Lokeçvara image in the fronton above the doorways and repeated representations of the fly whisk-bearing apsaras in the alcoves. Again there are exceptions to this rule as the example at Banteay Chhmar is actually quite poorly built compared to its counterparts at Preah Khan or Ta Prohm within Angkor. Boisselier also raised an important point that Kuk Top Thom is located within Beng Melea, which dates roughly to Suryavarman II, and therefore makes it the only *gîtes d'étape* not built within a temple established by Jayavarman VII (1952:218). Another important point related is that the sandstone examples connecting to Preah Khan KS do not extend past Beng Melea towards Angkor. In a further complication of the dating issue for these 'houses with fire', Jacques has argued that one of them is attached to Suryavarman I, though he does not list the temple that he refers to in the text (Jacques and Freeman 1997:269). While significantly more work is required to elucidate the architectural differences with these structures it is possible to follow Stern (1965) and Cunin's (2004) division of the main temples of the late 12th to early 13th centuries to suggest that the *gîtes d'étapes* represent several phases of building.

Based on the number and location of the *gîtes d'étape* on the Northwest road we can assume that they are the same structures mentioned in the Preah Khan inscription. The fact that they are made of laterite corresponds with Jayavarman VII's hospital chapels, which are contemporaneous examples of empire-wide building construction in this same material. This places the laterite examples firmly within the last few years of the 12th century. As the sandstone buildings do not conform in either number or location to the inscription it can therefore be argued that they represent a different construction phase. Following Cunin's (2004:451) framework for the different building phases of Jayavarman VII, if the *gîtes d'étapes* found within enclosures, such as Preah Khan (4th model), Ta Prohm (4th model), Preah Khan KS (2nd model), Banteay Chhmar (2nd model, 4th model), Ta Prohm Bati (3rd model), were built at the same time or subsequent to the temple they would represent different episodes within his reign. The exception to this rule of *gites d'étapes* found within Jayavarman VII enclosures is again the resthouse at Beng Melea which is attributed broadly to Suryavarman II.

Summary of Resthouse Chronology

The simple division into Suryavarman II and Jayavarman VII phases of resthouse construction remains the most readily identifiable temporal association based on the current data sets. While there are substantial issues that need to be sorted out for the entire dating sequence of all the early 12th century structures, the structural similarity between them indicates that they are probably part of the same phase. During the period of Jayavarman VII there appears to be a marked distinction between the laterite buildings corresponding to those described in the Preah Khan inscription and the sandstone examples that line the East road. Further divergences in the temple enclosures suggest that the plan of the resthouse was much more broadly applied within the late 12th to early 13th centuries. While it is somewhat dubious to base the date on the number of structures in the inscription, I would argue that the laterite buildings can be reasonably dated by the Preah Khan inscription and that the sandstone examples either pre- or post-date their construction.

Bridge Chronology

The dating of the bridges is less obvious than the resthouses as there is no direct inscription information. The generally accepted story is that the laterite bridges are constructions of Jayavarman VII; Parmentier suggested that this king was responsible for many of the modifications of the road network including the bridges (1948:120). From these early comments, which may have been attributed to inferences based again on the Preah Khan inscription, bridges have become permanently associated with Jayavarman VII. This proposition is illustrated by a comment made by Boisselier which associated this king with the bridge construction,

> Tous les ponts connus semblent avoir été construits sous le règne de Jayavarman VII encore que l'epigraphie n'y fasse pas allusion (1966:107).

In the last two decades, there have been minor shifts in the placement of bridges within the reign of Jayavarman VII. Dumarçay's (1992) discussion of the rapid alteration of the water management system pushes the bridges into the 13th century part of Jayavarman VII's reign. He argues, using the model of Spean Thma to the east of Angkor Thom (which is constructed from parts of a 13th century temple!), that bridges would have been made of wood on a laterite skirt and then replaced with stone (Ibid.:133-134). All bridges are built on top of this kind of laterite base, however, there is little to attribute the bridges to the 13th century. Bruguier (2000) argued against Dumarçay's temporal model and says that the bridges found along all of the Angkorian roads were Jayavarman VII's response to the supposed Cham attack on Angkor in 1177 when the wooden structures were likely burned. While this is an interesting idea, the fact that the sacking of Angkor is now historically questioned and that stone bridges are found on all of the Angkorian roads complicates this explanation. More recently, Jacques has argued that the stone bridges found between Koh Ker and Beng Melea show the importance of the Northeast road during the 13th century (Jacques and Lafond 2004:196). Again, this is based on an assumption rather than a specific line of evidence. Groslier (1973:118) takes a moderate perspective suggesting that Jayavarman VII may have constructed some of the bridges, and is more likely to have contributed the naga balustrades.

Dating Stone Bridges: Archaeological Perspective

No direct comprehensive or comparative analysis of the construction of the material or technique has been undertaken on the stone bridges. Following the argument that laterite construction dominated Jayavarman VII's early building programme – as seen in the resthouses on the Northwest road and the hospital chapels – the bridges could easily fit within this time period. Laterite, however, has been commonly used as a building material for hydraulic structures around Angkor since the early 9th century, such as the Krol Romeas on the East Baray and Bam Penh Reach, the large sloping laterite platform associated with the Siem Reap offtake down to the East Baray (Fletcher et al. 2006). The only admission in the literature that the bridges may predate the late 12th century was made by BP Groslier who argued that Jayavarman VII is most likely responsible for the naga balustrades bordering the bridges (1973:118) and therefore the bridges may pre-date this king.

Dating Wooden Bridges: Archaeological Perspective

Evidence of wooden bridges has yet to be verified in an Angkorian context, however there is substantial data indicating that wooden structures were commonly built in a variety of contexts (Cunin 2006; Greater Angkor Project 2006). The only 'direct' evidence is the depiction a floating bridge from the Bayon bas-reliefs and the possible reference in the Phnom Sres inscription, however the association with this bridge being wooden is largely conjecture (Michael Vickery, pers. comm. April 2007). From a logical perspective we cannot doubt that wooden bridges were regularly used to cross water courses before, during and after the Angkorian period. The fact that many crossings along the Angkorian roads do not have stone bridges (see Chapter 8) raises the issue of whether these locations only used wooden bridges.

Bridge Chronology Summary

From a purely technological perspective it is safe to suggest that wooden bridge building pre-dates stone construction. The fact that the stone bridges are not mentioned in any of Jayavarman VII's inscription indicates that either bridges were not yet built, were not built by him, they were not important enough to be included in his records or that we have lost his records on this topic. Obviously, the sample of historic evidence we have is only a partial record, however, given the number of inscriptions (68 [Coedès 1966]) attributed to Jayavarman VII, it is important to note that transport is never mentioned. Construction of larger bridges, such as Spean Toeup and Spean Praptos, should conform to a period when the roads were well-established, sufficient resources in manpower and resources to build and maintain them were available, and there was a specific need for a permanent crossing. Using this logic we could attribute the stone bridges to the reigns of

Suryavarman I, Suryavarman II or Jayavarman VII. Following Groslier's assertion that the naga balustrades are the only direct evidence of Jayavarman VII the bridges may therefore date back to the early 11th century.

Tank Chronology

Connections between tanks and roads were demonstrated in the spatial analysis in Chapter 8, which showed that tanks are regularly found near roads and several are built directly onto the embankment. Further evidence is provided by the historic data, with the obvious construction of the state *baray* at main sites and also the mention of tanks as part a local road building programme in the 11th century (Coedès and Dupont 1992[1943]:213; Jacques 1968:616-617). Other evidence relating tanks with the Angkorian period is the co-appearance with local temples and the general conformity to an east-west orientation of their long axis. This latter characteristic is a dominant feature of most Angkorian building projects. Other than these associations we have no direct evidence to determine when they were built and how long they were used. Many of these structures continue to be used today.

Clarifying the Issue of Jayavarman VII

A comparison of the chronology of resthouse and bridge infrastructure with the proposed dates of the Angkorian routes (Figure 9.10) shows both continuity and contrast. The dating of the resthouses is largely unaltered in this new model. Regardless of the potential issues of the overall architectural chronology, the *temples d'étapes* conform to the overall plan and layout of buildings constructed during the reign of Suryavarman II. The *gîtes d'étape* remain associated with Jayavarman VII, through association with the Preah Khan inscription and his temple enclosures, but the different types suggest at least three different phases of building within the Bayon style period (see Cunin 2004:451). At this stage it is not possible to say whether the sandstone buildings came before or after the laterite examples associated with the Preah Khan inscription.

The evidence for the bridges, however, suggests a wider temporal distribution than currently held in the literature. Placing the bridges within the context of regional movement, there is a strong indication that some of these structures pre-date the period of Jayavarman VII. The amount of activity on the East road, starting in the early 11th century and increasing through the 12th century with the appearance of the *temples* *d'étapes*, strongly suggests that bridges must have been in place. Because the Angkorian engineers were well-versed in water management structures from the 9th century onwards we also cannot discount an even earlier date for the first appearance of stone bridges. Until we find evidence of wooden bridges we have no idea of when such bridges were first used or where they were built. The only indication for different phases within the bridges, following BP Groslier, is the addition of naga balustrades by Jayavarman VII. These structures may also date to any part of the king's 50 year reign. Unfortunately, tanks lack any direct temporal association which this is regrettable as they represent the most prolific component in the Angkorian transport system.

The models presented above show that the initial routes have their origin in the early 11th century. Interestingly, this point is substantiated by Jacques who suggested that the inscriptions of Suryavarman I show the king's investment in the country's infrastructure. In particular he notes,

> The fine road from Angkor to Preah Khan of Kompong Svay springs to mind, and there are bridges, travellers's shelters and numerous water tanks throughout his empire (Jacques and Freeman 1997:134).

The massive building activities of Suryavarman I throughout the Angkorian territories strongly suggest that the basis for the transport system were solidified during this time. If not Suryavarman I, the activities of his namesake during the early 12th century must be considered as having contributed a similar amount of interest in facilitating regional and international communication. This is not meant to completely neuter the activities of Jayavarman VII, which were perhaps the most impressive of any Angkorian king. He built the laterite *gîtes d'étape* resthouses and likely modified the roadways to facilitate his internal and external activities. But it is important to note that in strict historical terms the inscriptions make no claim that Jayavarman VII built the roads – only that he added infrastructure.

The objective of the assessment in this chapter has been to downplay the reliance on a single inscription that has masked the fact that large-scale regional communication took place long before Jayavarman VII arrived on the scene. Like any other global empire, the concept of development needs to be introduced within our study of the Angkorian transport system. The Roman and Indian road networks were the subject of repeated developments over time. It is interesting to note that many of the developments, especially in the Roman period, took place during times of relative stability, economic growth, and as means of formally expanding the boundaries of an empire. Each of the reigns of Suryavarman I and II and Jayavarman VII, and possibly the later kings of the 10th century, can be attached to comparable eras of political and economic development in the Angkorian period.

Summary

This discussion has been directed toward testing the claims that the Angkorian transport system is largely attributable to the reign of Jayavarman VII. Using three different tests based on historic data it appears that there were multiple phases of development. The results derived from the construction sequence of main sites and distributions of historic events indicate substantial movement within the regions of the regional roads from the 11th to the 13th centuries. This result suggests that our reliance on the single Preah Khan inscription is over-stated and must be re-evaluated within the context of this new information. An important point of this investigation is that these tests refer to the establishment of the route, and not necessarily the road. Direct testing of the roads and infrastructure must be completed in order to determine when the roads were formalized. The historic evidence, however, strongly indicates a pre-Jayavarman VII establishment of the terrestrial transport system.

Chapter 10. Transport in an Imperial Context: Geographic Resources and Angkorian Settlement

> For too long have people talked about the megalomania of the kings or insisted on the importance of the cult in the construction of Angkor…the building of a city and dedication of a temple must be connected to the increase in resources
>
> BP Groslier 1997[1974]:113

> We have found here a society in total harmony with its geography, or, rather, deriving all the possible advantages from its natural environment, or more exactly still, extracting the best possible system from the country, given its means.
>
> BP Groslier 1986[1973]:40

The final application of the operational approach in this thesis is directed toward identifying the role of transportation in relation to the imperial requirements of the Angkorian empire. The above quotes by Groslier set the stage for this investigation by outlining two key points. First, that the Angkorian empire required access and control over resources in order to maintain its day-to-day operations and secondly, that the Khmer would have had sufficient knowledge of their surroundings to locate these resources (e.g., metals, strategic locations, sacred locations). In the past, the role of Angkorian roads has been dominated by military and religious explanations based on a combination of textual information (e.g., military activity, Preah Khan Inscription) and connected archaeological remains (e.g., resthouses). In order to expand our understanding of the transport system function we must literally look beyond the roads and infrastructure to consider why the end points, the major sites, were placed in the landscape.

By incorporating the theories of imperial control identified in Chapter 4, it is possible to investigate the relationship between sites, transportation and the three classes of economic, political, religious resources. A fundamental argument of this chapter is that the provincial sites played a key role in the broader imperial system. It is argued that the location of a major site may have been guided by the proximity to an important resource. As such the spatial locations of large settlements are examined in relation to the need to supply specific goods (e.g., precious goods, agricultural surpluses) for the local network or maintain control over geographic locations (e.g., hills, catchments, sacred places). GIS is again used to integrate these multiple data sets and also analyse the distribution of and distances between these cultural resources and the major sites. By comparing the relative resource potential of each site with the trace of the regional transport system (e.g., roads and rivers) it reflexively provides new perspectives about imperial settlement policies and transportation needs. This chapter concludes by investigating the role of sites connected to each of the Angkorian roads and also the presence of sites that would have relied on the river or secondary road systems.

Current Function of the Angkorian Transport System

The role of the Angkorian transport system is derived largely from historic interpretations of the archaeological remains. The road system in particular has been ascribed religious and military functions and, to a lesser extent, to trade.

Religious Ways

The religious association of the Angkorian roads relates to the movement of pilgrims both to and out of Angkor. As the hub of all the regional roads, Angkor would have acted as a destination for elite and local travellers. Further evidence supporting religious activity is the presence of the resthouses. Prior to the translation of the Preah Khan inscription, the regularly spaced *gîtes d'étape* were seen as way points for pilgrims between Angkor and its provinces (see discussion in Chapter 7). Subsequent arguments about their function changed with the translation of the Preah Khan inscription from serving regular travellers to being exclusively a home for the gods, and as a shelter for the procession of a 'sacred fire' undertaken by the Angkorian king (Jacques and Lafond 2004:388). Regardless of who was sheltered by these buildings, there is evidence that some form of religious-based communication took place on the Angkorian roads.

Military Roads

Angkor's roads are also commonly connected with facilitating military activities. This argument is substantiated by the recurring description in the inscriptions of invasions, rebellions and sacks throughout the Angkorian period (see Chapter 9). The fact that roads are raised above the flood level and are fitted with stone bridges within a set distance of Angkor is seen as enabling the army with year-round access to its provinces (Parmentier 1948:120; Bruguier 2000:542). Bruguier further suggested that the major sites set up by

Suryavarman I and II became walled garrison towns on the periphery of Angkor by the time of Jayavarman VII (Ibid.).

Trade Routes

The role of Angkorian roads in facilitating trade is often mentioned but rarely evaluated in detail. Evidence for the translocation of economic goods appears regularly in the Khmer language inscriptions in the form of tax collection (e.g., rice) and gift-giving over local and regional scales. Industrial goods and precious metals would have been an important part of this economic scheme (see Bronson 1992). The fact that Preah Khan KS is situated near Phnom Dek, the largest source of iron in Southeast Asia, suggests that specific economic requirements were influencing the establishment of major sites. The practical range of goods needed to establish a site, such as building materials (sandstone, wood), vessels for storage and cooking (pottery), and food (rice, fish) to support the local populace have been mentioned, but never directly evaluated in relation to specific roads. An exception to this is Welch (1998) who suggested that trade was occurring along the Northwest road. His surveys in Thailand noted the recurring presence of ceramic production sites along the roads, and he also raised the possibility of salt-salted fish exchange between Angkor and Phimai roads (Ibid.:214-216).

Rivers

By contrast with roads which were constructed between locations, the river system is often seen as the catalyst for settlement. Groslier argued the importance of rivers in defining settlement and by the 11th century the Angkorian kings had established centres on most of the major river routes (1997[1974]:141). Rivers have since been included in discussion of trade and the movement of economic goods. Since this network ultimately connects to the broader regional riverine and oceanic systems the variety and quantity of goods moved along them was likely to be extremely important. Hall noted that the Ban That inscription of Jayavarman VI includes reference to barges being used on the Mekong (1985:173). Rivers also acted as channels for military activity. The war canoes depicted in the bas-reliefs on the Bayon and Banteay Chhmar suggest that the river and lake system served as strategic routes for mounting attacks.

Regional Approach: Access to Cultural Geographic Resources

The perspective advocated here is that the Angkorian transport system served multiple purposes and, as illustrated in Chapter 9, developed throughout the Angkorian period. To expand our understanding of this system we need to consider why the end nodes, the major Angkorian sites, were placed in the landscape and developed. The basic argument is that sites are not placed randomly in the landscape. Berry noted that the location of primary Roman centres was based on specific factors, such as proximity to resources, and that secondary sites were more dependent on distances (1987:552). Initial settlement was directed to establish access to important resources, and later sites therefore are placed to meet specific demands of transportation. We need to investigate whether the location of Angkorian transport system is laid out following similar principles. The fact that Angkorian resthouses are regularly spaced along two roads suggests an important resource (i.e., religious, economic) was being transmitted between the two end points of the respective roads. A study of the resource potential around the major Angkorian sites is a logical step in assessing the overall road function.

The spatial relationships between major Angkorian sites and three types of geographic resources (e.g., economic, political, religious) need to be investigated. These geographic resources are modelled after the imperial requirements discussed in Chapter 4 and represent specific locations (e.g., hills, deposits) or areas (e.g., soils). It should be noted that this approach is not concerned with the specific nature of economic transaction (i.e., market economy, command economy, etc.) or political activity. Instead the objective is to analyse the spatial relationship between sites, resources and transport on a regional scale through the contrast between distance and access. Evaluating the proximity of the Angkorian sites will also indicate whether the major sites were situated to directly control resources, limit access to them, or, in the case of economic commodities, to act as primary distribution centres. While the emphasis of discussion is directed primarily toward the road system, access to the river is also important specifically as it would have more easily facilitated movement of bulk goods.

Access and Distance

Some basic definitions of access and distance in the Angkorian context are necessary for evaluating the role of resources in the question of the broader transport system. Following the work of transport geographers in Chapter 2, access is determined by defining the study area and selected locations, selecting the mode of transport and establishing the distance measure (Robinson 1977:73). The distance chosen for this investigation, 25 km a day, is based on the average distance of the resthouses (Groslier (1997[1980]:204). General topography would normally be an important factor in assessing the distance that can be travelled in a day, however, apart from the few mountains in the Tonle Sap basin and the Dangrek range the landscape is dominated by low relief.

Economic Resources

Economic resources are the sources of material goods commonly used to fuel the activities of the empire (e.g., iron needed for tools, cereal production for maintaining populations). The classes of economic resources to be investigated are subsistence – rice, salt, fish – and industrial – iron, copper/ tin, gold/silver and precious gems. Each of these resources can be localized in the landscape using modern information and their distances measured to the nearest major Angkorian site. Given that the resource locations are restricted to the most visible in the landscape it is argued that a site placed in proximity to this location (within 25 km) may have known of its existence and could have been situated nearby to gain access to this location.

Political Geographic Resources

Political resources are locations in the landscape that are strategically important for maintaining control over access either into or out of an empire’s territory. From a transport geography perspective these locations are referred to as breaks and would require a shift from one transport mode to another (e.g., oxen to foot; boat to cart). Examples of political resources breaks include mountain passes and location within the river system (i.e., along a major river, on catchment boundary). A further political resource is the location of sites on top of hills or embankments that would serve as a watch tower over the surrounding landscape. The distribution of Angkorian sites in relation to these breaks, both on and off the road system, can be used to investigate the issue of territorial management.

Religious Geographic Resources

Religious geography as a resource is the most esoteric of the three cultural resources. The major Angkorian sites in this discussion are temples and therefore are imbued with latent religious importance. The question is whether the sacredness of the site is based on a natural feature in the landscape (e.g., spring) or an artificial construction (e.g., temple pyramid). Two natural locations in Hindu-Buddhist philosophy that have significant religious value are mountains and springs. The question in relation to the regional roads is whether they served only to bring pilgrims to Angkor or whether the end nodes on the system had some attraction either for Angkor's kings or Khmer population in general. The evidence of resthouses, regardless of whether they served humans or gods, shows that religious perambulation was a major concern along at least two roads. By evaluating the topography of provincial sites it will be possible to assess the degree of 'religiousness' for each road.

Multiple Dimensions of Control and the Function of Angkorian Roads

These three types of geographic resources are not mutually exclusive; a site is likely situated in the landscape for several different reasons and the function of the road could and probably would shift over time. In the Angkorian context, for instance, a temple situated on top of a mountain may serve the dual purpose of religious sanctuary possibly representing the holy mountain in Hindu-Buddhist tradition, but also serve as a watch tower. By contrasting the various geographic resource types it is possible to assess overall patterns of settlement and the importance of communication within the Angkorian empire. This final section will also evaluate the potential roles of the roads, the sites that are connected by them and also discuss why so many sites are not connected by regional roads.

Economic Geography

The most basic geographic influence on settlement is the proximity to economic resources. Villages and towns that develop as centres of production might become the locus of exchange of products for other communities. As a result of the need for recurring transportation, routes often develop between the producing and receiving settlements (Cooley 1969:67). Resources that are deemed highly valuable will also see the placement of settlement in areas that would otherwise be completely uninhabitable because of lack of resources to support a local community (Ibid.:70).

As Knapp and Pigott (1997:301) noted, archaeologists have an impressive capacity for reconstructing the sequence of events, or *chaîne opératoire,* of ancient miners and metalsmiths. Instead of reconstructing the objects from the ground up the idea here is to take a top-down approach. We know the Angkorian Empire consumed specific commodities. The problem is to identify where they were produced and how they were transported into the regional system.

The process of analysing the spatial relationship of these resources involves two stages: 1) identify economic resources that played an important role in Angkorian society and are also mappable at the regional level; and 2) map and analyse the spatial distribution of these resources relative to the major sites.

Economic Resources: Angkor's Shopping List

Previously, economic resources have been only cursorily investigated in relation to settlement and broader issues of production in the Angkorian world. They have never been investigated in relation to transport. Higham raised the important point in the 1980s that there has been an absence of archaeological research aimed at locating centres responsible for surplus agricultural and industrial production, through identification of quarries, mines, iron and salt-working locales (1989:262). While work on individual resources in Southeast Asia has been published for resources such as metals (Bronson 1992; Pottier 1997) and salt (Nitta 1989; 1997; Welch 1984; 1997), the objective of this chapter is to redress the lack of integrated studies by examining the spatial distribution of a wide range of resources that were required in the Angkorian state.

The Angkorian empire produced and exchanged a diverse range of commodities for trade and tax in order to sustain itself and maintain power over distant regions. At the nexus of this system are the major temples which were active as collection and redistribution points for goods, specifically rice. A similar function is identified for the temples of the Vijayanagara period in India. The temples were positioned in the hinterlands to participate in the trade of metals, salts and specialized items collection of comestible produce from the immediate region (Heitzman 1987:810).

Our knowledge of these products, which includes numerous agricultural, mineral, and arboreal commodities, comes from a variety of sources including foreign accounts, inscriptions, bas-reliefs and archaeological remains. The account by Zhou Daguan provides one of the most-cited lists of goods produced locally and also identifies the major metals sought from Chinese sources in the late 13th century (Table 10.1). Zhou also noted that he was not aware of any local source of either gold or silver in Cambodia (Pelliot 1902:167). By contrast, the Portuguese explorers to Cambodian in the 16th century suggest a different list which includes,

> …gold, in alluvial deposits or in veins; silver, the mines of which are, according to Jaque, actively exploited; lead, copper, tin and alum. Argensola adds many details about precious stones which, according to him, were found in quantities. In fact, the common products of Cambodia are rice, cattle, and fish, obviously (Groslier 2006:116).

The number of potential resources is too vast to be discussed equally, therefore this study is restricted to those goods that can be more accurately recorded on the landscape (e.g., ore deposits, agricultural land) versus those that are more ‘mobile’ (e.g., wax, honey, spices). Categories of resources that are identified as highly valued or universally required can be grouped into comestible (rice, salt, fish) and industrial (iron, copper, tin, gold, silver, gemstones) commodities. Comestible resources are ‘living’ products used for maintenance of a population. In order for a settlement to continue at a location its community must have access to sufficient produce to remain viable. In the case of extreme abundance, the location may become an important distribution node in the system. For example, a site situated in ideal farming land may become an important exporter of comestible goods or livestock to lesser endowed regions. Industrial resources refer to metals and precious stones used to produce tools, weapons, in the decorative arts (i.e., jewellery, statuary) or included in foundation deposits. By contrast with comestible products these locations are defined by a specific point in space (i.e., mine) versus a broad area.

Several important resources are not included in this study because of their general source distribution, such as sandstone, laterite, wood, or are inherent mobile such as elephants, cattle, or honey. Of these products, only sandstone has been mentioned in a resource-procurement context, specifically the numerous locations along the edge of the Kulen hills east of Angkor (Doudart de Lagrée 1866; Lunet de Lajonquière 1911: xxiv; Boulbet and Dagens 1973:33-34). The projected use of water transport to move sandstone blocks has been mentioned since the initial surveys of the region (Lunet de Lajonquière 1911: xxiv) though its practicality was recently questioned by ethnoarchaeological tests undertaken by Goodman (2000). No detailed study of the forest products or animal resources from the densely wooded areas in north-central and eastern Cambodia has been undertaken.

Mapping Economic Resources

The location of the comestible and industrial resources was derived from a combination of modern data sets and integrated within the GIS. Compiled by various international organizations (i.e. United Nations ESCAP; Mekong River Commission) these data sets often emphasize sources that would be viable for modern purposes. As such there is a bias toward the larger sources and many of the smaller sources suitable for artisanal uses are not included. Since the Angkorian Khmer positioned themselves across most of Cambodia, southern Laos and northeast Thailand they would likely have been aware of the significant resource locations within their territory. Bronson suggests that mining of ores rarely involved digging underground and was normally restricted to panning from river sands, broken from outcrops or dug from shallow pits (1992:68). While these smaller sources will likely be missed it is argued that the larger sources are more visible and therefore would likely have been known in the Angkorian past. It should also be noted that the surface component of many deposits used during the Angkorian period may have been completely exhausted and would not show up on a regional survey. Because the nature of comestible and industrial resources is different, the types of information used to assess their appearance in this study will vary on an individual basis. The process of evaluating a site's access to these resources involves one of two principles: 1) straight-line distances between the site and resource, and 2) describing the land within a day's radius travel (25km) around a site.

Comestible Resources

Access to comestible resources is important as it provides the site with sufficient foodstuffs to maintain a population, and in the case of extreme abundance, supply other parts of the state. The three comestible resources included in this discussion are rice, salt, and fish.

Rice

Rice is the basic staple of Southeast Asian society and has played an important role in the development of the region (see Bellwood 2005). The production of surplus rice is linked to the sustained expansion of settled communities and is often viewed as an important mechanism in the rise of early states into the regional and interregional trade between South and East Asia (Van Liere 1980:269; Stark 2006:417). Portuguese accounts of the 16th and 17th centuries indicated that the abundance of rice made Cambodia 'one of the richest provisioning centres of Southeast Asia' (Groslier 2006:117). Numerous studies of

Cambodian rice production have since been published that attest to its importance in the local and regional economies (i.e., Delvert 1961)

As discussed in Chapter 6 rice was both the primary staple and one of the most important commodities used in exchange and taxation during the Angkorian period. Vickery argues that the pre-Angkorian movement towards consolidating Battambang, to the west of the Tonle Sap Lake, and its rice potential was a critical aspect of Angkor's later success (1998:318, 396). The importance of this relationship was noted on a broad-level by Georges Groslier who identified that Angkorian settlement in Cambodia was placed on land suitable for producing rice (1921:141-143). A first test of a site's resource potential is to systematically evaluate whether it was able to produce rice.

Rice and Major Soils

Defining what qualifies as suitable land for rice agriculture is dependent on the different types of rice agriculture (i.e., wet, dry, wild) and the physical characteristics of the landscape such as soil type, slope, drainage, exposure; all are important physical characteristics that can be measured (Hanks 1972:49). Since the purpose of this test is to compare the landscape around each of the primary Angkorian centres, major soil types based on current geological maps are examined within the 25 km radius of the site. This approach is based on similar principles employed in site catchment analysis as defined by Higgs and Vita-Finzi (1972). Using modern soils as an indicator of rice production in the past is deemed a valid method for assessing Angkorian settlement choices because the parent soils have not changed and there is little evidence of vegetation and climate change between the 10th to 19th centuries CE (see Dudal 2005). Micro-climate changes may have occurred, but large scale climatic differences that would have permanently altered the distribution of plants and animals are not evident from the Cambodian region (REF).

Distribution of Major Soils

The ratio of major soil types in the study areas (Figure 10.1) is predominated by a single type, acrisols. An acrisol is defined, broadly, as a soil with subsurface accumulation of low-activity clays and low base saturation and are suited to shifting cultivation of rice (Dudal 2005:98-100). Looking at distribution and ratio of soil types within the 25km radius of each site (Figure 10.2; Table 10.2) it is not surprising to discover that acrisols predominate. The exceptions are the three sites in the Battambang region which are situated in luvisols, and Vat Nokor which has mostly cambisol as the major soil type. Luvisols are described as young alluvium that is ideal for rice growing with irrigation (Ibid.). The Battambang sites are therefore better situated to produce rice than most in the Angkorian empire and it makes sense that kings such as Suryavarman I made such efforts to include it within his area of bureaucratic control. While the predominant soils around Vat Nokor (cambisols) are not suited to rice agriculture, there are also substantial areas of acrisol suggesting that rice could be grown in the immediate region.

The results from the comparison of major soil types show that major site settlement was positioned in locations suitable for rice production. While this supports Groslier's claim, when we look at the overall distribution of suitable soils it suggests that rice could actually be grown in most locations in Cambodia. The ubiquity of this resource indicates that other factors must have promoted or sustained the placement of major Angkorian settlements. We now turn to the other resources with the hope of identifying specific influences on Angkorian settlement.

Fish

Fish has been exploited within mainland Southeast Asia at least since the 2nd millennium BCE based on the discovery of fish bone and fish hooks at Kok Panom Di in northeast Thailand (Higham 2002:58). Within Cambodia the presence of the extensive fish resources in the Tonle Sap Lake have likely drawn settlement since the early Iron Age and earlier (Moore 1989; see Pottier 2005). The vast stocks of fish that come into the lake to breed during the reversal of the Mekong provide massive quantities of fish that today still provides the majority of protein for the country. During the Angkorian period, the vast volume and diversity of fish from the Great Lake was mentioned in the travel notes of Zhou Daguan (Pelliot 1902:169-170). Tangible evidence of the use of fish is presented in the bas reliefs of the Bayon and Banteay Chhmar which depict water courses teeming with fish and people grilling their catch on a fire (Vouen 2004). Fish remains, though difficult to find, have been identified both at excavations in Angkor Borei (Voeun 2003) and at Angkor (Pottier 2005:40). Groslier noted the role of the Tonle Sap in orienting Khmer settlement (1921:143). More specifically, he argued that it played a key role in enabling Angkor to rise to pre-eminence during the 9th century. Access to fish is a likely factor in the location of Angkorian settlement.

Distribution of Fish

Comparison of Angkorian sites with fish resources is based on two types of access. First is the distance to the Tonle Sap itself. Access is calculated as a direct connection between the site and the lake during the rainy season. As discussed in Chapter 5, the lake expands five-fold in the wet season, dramatically reducing the distance from sites. The second type of access is comparison of locations of current fish breeding from the Mekong River Commission reports (2005). While this makes a considerable assumption that fish stocks have not changed dramatically over the past 1000 years it is argued that the lack of major damming projects along the major river systems supports at least a basic comparison. It must be made clear that fish could have been obtained throughout the system; these locations represent the most visible locations for this resource.

Figure 10.3 illustrates the relationship between settlement and access to fish resources. Most of the sites situated around the lake are located at the edge of the floodzone, indicating that they would have direct connection to the fish stocks in the Tonle Sap for part of the year. A few sites, such as Phnom Srok and Sambor Prei Kuk are not next to the lake but are still within a single day's travel to reach the maximum flooded area. The data describing the locations of individual fish stocks illustrates that the Tonle Sap has substantial fish reserves; however the largest quantity are found up the Mekong River. A few sites appear near these individual resources, with Angkor Vat Phu, and Vat Nokor positioned near multiple locations. The occurrence of fish near Preah Khan KS is interesting given that is not situated close to the floodzone of the Tonle Sap.

As the 'fish bowl' of Southeast Asia, it is not surprising that the Tonle Sap Lake attracts settlement around all sides along the edge of its floodzone. Within the sample of Angkorian sites over a third are positioned to gain access to the fish stocks in the lake. The Mekong, which has a comparable quantity of fish migrating up and down its length throughout the year, is marked by a near dearth of Angkorian settlement. The fact that sites are not situated near this resources suggests that either easier to obtain fish from the lake, versus the flowing river, or that access to other resources (i.e., rice growing lands) took priority.

Salt

Salt, or sodium, is a vital part of the human diet. For inland agricultural societies, such as the Maya, where the food is dominated by largely sodium-free plants, mineral salts are needed to supplement diets and to add flavour to meals (Andrews 1983:1). Rice is among the least saline of cereal crops (Adshead 1992:38) and therefore the Angkorian Khmer would have required access to secondary sources of salt to meet their dietary requirements. A further issue in tropical zones is that hard labour would require substantial reserves to replace the salts lost through activity (Andrews 1983:1). The importance of salt for on an individual is matched on a societal level as lack of access or shifts in supply-and-demand have caused havoc in empires through time, often leading to warfare (Andrews 1983:1; see Adshead 1992). Salt in China had been imperially administered since the late 4th century BCE and has continued through to the present day (Adshead 1992:39-43). Zhou Daguan noted with surprise that the Angkorian kings had no restrictions on salt production (Pelliot 1902:170).

Within tropical Southeast Asia, salt has been ubiquitously sought after and traded as a commodity for over two millennia (Van Liere 1982:116). Production and control sites have been identified in northeastern Thailand at such sites as Non Dua during the 1st to 2nd centuries CE (Higham 1989:215). The location of Non Dua and the scale of industrial activity around the site suggest that its production far exceeded local needs and must have been involved in regional trade (Ibid.). Similar sites placed to control access and movement of salt have been recognized by Colani in upper Laos (Ibid.:229-230). Specific ethnographic studies of salt-making processes and excavation of salt-producing sites have been completed by Nitta (1989; 1997).

The importance of salt in Cambodia has been dated to the pre-Angkorian period with the translation of a text that refers to an impost placed on salt (Higham 1989:261; Vickery 1998:295). Within the Angkorian period we have historic and archaeological evidence attesting to the use of this mineral on a regional scale. Zhou Daguan noted that salt was obtained from boiling sea water or collected from mountains (Pelliot 1902:170). Welch's survey of archaeological sites in northeast Thailand identified several new sites dating to the Lopburi phase (1000-1300 CE) on the salt dome northeast of Phimai which suggests a historic increase in salt production in the Khorat (1998:216). There is also evidence of regional trade in salt from the early colonial periods. European travellers to Cambodia frequently mentioned that settlements around the Tonle Sap Lake were able gain access to the Delta region and its abundant salt supplies. In an interesting movement of economic resources, Bastian reported that people bought rice from Battambang to sell in Udong and returned with salt and ureca (2005:102).

Distribution of Salt

Figure 10.4 shows that Angkor – and Cambodia more broadly – is devoid of local salt. Recent geophysical tests of the soils around Angkor have shown that the saline levels are so low that it affects the application of soil conductivity tests (see Player 2006). The resources map indicates that the Angkorian Khmer would have relied on salt procured from the vast domes of the Khorat and Sakhon Nakhon basins (Jimreivat 1993:106; ESCAP 2001:96) and the evaporative salts produced in the Mekong Delta (see Martin 1993). The importance of salt in Khorat today can be seen in the presence of multiple factories and also the trade relationship between the plains villagers who produce and trade salt for the products collected by the montagnard peoples (Jimreivat 1993:111). These southern and northern sources may correspond to the two types of salt (i.e., boiled sea water and mountains salts) described by Zhou in the late 13th century.

Only Phimai is directly located within the general proximity of these salt zones. The correlation between this site and salt economy further enhanced by Welch's discovery of historic period sites on top of the salt domes. To the south the site of Phnom Chisor is, possibly de facto, the closest of the Angkorian site to the southern salt resources based in the Mekong Delta region. It is located much further from the location of salt, however,it, and possibly Ta Prohm Bati, likely played a role in its distribution up the Bassac River toward the sites around the Tonle Sap Lake. The lack of larger sites further south may be an indication of territorial issues for the Khmer kings with the Cham. If access to the salt resources in the delta were cut off by political conflict with the Cham, the Angkorian Khmer would have to resort to crossing the Dangrek to obtain sufficient salt for their population.

An interesting economic relationship exists between the access to fish and salt. The process of salting fish is common throughout Southeast Asia (see Le Roux and Ivanoff edited volume, 1993; Butcher 1996). Within Cambodia today the large proportion of salt is used in the conservation of fish to make *prahok* (Martin 1993:67). South of Angkor at the foot of Phnom Krom fish are still dried and then salted to make this condiment. As a result of the great quantity of salt and fish at either end of the Northwest road, Welch suggested that these resources would have been moved between the Tonle Sap and Khorat plateau (1998:214).While no direct evidence of this process has been identified from archaeological sources, the sheer volume of each of these important resources strongly suggests that it played a part in the past.

Comestible Resources Summary

Access of main Angkorian sites to the rice-growing land, fish and salt within a single day's travel is summarized in Table 10.3. This data shows that sites are at the very least situated near land that is suitable for rice agriculture. The only exception, Vat Nokor, has soils that are largely marginal but it would still be possible to grow some rice in the surrounding landscape. Many sites are also proximally located to the substantial fish resources of the Tonle Sap or isolated stocks nearby. It is interesting to note that sites are not connected to the roads appear to have greater access to both rice and fish reserves than those situated on the road system. This should not be surprising given that the function of the roads is likely to cross terrestrial space; the roads act to connect areas that are not directly linked by the river network or are more easily reached by land. A further point that shows the importance of rice and fish is that the rice paddies act as breeding grounds for fish. Salt is the only commodity that shows some evidence of specialization. The location of Phimai is directly situated to have access to many salt domes; though less strong evidence, the presence of two major Angkorian sites near the vast marine swampland of the delta suggests that they may have also played a role in salt distribution. Overall, the study of economic resources shows that Angkorian sites were largely well-suited to meet the food requirements of a local population.

Industrial Resources: Mapping and Analysis

Non-comestible materials such as metals and precious stones are another important class of economic resources that the Angkorian kings would have sought to control. These industrial resources were essential in the manufacture of tools and the accumulation and display of wealth, either through the creation of statuary or decoration of temples. Bronson argues that further to the general utility of metals, they are also valuable because of their inherent scarcity and many of them are extremely labour-demanding to produce (Bennett 1992:65). Four groups of industrial resources to be examined here are iron, bronze (copper and tin), gold and silver, and precious stones. This analysis is a follow up on the initial study of metal trade in Southeast Asia by Bronson (1992), which indicated that, beyond iron, the Angkorian kings would have been forced to import all other important metals (1992:98). Recent work has altered this perception of a nation bereft of local metallic resources. Pottier (1997) identified a lead deposit exploited during Angkorian times. Dagens's summary of Khmer civilization suggests that metals other than iron – gold, silver, lead and copper, exist in several locations in the Khmer lands, in the larger sense of the term, with exploitable deposits that may date to ancient times (2003:127). The object of this discussion is to pinpoint whether major Angkorian sites are found in proximity to these resource locations. Unlike the discussion of comestible resources the industrial commodities are at point locations which can be derived from geological maps and descriptions by Dottin (1971) and more recent summaries published in the ESCAP series[7] (1990; 1993; 2001). Direct distance between major sites and the resource is considered to be a sufficient indicator of potential access.

Iron

Iron was widely used in Angkorian times for making tools, utensils, weaponry and architectural supports (Boisselier 1966:352; Moura 1883:235). As indicated above, iron is one of the most visible metal resources in Cambodia. Historically, the two most discussed regions are the Phnom Dek between the Staung and Sen Rivers and in Battambang. The Phnom Dek is one of the most abundant sources of iron in mainland Southeast Asia and has been exploited in the both recent and distant past. Early French explorers noted that axes produced in the south of Cambodia were made from iron extracted from Kampong Thom province, near Kompong Svay (Bastian 2005:122). The people associated with manufacturing iron are called the Kuoy and their production techniques were first described during Harmand's travels through Preah Vihear and the Sen river valleys (1876:360). During this time, Chinese merchants annually made the journey from Stung Treng on the Mekong to the Sen river to exchange goods with the Kuoy for ingots of iron (Ibid.:348). Iron ingots were among the most common and valued forms currency across this region (Ibid.:347). The relationship between Preah Khan KS and this region has a long history in the archaeological literature. specifically because of the location of extensive iron-producing works within the sites main enclosure (Jacques and Lafond 2004:REF). Another source of iron frequently cited in publications is Battambang (Higham (1989:254; Vickery 1998:317).

[7] It should be noted that some of the sources have not been re-visited since Dottin's surveys and there is some variability between the description and geographic coordinates in these documents. Another issue that appears infrequently is the variable identification of resources on different maps of the same region. For this study, all sources were compiled together to give the broadest range of data.

Distribution of Iron

The largest concentration of iron sources is located to the east of Preah Khan KS, with the largest of these being the site of Phnom Dek (Figure 10.5, Table 10.4). Surveys of the Phnom Dek region indicate that superficial deposits at the site have been known for more than a thousand years, and it is suggested that the ore was intensively exploited from the 9th to 13th centuries (ESCAP 1993:33). Modern political reasons and lack of suitable transport routes to the area prevented large-scale extraction of iron which is estimated at 8MT (Ibid.). An interesting point is that Preah Khan KS is situated 30km awayfrom these sources. This may reflect the site's importance as a production and distribution centre. The location of Preah Khan KS at a distance from the actual source of iron has two potential explanations. First, is that the site is situated on the Stung Staung as it is the primary distribution mechanism for iron goods. The second explanation, which may be more likely, is that the iron producing Kuoy were responsible for the extraction of iron and transported it in some form to Preah Khan KS to be transformed or moved into the Angkorian economy.

The other significant concentration of iron is along the right bank of the Mekong to the west and northwest of the modern town of Stung Treng. While no Angkorian site was visible in the ASTER data at this location, it is important to note that Stung Trends played an important role at least within the pre-Angkorian [eopdtimes (Levy 1970). By contrast with these two regions, the import of iron from Battambang appears less obvious from the evidence of modern resources. The only source identified in the region is located 35 km upriver from Banon. This journey might be feasible but Bastian indicated that the Stung Sangker was only navigable one day upstream from Banon (2005:100). Two other sources that may have been important in site location are found near Angkor and Beng Melea. Small outcrops of iron were likely exploited by the Angkorian Khmer. Bronson suggests that superlative ore deposits are not necessary for determining major iron production, however if smelters have access to superior iron ores they will be able to make and sell better iron at a lower price (1992:75-77). Again, this points to the importance of the Phnom Dek and the industrial rise of the site of Preah Khan KS.

Bronze: Copper and Tin

Bronze and its component materials, copper and tin, has been exploited in Southeast Asia since at least 1500 BCE as tools, jewellery and most famously in the bronzework of the Dong Son culture (500 CE) (Higham 2002:113;175-176). Angkorian smelters for their part produced an immense amount of bronze items including jewellery, statuary and architectural elements (see Boisselier 1966:323-346). The importance of bronze objects is attested to by the presence of bronze pots in temple foundation deposits (see Pottier 1997) and numerous mentions in the Khmer language inventories of temples. Bronson argues that the massive market in Cambodia would have resulted in a ‘golden age for Southeast Asian copper production’ (1992:100).

Historically, copper was viewed as an import item .Zhou Daguan note that copper was not generally available in the late 13th century CE (Pelliot 1902:168) and this fact was also noted in the 16th century Portuguese reports (Groslier 2006:123). Bronson argued that copper was much less abundant than iron and very unevenly distributed in Cambodia (Bronson 1992:78). Tin was even less common in Cambodia however the concentrations of this metal along the Myanmar-Thai border have and continue to be the regions greatest material export (Bronson 1992:102).

Copper and Tin Distribution

Copper (Figure10.6; Table 10.5) is found sparsely across central and eastern Cambodia in deposits that are relatively small and have no modern economic interest (ESCAP 1993:21-23). Several scholars have pointed to specific locations of copper and to a much lesser extent tin. Groslier who noted veins of copper in Rovieng (Kampong Thom) and at Phnom Thmar Prak (Kampong Speu) (2006:117).Vickery lists copper deposits along the Mekong and eastern tributaries in Kompong Thom, Kratie and Stung Treng provinces and suggests that they would have been a boon for settlement (1998:316). With the exception of Kompong Thom, these locations are also identified in the ESCAP map. None of these sources, however, have a major Angkorian site situated near them. Preah Khan KS is the only site in Cambodia situated close to copper sources, one of which Phnom Pel, is located a mere 8km to the northwest of the site. By contrast with the Tonle Sap basin, there is a tremendous concentration of copper in southern Laos, including several near the site of Vat Phu. Three sources are located on the same side of the Mekong within two days travel from Vat Phu while there are at least seven further sources on the opposite side of the river in Attapoeu province (ESCAP 1990:11). An interesting point that can be made about copper at Vat Phu is that items made of this metal appear more frequently listed in its temple inventories than at any other site (Lustig database 2007). While it is difficult to make a direct correlation between these raw material and finished goods, the fact that copper is so common in both data sources strengthens this relationship. Tin sources within the Angkorian territory are extremely rare but it is interesting to note that Angkorian sites Vat Phu and Phnom Chisor are situated near the within a couple days'travel.

Gold and Silver

Gold and silver were extremely important metals in Angkorian society. Boisselier noted that while actual evidence of gold and silver is quite rare, there is substantial textual reference to support its value during this time (1966:352-353). In Southeast Asia, gold requires little extractive resources and is generally available in small quantities all over the region. The notion that there is no native gold or silver in the Angkorian territory dates back to the 13th century report by Zhou Daguan, who indicated that these metals were often brought in from China (Pelliot 1902:167). Understandably the value of gold has meant that it is rarely found in archaeological contexts; however it has been found in the form of jewellery and rings (Boisellier 1966:353) and in nearly all temple foundation deposits (Pottier 1997:400-401).

Bastian's travels between Bangkok and Angkor in the 19th century made numerous references to gold prospecting activities in eastern Thailand near Kabin, Vattana (Nakhon Wattana), and Muang Aran (Aranyaprathet) (2005:10,28,33). Within the modern boundaries of Cambodia, Bastian also described travellers around Svay Chek going to a prospect for gold at a location called Bo Sai (Ibid.:34). BP Groslier lists alluvial traces and traces of veins near Sisophon (Battambang), in Kampong Thom and at Bo Kham (Stung Treng) (2006:117). Recent studies, however, claim that the Angkorian kings were not in direct control of a source of silver or gold (Bronson 1992:83; Dagens 2003:115). Early French explorers in southern Laos noted numerous sources of gold in the region of Attapoeu and suggested that much of Cambodia's gold came from this region (Harmand 1876:349).

Distribution of Gold and Silver

The UN documents describe numerous small scale locations of gold throughout the northern half of the country (Figure 10.7; Table 10.6). The most important deposit in the Tonle Sap basin, Bo Sup Trup, is estimated to contain 6.6 tons of gold metal and the surrounding gold-bearing alluvium extends approximately 20 km^2 (ESCAP 1993:30). In addition to gold this source is said to have small veins of silver (Ibid.:38-39). Interestingly, the site of Banteay Chhmar is situated right in the middle of this zone.

Generally, these sites are deemed suitable for artisanal mining and many show evidence of old workings (Ibid.:29). A few sources of gold are found in the Phnom Dek region to the east of Preah Khan KS; the remaining sources of both gold and silver are generally too far away to suggest that sites were situated to control or distribute the small amount of metals produced at these locations. A possible exception is Vat Phu which, in addition to having a single source nearby, is situated near six substantial gold locales to the east in the province of Attapoeu (ESCAP 1990:10-11).

The fact that the Bo Sup Trup deposits are spread across a vast area near the surface suggests that the Angkorian kings may have been motivated by this resource to build Banteay Chhmar in that location. Vat Phu's strategic position at the western edge of the montagnard sources of gold in Attapoeu is another striking relationship, especially given the historic comments about the origin of Cambodian gold. Beyond the isolated source of silver in southern Cambodia it would appear that the Angkorian rulers would have relied on imports.

Precious and Semi-Precious Stones

The use of precious stones, such as sapphires, rubies, and quartz, have been found in both the foundation deposits of major temples and also mentioned in the Angkorian inscriptions (Lustig database 2007). Pottier's summary of the foundation deposits notes the presence of gems, quartz and pearls in twenty temples throughout Angkor (1997:400-401). The fact that we rarely find precious stones is attributable to the universal value of precious stones which would likely have been removed and/or curated for later use.

Distribution of Precious Stones

The comparison of gem locations and sites shows that both Preah Vihear and Vat Phu are within a day's travel of a single gem source (Figure 10.8; Table 10.7). Further away from the major sites, Vat Phu and Preah Khan KS may have had access to several different mines. The position of the Battambang sites may have allowed the Angkorian kings to extend their reach into the valuable gem mines in Pailin, one of the most important ruby producing regions in Southeast Asia. Overall, the distribution of sites and their relative distances indicates that it would have been possible to access these resources.

Industrial Resources Summary

The number of industrial resources near Angkorian sites is much more limited than found for the comestible economic counterparts (Table 10.8). While the majority of sites have no industrial resources within their immediate vicinity, there are a few noteworthy exceptions. Based on the number of different resources, Preah Khan KS and Vat Phu appear to have been placed to take establish a point of access over several resources, but particularly iron and copper. Evidence of extensive iron working at Preah Khan shows that the site was directly involved in the extraction of this metal from its surrounding regions. The fact that there is a copper source to the northwest is interesting especially given that one of the secondary roads mapped at Preah Khan KS was directed toward this location. Unfortunately, the ultralight survey was not able to verify the remote sensing imagery, though a few tanks were found in the immediate vicinity. The fact that Angkorian settlement appears to end to the east of Preah Khan KS suggests that the resources in this site played a large role in their facilitating access and distribution. Generally, Vat Phu is much further away from the resources, particularly the gold in Attapoeu, however the existence of several copper sources on the same side of the Mekong is important. The fact that both of these sites are found at the end of their respective roads suggests that these commodities could be transported along their lengths.

Excluding the possible access to gems and tin at Banon and Ta Prohm Bati, there are four sites that are positioned near extremely valuable commodities of iron (Angkor), gold (Banteay Chhmar), gems (Preah Vihear) and tin (Phnom Chisor). The position of Banteay Chhmar on top of the large gold field of Bo Sup Trup is the most striking revelation in this analysis; the fact that the site lacks a regional road may relate to maintaining control over access into rather than out of the location. Given that Preah Vihear and Phnom Chisor are built on hills it could be questioned whether the prime directive was to maintain access over these precious commodities.

The correlation between industrial resources and Angkorian sites is substantially more varied than for comestible resources. Those sites with access to industrial resources are found both on and off the road system. An important difference appears when we consider the type of transport needed for moving these resources. Each of the connected sites has resources (copper, iron) that would be heavy and possibly extracted in bulk. By contrast, the sites built away from the road system are near resources (e.g., gold, tin, gems) that likely would have been transported in much smaller volumes.

Looking at the distribution of industrial resources along the roads we find a marked dichotomy between the Northeast and East roads, which have access to numerous resources, and the other roads in the system, which have almost no industrial value. This evidence strongly suggests that that the West, Northwest and Southeast roads were not used for the specific movement of industrial resources.

Political Geography

Political geography can be evaluated from two perspectives. The first is related to the control of economic resources, discussed above, that become sought after on a regional level. Access to resources to continue production and reproduction in the landscape is a critical element in maintaining political control (see Sinopoli and Morrison 1995). The second perspective of political geography is to identify features that relate to regional control or strategic access. An example from Roman Gaul illustrates this point,

> Among the factors other than distance that seem to have affected the site selection and economic viability in the case of the *vici* (rural towns), several stand out: proximity to a ford on the Arroux; presence of an intersecting route with the main Roman road; position on a geological interface; and riverine location (Berry 1987:553).

This has implications for the extent of territory under control. Ispahani argues that the evolution of a state's borderlands is best achieved through a political-geographic approach using the routes and the settlements in the landscape (1989:2). He suggests that routes are an abstract form of regulation and control corresponding to access, and then the study of the access itself informs on crucial aspects of state activity, security and development (Ibid.). In order to maintain control we need to examine the physical locations, or breaks, that would provide key points of access either into or out of the Angkorian core area.

Political Geography and Angkor

Angkorian historians, particularly since the 1970s, have emphasized the need to study political geography. This was manifest through the mapping of sites through time. The examination of political geography here is directed toward identifying features in the landscape that would cause breaks in transportation and thus provide some political or military advantage. The types of breaks that would have an immediate impact on territorial control and defence are the rivers and topography. The extensive river system that connects the Angkorian sites to the Tonle Sap and Mekong provides an excellent mechanism for transport that must be controlled to ensure security in the region. Two locations to be examined are the proximity of sites to the major rivers and also along catchment boundaries.

Topographic breaks are locations that impede movement or require a shift in transport type (e.g., cart to foot; foot to boat). The Dangrek Range is the most obvious terrestrial break in this study as the Angkorian Khmer settled on both sides. A simple comparison of sites located near the major passes through the Dangrek will present a model of the importance of maintaining access up and down the escarpment. A second example of topography as a political resource is to identify the number of Angkorian sites placed on hills. While the primary argument for building sites on hills generally associated with religious purposes (see below) these locations must also have served as important watchtowers over the immediate area.

River System Resources: Major Rivers and Catchment Boundaries

The argument for examining the location of sites in the water system is based on the need to maintain control over one or more river catchments. A site built on a major river is able to control the flow of both upstream and downstream traffic; the regular appearance of sites along rivers suggests that fluvial transport played a significant role in regional movements. It is argued that placement on a major river equates to greater regional control than would a secondary river or tributary. In the latter case we would argue that other resources were involved in site selection. A site built on the border of two catchments may have been positioned to maintain land access between the river systems. The site is therefore a kind of transition or a portage function between two broader regions.

Major Rivers, Catchment Boundaries and Angkorian Sites

Figure 10.9 illustrates the spatial distribution of Angkorian sites relative to the major rivers and catchments. As with the initial discussion in Chapter 8 most of the largest Angkorian sites are not placed directly on a major river (see Table 8.13). This being said it is interesting to note that four of the sites that are situated on the river are also found on the visible end of their associated road (e.g., Preah Khan KS, Vat Phu, Phimai, Sambor

Prei Kuk). This suggests that the sites may have been using both the riverine and terrestrial systems.

More sites are actually situated on catchment boundaries than on the major rivers and an equal number are found on and off the road system (Table 10.9). The most notable examples are Beng Melea and Banteay Chhmar. The former site is positioned at the mid-point between Angkor and Preah Khan KS and acts as the starting point for the road leading towards Vat Phu. In the case of Banteay Chhmar, arguably the most important site in northwest Cambodia, its position has long puzzled researchers as it is not part of the regional road network. By placing it on the boundary of two catchments it is possible that it acted as the go-between for traffic coming from the west and northwest towards Angkor.

A third group is sites not situated in relation to either the major river or on a catchment boundary. The majority of these sites are positioned on the road system including Phnom Rung and Muang Tam, Sdok Kok Thom and Koh Ker. Since access to the major river system was not one of the primary considerations for these sites, we must conclude that it is the position on the road that is important and each site is situated along an established land route to Angkor. From this perspective the mystery of why Koh Ker, the 10th century capital, was established in its present location is explained as a blockade along the land route between Angkor and the sites of Preah Vihear and Vat Phu.

Topographic Resources: Dangrek Passes and Lookouts

The two types of topographic features to be examined here are the passes that lead through the Dangrek Range and the distribution of sites on hills as potential lookouts. Stretching over 120 miles (193 km) in length and up to 300 metres in height the Dangrek is the greatest physical barrier in the study areas. According to Aymonier there are a dozen natural staircases through this escarpment, however only three of these can be passed uneasily by carriage (1901:202). The presence of Ta Muen Thom and Ta Muen Toch, a laterite *gîtes d'étape*, on top of the Dangrek near the Northwest road supports the proposition that the Angkorian Khmer monitored these passes. Using a combination of the modern crossing with the evidence from Aymonier, the objective of this analysis is to determine whether any of the main Angkorian sites were situated to monitor access through this range.

The other aspect of topography is that the construction of sites on hills affords substantial use as a regional lookout. Angkorian builders regularly placed temples on top of mountains. The hills of Phnom Bok, Phnom Krom, and Phnom Bakheng around Angkor are invested with a temple and on a clear day are inter-visible. The objective here is to see if similar locations were chosen outside of Angkor.

Passes, Lookouts and Angkorian Sites

Figure 10.10 shows the distribution of passes and sites situated on top of natural hills. Of the five sites within a day's march of the Dangrek passes (Table 10.10), only Preah Vihear is situated close enough to directly monitor flow up and down the mountain. Neak Buos is the only other site within a single day travel of a pass. Vat Phu is located just outside the 25 km range, but the fact that there are four potential passes to the west suggests that it would have also played a part in communication across this pass, possibly connecting to Preah Vihear. Again, the lack of a formalized route to Preah Vihear stands out as it appears to have been an important political locale. The fact that the main sites are concentrated in two areas suggests that these passes may have had more significance for the Angkorian Khmer.

Preah Vihear is also an important lookout point over the Dangrek. The small number of major sites situated on hills are quite widely distributed across the landscape and there are sites in nearly all directions out from Angkor. Excluding the sites built on natural hills at Angkor, only two sites, Phnom Rung and Vat Phu, are situated on the road system. Further south, the site of Vat Nokor may have been strategically placed on the Mekong; this fact has been previously identified by Cunin (2004:417) among others. Phnom Chisor's position near the Cham border also suggests that it served an important function as a lookout.

Discussion: Political Resources and Transportation

The results for the political resources are summarized in Table 10.10. We can conclude that the majority of Angkorian sites are within the immediate vicinity of at least one political resource. Within the river system, sites are found more often on the catchment boundary (10) than on a major river (6). Topographic locations with political influence are much less common. This is attributed to the fact that sites must be placed close to the Dangrek (5) or on hills (7) – which is less common than flat land spaces in the region.

Preah Vihear has the largest number of political resources; most of these are attributable almost exclusively to its location on the Dangrek. Preah Vihear has access to two catchments (Stung Sen and Mun), is located at a crossings through the Dangrek, and its position on the escarpment provides an excellent view across the Tonle Sap basin. Regardless of the historic and architectural interpretation of Preah Vihear as a pilgrimage site, these characteristics strongly suggest that it could have had an important political role in the past. The six sites with two political resources vary considerably, with combinations of river-topographic resources and both topographic types. Using these parameters it is possible to identify three sites – Sdok Kok Thom, Koh Ker and Prasat Don An – that have no visible political resource. While Koh Ker and Prasat Don An do have water smaller water sources nearby (see Chapter 8), the fact that there is no obvious political resource within the area of Koh Ker is again rather remarkable.

Comparing sites situated on and off the road system the only visible difference in resource tendencies is that road sites are more commonly located near major rivers. As indicated above, the fact these latter sites are also situated at the end of an Angkorian road suggests a much broader transport network was in use at these locations. Overall, this review shows that there is no real difference in the political location of Angkorian sites that are connected or not to the road system.

Religious Geography

The final cultural resource to be examined in the context of the Angkorian case study is whether the sites, and the roads, were established according to religious resources within the landscape. Here we are talking not of constructed religiousness (i.e., the temple) but natural features that would have been sacred to the settling community. Kulke suggests that there was a shift in the topography of temples within the Angkorian period; initially temples of major importance were built for political and religious purposes at specific holy places (e.g., Vat Phu). After a certain time, temples became to be created near or at the political centres, emphasizing the magico-political importance of the centre (1985:14). In the context of the Axial religions (i.e., Hinduism and Buddhism), rivers, springs, mountains, and caves acted as the playgrounds of the Hindu gods and are therefore seen as important as pilgrimage locations (Saraswati 1985:3; Bharwaj 1973:32; Michell 1988:69). A similar reverence for the sacred mountain is found in Buddhist

China, dating back to the Zhou period (11^{th} to 221 BC) (Barnes 1999:119-120). Since the scale of this study is very much regional in focus, the two natural features that will be examined are the sacred mountain and river sources.

Bharwaj raises two important points of Indian sacred space that must be considered in the discussion of an Angkorian religious geography. First is that ‘the whole of India can be regarded as a vast sacred space organized into a system of pilgrimage centres and their fields’ (1973:7). Bharwaj then tempers this blanket association by stating that some holy places are more sacred than others, either because they represent different sects, regions or fluctuate throughout the year (Ibid.:97). The question to be answered in looking at Angkorian settlement and transport is whether particular sites were more sacred than others and how integrated these are within the broader communication network.

Religious Geography and Angkor

BP Groslier argued that religious geography is an essential part of studying the Angkorian period (1986:64). The most ubiquitous religious component of Angkorian society is the temple. As such the major sites chosen for this sample represent sacred locations within Angkor’s territory. The issue is whether these temples were chosen because the location is inherently religious in nature. The approach used to investigate this issue focuses on two main types of natural features, mountains and river sources.

Sacred Phnoms and River Origins

The concept of the sacred mountain, the Mount Meru, is a recurring feature in Angkorian religious architecture and iconography (see Mus 1937; Filliozat 1954). As discussed in relation to political resources, Angkorian kings frequently built temples on top of hills, however, in this context the building is seen as a recreation of a sacred location rather than a lookout. The concept of a sacred river has not been addressed in detail within the Angkorian period. Im’s (2002) paper examined the potential of the Stung Siem Reap as a mini-Ganges represents one of the few attempts to make such a comparison. The carving of the Kbal Spean (Figure 10.11a-b) in the waters at the source of the Siem Reap origin of the river suggests that these features would have been revered on a broader scale.

The method for evaluating the religious resources will again look at the location of sites situated on hills (*phnoms*) versus those built on flatland. Since not all sites are situated on mountain tops, the second comparison will look at the location of sites relative to the headwaters, or origins, of the main rivers in a catchment.

Sacred Phnoms, River Origins and Angkorian Temples

The distribution of sites on sacred mountains is the same as for lookouts (see Figure 10.10). The difference from the religious resource perspective is that these sites can be seen as loci attracting religious activity rather than providing a means of identifying groups approaching Angkorian territory. Vat Phu and Phnom Rung are the only phnom sites situated on the road system. While the importance of Phnom Rung is not clear, the fact that Vat Phu has been venerated by kings from the pre-Angkorian to Angkorian periods suggests that the road has some deeply imbedded religious importance. Preah Vihear is another site with a long history of being venerated by Angkor’s elite, however, it lacks any formalized connection to the road network. The fact that none of the other phnom temples in this sample (i.e., Banon, Phnom Chisor, Vat Nokor) or other known sites (i.e., Phnom Sandak, Phnom Preah Net Preah, Phnom Da) are near roads indicates that the transport system was not directed to facilitate movement to visit sacred mountains in Angkorian territory.

Turning to the location of the sites and river origins, the only site that meets this parameter is Preah Vihear. Though it is situated above the source of the Stung Sen, its general proximity and the presence of substantial settlement at the base of the escarpment suggests that this may have increased the religious potential of the site. Generally, sites are situated further down the river system, suggesting that other considerations are more important in the establishment of these sites. It is likely that, as at Angkor, the sources of these rivers would be marked by smaller temples.

Discussion: Religious Resources and Angkorian Sites

Table 10.1 illustrates the frequency of sites on top of sacred mountain and in proximity to a river origin. The appearance of *phnom* temples across the study areas supports their general importance in Angkorian society however many of them are not connected to the road network. The presence of Vat Phu at the end of the Northeast road strongly suggests that pilgrims, or at least the king, would have visited the site somewhat regularly. An important point to remember about Vat Phu is that it had been an important capital since the pre-Angkorian period. Chapter 9 demonstrated that kings repeatedly attached themselves to this site, symbolically linking themselves to the religious and ancestral power of the site. Phnom Rung is located along the mid-way point between the Dangrek and Phimai on the Northwest road. This location no doubt served as a beacon for travellers moving up and down this route, a fact supported by the presence of the laterite *gîtes d'étapes*. Interestingly, the sites of Preah Khan KS or Beng Melea do not have any outstanding religious resources that would merit a comparable string of resthouses.

Two possible explanations can be raised for why the other sites (Preah Vihear, Vat Nokor, Banon, Phnom Chisor) are not connected by a formalized road system: 1) these sites were not part of a regular pilgrimage route; or 2) that a formalized route was not required. The latter reason may reflect the type of people visiting these locations (i.e., pilgrims rather than royalty).

The discussion of the religious resources along the roads emphasizes the symbolic importance of sites based on the Hindu-Buddhist concept of sacred mountain. Evidence of ashramas built by Yasovarman indicates that pilgrimage played an important part of Angkorian life; however, the scale and number of pilgrims is not possible to determine from the current information. It is easier to discuss the royal attention paid to *phnom* sites such as Vat Phu and Preah Vihear which had historical evidence of kingly visits. Moving from an outward to an inward perspective, the roads more likely acted as conduits bringing regional elites and pilgrims to Angkor for religious and political purposes. This politico-religious activity is highlighted by the inscriptional evidence for the 'Anniversary of the king' described in Chapter 7.

Comparison of Geographic Resources

The establishment of Angkorian sites is likely linked to multiple types of resources. Table 10.11 shows the rank order of resources by site. The first point to be made is the lack of direct correlation between resources and connection with the formalized road system. Several sites along the road system are extremely well endowed with resources (i.e., Vat Phu, Angkor, Preah Khan KS) while others have very little geographic value (i.e., Sdok Kok Thom, Muang Tam, Beng Melea, Koh Ker). The position of Vat Phu and Preah Khan KS at visible ends of the network suggests that these were major collection/bureaucratic locations in the overall system. The iron working sites in Preah Khan KS attest to this role, however Vat Phu's function in this matter is unclear. On the other end of the scale, we are again faced with the problem of Koh Ker. Based on the resource availability between Angkor and Koh Ker, why would Jayavarman IV have moved his capital away from one of the most ideal locations in the Angkorian world? While this approach is perhaps too pragmatic and lacks the subtleties of the historical dynamics involved, the fact remains that the region surrounding Koh Ker has no obviously redeeming geographic features. Further work in the region around Koh Ker will no doubt elucidate the benefits of moving the capital to this location.

If we assume that these sites were integrated into the broader Angkorian system then the river transportation system must have been used contemporaneously with the roads. The relationship between these two systems will be investigated in more detail in the following discussion.

Discussion: Roads and Rivers, Sites and Resources

From the previous discussion it is clear that Angkorian settlement is placed, as one would expect, to extract at least a base level of resources (i.e., rice and fish). On an individual basis several sites were placed to take specific advantage of commodities with more specific cultural value. The following discussion will address the implication of site location/resource availability within the context of each of the Angkorian roads and also as part of a broader water-based system. Before looking at the roads on an individual basis, we must first discuss Angkor as a keystone for the resource-based decisions that guided Angkorian settlement across their territory. Through this approach it will be possible to identify whether the Angkorian sites are placed to meet the economic, political and religious needs of the empire. An important consideration is whether the direction of flow along these routes was focussed on feeding the demands of Angkor.

Angkor, the Model of Resource-Driven Settlement

The position of Angkor has long been considered one of its greatest assets (Groslier 1921:141-142; Vickery 1998:317). Situated on the north side of the Tonle Sap, Angkor receives the vital floodwaters for irrigating rice fields but unlike the southern side it retains direct access to the lake in the dry season. These same features also enable Angkor to take advantage of the enormous fish stocks in the lake and flooded regions.

A second important physical feature is the series of small hills that create an arc around the eastern and southern part of the site. Travelling northward up the Tonle Sap Lake the only visible landmark is Phnom Krom located to the south of Angkor. From this hill you can see the Phnom Bakheng, which served as the sacred fulcrum around which most of 10^{th} to 13^{th} century construction in Angkor was focussed. On top of Phnom Bakheng it is possible to sight Phnom Bok to the east, and from there to Phnom Dei at Banteay Srei and finally north to the gap between the Kulen and Krau Hills. These hills provide an excellent line-of-sight that would have been an outstanding asset in monitoring movements into Angkor from this direction. The fact that each of these *phnoms* has a temple on their summit attests to their recognized value. Regular access to water is another important feature that is hyper-represented at Angkor through the modified path of the local Puoc and Siem Reap rivers and the massive *baray* used to capture them. Material resources including sandstone from the Kulen, clay to the east of Angkor, and the iron deposit described at Phnom Veak (see Figure 10.5) are a further benefit for settling in this region. With the consolidation of Battambang into the empire, rice would also have been moved across the lake to the capital.

The lesson from Angkor demonstrates some important precedents that may be mirrored in provincial settlement. Of utmost concern is the access to food and water. That Angkor is placed within a setting that has substantial resources to support both the local population (i.e., fish, rice) and its elite concerns (i.e., access to stone for temple building, several sacred mountains) indicates that the Angkorian Khmer may have recognized the importance of these resources before constructing a provincial centre.

The benefit of recognizing that temples serve multiple roles has dramatically altered the study of the internal workings of the Vijayanagara Empire in South India. Previously, the role of the temple was thought to function only as a location for ritual and the spread of ideology; recent re-working of their role has revealed that temples actually served as important locations for agricultural investment and land control (Morrison and Sinopoli 1992:339; Morrison 2001b:265). The temple also acted as small cities that supported ritual specialists, craftsmen as well as administrators and actively invested their resources toward agricultural production (Morrison 2001b:265). A similar perspective in Angkor will no doubt increase our knowledge about the more ‘mundane’ aspects of the temple in daily life and possibly compensate for our lack of information on the settlement around it.

The Angkorian Roads in Context

Moving out from Angkor we can now assess the relationship between the resources available at sites to expand our conception of the function of the Angkorian roads. The graphic representation of the resources as they appear along the roads is depicted in Figure 10.12. As indicated in the graphic, rice and fish are considered to be baseline commodities essential to any site and are not factored into much of this discussion.

West Road

The route that connects Sdok Kok Thom-Phnom Srok-Angkor shows very little resource potential. Phnom Srok's proximity to the catchment boundary of the Stung Mongkol Borey and Stung Sreng is the only identifiable resource of sites along this route. Road visibility also suggests that this road was generally not that important in the overall transport network. The fact the road becomes difficult to locate west of Phnom Srok suggests that the connection to Sdok Kok Thom is merely a path and was not devised for the purpose of moving goods on a regular basis. It would be safe to conclude that the sites on the west road are stopping points on the route that would ultimately connect Angkor to the sites of Lopburi and Ayutthaya in central Thailand. It may have therefore served as a military or trade access with these western regions, however, the fact that the bridges and the road itself drop off past Phnom Srok indicates that the bulk of movement was within the first half of the defined route.

Northwest Road

The Northwest road shows a few extra resources however the presence of salt, a commodity that Angkor completely lacks, must have factored into the development of the route. Phimai's location near the vast salt domes of the Khorat Plateau is an obvious reason for its construction in the landscape. While it is on the end of the road to Angkor it is also built next to the Mun, the largest river in northeast Thailand. Jacques suggested that its position on the Se Mun acted to fill the moat, *baray,* and also act as a canal and a port (Jacques and Lafond 2004:302). The extent that the Mun river was used to reach sites in the Tonle Sap floodplain was probably small, as both in the actual distance along the river and the fact that river transport is impassable south of Vat Phu prevent broader connections. While more resource intensive, the construction of a roadway linking Phimai to the Tonle Sap Lake is a much more logical means of communicating between these two regions.

The position of Phnom Rung and Muang Tam halfway between Phimai and the Dangrek pass presents several interesting issues for transportation. While Muang Tam is likely the city that served Phnom Rung, the mountain itself is actually located along the axis between Angkor and Phimai. As the most obvious line of sight coming up from the Tonle Sap plain or travelling from Phimai, the hill is a landmark that would have served the same function as the hills around Angkor.

The directional flow of traffic on this route (i.e., to Angkor, to Phimai) would vary depending on the nature of the resource. The presence of the laterite *gîtes d'étapes* on this road is one of the primary arguments used to identify it with religious purposes. Since the physical location of Phimai has been shown to have no inherent religious geographical value, it is likely pilgrims were taking the road toward Angkor. The presence of Phnom Rung along the road may have had some influence on pilgrimage but it is unlikely that the resthouses were built to guide people from Phimai and Angkor to this spot. From an economic perspective I would agree with Welch (1998) that salt and salted fish must have been traded between Phimai and Angkor. The resthouses, though designated as sacred houses for the gods, would have no doubt served as stopping points around which traders would have sought shelter or safety. Given the value of salt it may the resthouses may have served an extremely important role in preventing thieves from stealing the salt destined for Angkor. The limited distribution of bridges may reflect a similar pattern to the West road, suggested by Bruguier, that they demarcate the edge of military access in the core of the empire. The position of these bridges may have also played political role as a propaganda tool of the kings of Angkor; essentially, they inform the traveller that they have entered into the areas controlled by the capital.

Northeast Road

The terminal point of the Northeast road, Vat Phu, has a substantial concentration of resources. Like Phimai, Vat Phu is situated on both the road and river system and has access to critical economic resources (i.e., gold, copper) vital to Angkor's elite workshops. The vast quantities of copper and gold available in the mountainous regions east of Vat Phu must have been known during this time, which meant that the site was well-placed as a distribution point for the rest of the Angkorian territories. The fact that the Mekong River is an unsuitable route to reach the Tonle Sap directly supports the need for a road between Vat Phu and Angkor. Unlike Phimai, Vat Phu is also a major religious site in the Angkorian territory and pre- and Angkorian kings made considerable efforts to associate themselves with this location through the placement of inscriptions or architectural modifications.

In complete contrast with Vat Phu, the other sites situated along the road connecting to Beng Melea (see below) have little obvious resource-based value. Neak Buos is situated close to one of the passes through the Dangrek and is a potential jumping off point to access Preah Vihear. The geographic position of Koh Ker has long puzzled Angkorian researchers. Jacques (2004:156) and Coe (2004:108) suggested that agricultural and or mineral resources may have played a major role in its location. The results from this study show, however, that Koh Ker is not situated in a region of highly productive soils for rice production and there are no major sources of metal identified in close proximity to the site. A potential explanation may be identified from Koh Ker's position on the road. If Vat Phu was as important as this resource analysis and historical data suggest, then Koh Ker may have been placed to cut Angkor off from vital sources of religious and economic power. Jayavarman IV may have decided to lose access to fish and regional communication in favour of the other boons offered in the northeast part of the territory. Further research at Koh Ker and surrounding sites (i.e., Cheam Sram, Phnom Sandak, Prasat Khompus) will hopefully clarify this issue.

Movement along the Northeast road appears to have been bi-directional. Goods would have moved into Angkor and religious and or politically-motivated pilgrimage would have travelled out to Vat Phu. Given that the Vietnamese coast is accessible through passes to the east of Vat Phu, this site would have also served to move troops during battles with the Dai Viet and Cham.

East Road

The function of the East road appears to be directed heavily toward gaining access to the economic commodities found within the region of Preah Khan KS. Iron, as well as copper, gold, and possibly gems could have been accessed from the site. The industrial association of Preah Khan KS has already been the subject of intense discussion (see Groslier 1960-1970; see summary by Jacques in Jacques and Lafond 2004:259-300) and there is extensive evidence of iron smelting activity within the site. The fact that Preah Khan KS is situated a distance from the major iron source, Phnom Dek, is attributed to the relationship between the Angkorian Khmer and the Kuoy, who remain the traditional iron-smelters in Cambodia today (Groslier 1986:72). Groslier argued that the Khmer did not build their site closer to the resources because they settled in *sre*, or ricefields, and avoided the *prei*, or forest, that was inhabited by the Kuoy (Ibid.). From a more practical perspective, the placement of Preah Khan KS on the Stung Stuang suggests that it may have been used as a means of transporting ores down to the Tonle Sap Lake. Groslier also proposed that Preah Khan KS was built as a frontier post during the early 11th century conflicts with the Cham (1973:117; 1986:40). While this is an interesting political mechanism for the establishment of the site, and the road generally, we have no direct information about the extent of Cham and Khmer borders at this time.

Jacques has rightly suggested that Preah Khan KS might not be the work of an Angkorian king but was an independent state that rose to power on the production of iron (Jacques and Lafond 2004:275). In this case the industrialists of Preah Khan KS may have constructed the road and the temples at the site, with Angkor eventually taking over the route as the site was integrated into the empire (Ibid.:286). A further fact that may support a Preah Khan KS power base is that the sandstone *gîtes d'étapes* are found between Preah Khan KS and Beng Melea and do not connect to Angkor.

Though sandstone is not included in this study, Beng Melea is often connected with monitoring the distribution of stone from the quarries at the base the Kulen Hills to the Damdeck Canal and into the Tonle Sap. Beyond its potential role in stone distribution and a single location of iron to the north, Beng Melea provides no extra economic commodity to the greater system. The importance of Beng Melea, however, lies in its strategic location along the catchment boundary of the Stung Siem Reap and Stung Staung and as the junction between the East and Northeast roads. This latter position would have enabled the site to control over important economic goods moved into the capital. The political importance of this location was previously noted by Jacques (Jacques and Lafond 2004:345).

In addition to the economic and political potential of the East road the presence of the two sets of resthouses suggests that religious practices were part of this route. As with the resthouses built on the Northwest road, neither Preah Khan KS nor Beng Melea is situated in an overtly sacred location. Jacques raised the important question that the *temples d'étapes* may have been built to put the distribution of iron under the protection of the gods (Jacques and Lafond 2004:286). Again, a more pragmatic interpretation is that the iron would be safely housed at night en route to its final destination. If this economic-religious association is viable, then the laterite *gîtes d'étapes* may have served a similar purpose for salt.

The presence of the sandstone *gîtes d'étapes* on this road have been associated with the Preah Khan inscription route lined with resthouses to Champa; however, Jacques concluded that since there are no further buildings past Preah Khan KS the site must be the intended destination and not one of the roads in the text (Jacques and Lafond 2004:286, 289). The presence of the Spean Stung Krasan and the faint trace of a route leading to the east (see Chapter 8) indicate some form of communication took place, however, since it is much less formalized than its counterpart to the west.

The evidence of resources and infrastructure (resthouses, bridges) indicate that the East road was an extremely active route through much of the Angkorian period. The flow of goods no doubt moved from Preah Khan KS toward Angkor, with the possibility that other centres were accessing its iron reserves via river access. An important question that needs to be addressed is what commodity were the rulers of Preah Khan KS obtaining in exchange for its vast material goods? The lack of any natural religious resource suggests that Preah Khan would not have been a sacred destination. Instead, the placement of the two types of resthouses may have been used to safely move their goods first to Beng Melea and then on to Angkor.

Southeast Roads

Beyond the gaining access to lands suitable for growing rice and catching fish, the only resource derived from the major sites along the Southeast roads is access to the Stung Sen. As with Koh Ker, the fact that a major capital, Sambor Prei Kuk, of the historic period is found near little higher value commodities is striking. The overall function of the roads is to provide a year-round connection between the Sen and Angkor. The distribution of bridges along the Southeast Upper road stops at the Stung Chikreng; the fact that numerous major water crossings are found past this point suggests that the bridges demarcate the effective territory of Angkor. A further point that should be made about the bridges is that their placement on these rivers would have prohibited their use as transport conduits by large vessels to the lake. Land transport may therefore have been more important within the maximum extent of the Angkorian bridges.

Rivers and Secondary Roads

The model of site connection is also interesting when we consider what resources would have guided the placement of the other large sites in the empire. Sites that are not connected to the landscape are also guided by the same principles of need.

By dividing the regions around Angkor into four quadrants it is possible to summarize the resource potential for the sites that fall within these regions (Figure 10.13).

Water transportation likely played a major role in moving goods, especially bulk products such as rice, between sites not situated on the formalized road system to Angkor. A comparable policy was used during the Roman period where bulk goods were sent by water and precious commodities were sent by land (Lopez 1956:17; Berry 1987:579). Similar use of water transport in Angkor has been speculated for the shipment of stone (Lunet de Lajonquière 1911:xxiv; Goodman 2000 and it is possible that other heavy goods such as iron were shipped the same way.

Northwest

Banteay Chhmar is the only site situated off the road system to the northwest of Angkor. Like Koh Ker, the position of this site has long puzzled Angkorian scholars (Jacques and Lafond 2004:363). The importance of Banteay Chhmar is attested to by its large enclosure and *baray*, large-scale canals and numerous smaller shrines, including a sandstone *gîtes d'étape*, are found in the immediate area. The fact that it is not connected is curious given that the site is attributed to Jayavarman VII and/or his immediate successor Indravarman II. As discussed above, the most striking discovery was that the site is positioned in the immediate vicinity of Bo Sup Trup, the largest gold source in Cambodia. The fact that it is not located on a road may be understood when we consider that it is situated on catchment boundary between the Stung Sreng and Stung Mongkol Borey. Its position allows access to both river systems which would see traffic coming in from the west and also down the Dangrek toward Angkor. Its position on the Srong tributary facilitates travel to the east, connecting to the Stung Sreng and the formalized river system at Phnom Srok. Overall, Banteay Chhmar would have been quite accessible through the water system. If the site was placed at this location to extract gold, then a potential reason for not connecting it with a formalized road may have been to discourage direct access to the gold reserves in the region.

Northeast

From both the histories and access to natural resources the site of Preah Vihear is one of the most important sites in the Angkorian world. It importance is perhaps only matched by Vat Phu; the greatest difference, however is that Preah Vihear appears completely isolated. Jacques argues that Preah Vihear cannot be a stop but is a goal of expedition (Jacques and Lafond 2004:235). Hall argues that Preah Vihear would have been ‘the scene of intense religious and economic development during the reign of Suryavarman I and therefore represents a vital trading route through the Dangrek Range (1975:325). Looking at its immediate resources, the only economic commodity in its vicinity are gems, which would have an extremely high value but low requirement for transport. In terms of its role for transport, the staircase at the foot of the escarpment allows direct access but it is not the easiest route through the Dangrek (Aymonier 1999b:243). Its position near the headwaters of the Sen suggests that water routes could have been used to reach the site from the Tonle Sap side of the Dangrek. The resource picture of Preah Vihear supports the idea that it would have been a pilgrimage destination accessed by the king, other elites, or simple pilgrims by informal land routes or by up the Stung Sen.

Southeast

The lack of formalized roads to Vat Nokor, Ta Prohm Bati and Phnom Chisor is probably linked to their location on the southern edges of Angkorian Khmer territory. Groslier suggested that Jayavarman VII built Vat Nokor and Ta Prohm Bati in order to take revenge on Cham territories to the far south (1986:40). The fact that these Angkorian sites are situated to the west of the Mekong suggests the importance of this river as a political border. The strategic value of both Phnom Chisor and Vat Nokor is further attested to by their location on hills. The position of Ta Prohm Bati, some SSkm north of Phnom Chisor, appears to have little obvious resource potential.

Beyond political intentions, only Phnom Chisor appears to have any significant economic resource value in this region. This site is situated near a source of tin, and potentially the salt producing areas further toward the Mekong Delta. The single tin source south of the site is not well described, but the ubiquity of salt from the Delta region would have been a definite boon. Cunin (2004:441) noted that the position of Vat Nokor along the Mekong would have been to take advantage of the river’s resources. Specifically, this would include access to fish stocks and trade moving up and down the river from the sea and up to the important trade entrepot of Thalaborivat, at the convergence of the Mekong, Tonle

Sre Pok and Tonle Kong. Each of these latter rivers likely communicated with groups on the other side of the Annamite Chain.

Southwest

The evidence of resources around the three sites around Battambang and Prasat Don An appear to have been built for one purpose: rice agriculture. No other economic resources are found within direct proximity to the any of these major centres. Direct evidence this is that the Battambang temples are situated in land that is extremely suited to intensive rice agriculture. The fact that there is no road connecting to these regions to distribute surplus rice is an initial indicator that water transport would have been commonly utilized. For the transportation of large volumes of rice to Angkor, or other centres, it would have been easier to simply cross the lake by boat or raft. Two factors can be raised to further support this claim. First, is that these sites are situated close to rivers and, with the exception of Banon, are within a short distance to the maximum flooded area of the Tonle Sap Lake. Second, the terrain to the west of the lake is extremely difficult to pass by cart (Pavie 1901:101-102). The claim that these sites were established to take advantage of the 'rice bowl' is supported from this perspective.

Several reasons can be proposed for the lack of roads between these sites: 1) riverine transport was used; 2) goods were not shipped in volume to the capital; 3) the terrestrial routes were never formalized into the embanked roads seen in other parts of the empire; 4) they were intentionally kept separate from the road system.

Angkor, the Axis of a Regional System

On both the local and regional scale, Angkor is ideally positioned to take advantage of numerous resources across its territory via the road and river systems. It acted as the religious and political head of the Angkorian empire and would have attracted substantial traffic from its various territories. In order to maintain access to important resources in the landscape its rulers needed to create regional centres. Following the rationale that the construction of roads was driven by a particular purpose, the points connected by these routes had specific value to the capital.

From an economic perspective it is striking to note that three of the roads (East, Northwest, Northeast) end at sites which have important and/or substantial material resources (e.g., iron, salt, copper). An important characteristic of these regional centres is that they are not placed on top of the resource directly. For example, Preah Khan KS is situated a little over a day's travel to the west of the iron sources of the Phnom Dek. The fact that the Angkorian Khmer did not establish themselves closer to this source may be related to Groslier's *sre*/*prei* dichotomy between the Angkorian and Kuoy territories. Evidence of smelting at Preah Khan KS however supports it as a production/distribution centre for iron which took advantage of both terrestrial and fluvial routes. Similar relationships are not readily identifiable for the Southeast and West roads, yet the major sites on these roads would act as collection and distribution centres. The 'terminals' of the transport system are also situated close to a main river which suggests their broader communication with territories beyond Angkor's bureaucratic control.

The different requirement for transporting bulk and precious commodities is an important issue in the construction of roads. Sites with access to precious commodities (gems, gold, silver) generally do not have a formalized road connecting to them; by contrast those near sources of iron, salt and copper do have major roads. Rice, which had ubiquitous economic value, was better suited to fluvial transport given the lack of any road connecting the 'rice bowl' of Battambang with the capital.

We cannot doubt that the roads served some kind of religious function, however, the extent of their 'religiousness' needs to be examined. The dramatic example of the lack of connection between transportation and religious resources is the case of Preah Vihear. All sources indicate that this temple was regularly involved in the plans of the Angkorian kings, yet there is no visible trace of how they reached this destination. The presence of stone resthouses (read temples) along the roads indicates some form of pilgrimage, be it people, the king or for the sacred fire. Looking at the end points of the Northwest and East roads we can identify nothing particularly 'sacred' about their locations. An interesting idea raised by Jacques is that the resthouses, particularly those between Preah Khan KS and Beng Melea, served to put the road under the protection of the gods. The question becomes what was being protected? Overall, the information suggests that the flow of traffic was directed inward to Angkor. If the objective was to provide a place of worship during travels into Angkor, why are there no comparable structures on the other four roads? Moving the other direction, were the other roads not important to Angkor? Returning to the point made earlier by Kulke, the proliferation of major temples built on flatland rather than hilltops suggests that the Angkorian rulers were creating their sacred landscape. His use of the term magico-political importance to define the structures underlies the fact that the decision to place a site is based on a bureaucratic decision. However, the considerable infrastructure along the East road (i.e., two types of resthouses) suggests that land transport may have extremely important, and may have been placed under the protection of the gods.

Political resources, such as strategic access points, are often part of the Angkorian settlement plan. Sites are commonly positioned at strategic river locales both on (Beng Melea) and off the road (Banteay Chhmar) system. Many sites are situated away from the direct access on the Dangrek and major rivers but those that are (i.e., Vat Nokor) were likely positioned as a political statement of the king on the edge of his territory. Military functions definitely played an important part of the Angkorian road system. Bruguier's claim that the extent of the bridges mirrors the area directly controlled by Angkor is an important issue that needs to be examined in greater detail (i.e., local construction versus imperial directive). The sudden termination of each Angkorian road indicates that the goal of the system is to facilitate internal movement. This is in direct contrast to the Roman military roads that extended into their newly conquered territories. the Angkorian roads are very much a localized centralist phenomenon.

Summary

The introduction of a settlement-resource based investigation to the study of Angkorian transport roads has demonstrated that the system was more than just military routes and pilgrimage trails. Establishment and connection of sites to the transport system seems to follow a tripartite pattern that may have a temporal connection. The first consideration of any site is to ensure that food requirements (i.e., rice and likely fish), are met. The Angkorian kings, as Groslier pointed out, stick to the lands that are suitable for their particular style of rice agriculture. Given that rice commonly bartered and taxed, the ability to grow a suitable quantity was a necessary part of fitting into the Angkorian bureaucratic system. A second class of sites are established to obtain access or control over highly valued economic resources such as iron, copper and precious stones. The last type of Angkorian site is situated at locations that are important from a political perspective, either monitoring/gaining access to the system or on the edge of their territory as an outpost.

Chapter 11. The Road Less Travelled: Conclusions and Future Directions

The objective of this analysis and assessment has been to demonstrate the utility of an integrated operational approach to archaeological transport. The preceding chapters have outlined the basic framework for integrating and testing data sets of transportation based on the communication requirements of society specifically within the context of an empire. The focus of this thesis has been to bring together the diverse information about the Angkorian transport system – inscriptions, archaeological evidence, traveller's accounts, geographic setting – within a single enquiry using a GIS database to put the information together. From this database it has been possible to test the proposition that the Angkorian road system had a long and varied development history and function and to assess the prevalent assumption that a single king, Jayavarman VII, was responsible for most of the Angkorian transport infrastructure we see today.

In this chapter, the results from Chapters 8, 9 and 10 are brought together and reviewd with an emphasis on the role of plurality both in development and function of the Angkorian transport system. In contrast to the static association with Jayavarman VII, this review highlights the spatial and temporal dynamics of the road system which is manifest in the varied distribution of components and the appearance of routes as important precursors to the formalized roads we see today. The functional analysis of transport and settlement similarly emphasizes a plurality in that roads/routes served not only military, religious or economic functions but varied throughout the course of the Angkorian period. An important point of this discussion is the recognition of the point in the life cycle of a road that is being investigated. From this regional scale focus a list of new directions for research on the Angkorian transport system is presented at the level of the various components and the introduction of new transport concepts (e.g., seasonality). The chapter concludes with an examination of the importance of the operational approach as an integrated and dynamic approach for the study of transport in empires.

A New Perspective on the Angkorian Transport System

The assessment of the Angkorian empire in this thesis has firmly established the spatial, temporal and functional characteristics of its transportation system. At a base level, the Angkorian empire facilitated movement across its home territory by formalizing roads serviced by three types of infrastructure – bridges, resthouses and water tanks. River transport also played an important role in the structuring of settlement and may help to explain why certain sites were not connected by the terrestrial system. Within this broader network there is evidence for a secondary system of roads that acted to connect main sites to places in their immediate vicinity.

The in-depth evaluation of the spatial relationships between the Angkorian transport components shows that, while there is some patterning in the spacing of resthouses and maximum distance of stone bridges from Angkor, a uniform plan was not generally applied across the system (see Figure 11.1). This point was made by Lunet de Lajonquière's during his surveys over a century ago and numerous examples can be cited from the spatial analysis in Chapter 8. Road visibility varies dramatically along most roads, suggesting that they were either less important, did not require as much substantial improvement or have been subsequently destroyed. Only the East and Northwest roads are fitted with resthouse buildings; though Albrecht noted the possibility that a series of *éléphant étapes* along the Southeast Upper road were destroyed by the Thai in the 19th century. The Southeast Lower road, formerly associated with the Southeast Canal connecting south of Roluos, possesses no infrastructure at all. Tanks, which were studied in detail here for the first time as part of the system, frequently appear within 100 m on either side of the roads. It is not possible, however, to identify physical characteristics of the tanks (e.g., size, spacing, orientation, alignment) that indicate contemporaneous construction with the road or whether they were built specifically to service the roads. As Lunet de Lajonquière also pointed out, tanks served as markers for routes on which roads eventually developed. It is also possible that tanks were placed near roads as it attracted settlement. The spatial diversity leads us to conclude that there were many different influences at work on the roads. Were roads and infrastructure under the control of Angkor directly or were provincial elites responsible for construction and maintenance of these structures? And/or were they built by central order and left to regional authorities to maintain? Following on the point that tanks often served as route markers for transport, the implication of the tank distribution on the south side of the Tonle Sap lake suggests that a secondary route may have connected Battambang to the region of Oudong and Phnom Penh to the east (see Figure 8.17). The fact that there are fewer sites (Figure 6.7) on this side of the lake indicates that a formalized route like those on the north may not have been required or possible.

The inherent diversity of the Angkorian transport system is explained through the notion of the plurality of development. This plurality is clearly evident in the amount of activity that took place between Angkorian sites from the 10th to 13th century inclusive. Based on the architectural modifications, inscriptions and event histories; the result of these activities is the establishment of the routes that would eventually become formalized roads. Shifts in regional emphasis through time – from the Northeast to the West and back to the East – show that each route fluctuated in importance.

Conventionally, scholarship holds that Jayavarman VII was responsible for much of the extant transport infrastructure. In keeping with Jacques' assertion that there is more temporal diversity in the formalized system, the GIS modelling in Chapter 9 suggests that the roads were in use as routes back to the 11th century. Much of what Jayavarman VII claimed as part of his territory was, in fact, held by Suryavarman I. Moving into the early 12th century Suryavarman II would have had a similar impact on regional transportation, in particular because of the large scale transport requirements to move forces from Angkorian territories against foreign states. Ultimately, the challenge to Jayavarman VII's claim to the road system comes from the lack of direct evidence at the level of each transport component. The Preah Khan inscription is conclusive evidence that the laterite *gîtes d'étapes* were part of his building scheme. However, this text cannot be used to link Jayavarman VII directly to the other transport components. Even the resthouses on the East road do not conform to those in the Preah Khan inscription and could represent a second wave of construction independent of this history. The only apparent association of Jayavarman VII to the bridges is the naga balustrades. The historic explanation of the appearance of bridges after the sack of Angkor in 1177 CE has no direct support given that bridges appear everywhere on the road network. If the event occurred in the first place, the Cham would have only burned those on the roads they encountered, probably along one of the eastern roads. This does not explain the appearance of bridges along the Northwest and West roads.

The implication is that there were multiple phases of development beginning with the initial consolidation by Jayavarman II and continuing through to the first ‘imperial kingdom’ of Suryavarman I and his influential successors Suryavarman II and Jayavarman VII. This diversity of development and function has not been overtly recognized or assessed rigorously within the Angkorian literature or evidence. From the perspective of development we can talk of the distinction between the establishment of a route and the construction of a road. There is no doubt that individual Angkorian rulers improved roads for specific purposes; however, the placement these roads appear to have been embedded in pre-existing routes. The concept of route thus allows the researcher to discuss the road within a temporal context (Dowdle 1987:270) that is often lacking in terms of absolute dating methods. This also applies to post-construction development and function as the primary use of the road shifted through time. It is essential to realize that there is a marked difference between determining the reason for a road’s initial construction and its subsequent long-term use or modification. Schreiber (1991:251) makes the pertinent statement that it is not who built the roads but who used and maintained them that is important. The results of a particular study are therefore dependent on the question being asked, or more directly, the transport concept that represents part of the life cycle of the road itself. The Roman military roads represent the foundation for many motorways currently used in Europe today, and have largely eschewed their violent origins. The theoretical difference offered in the operational approach to transport is that rather than identifying the historical initiating cause, the objective is to seek out the general cultural milieu in which these routes might have been brought into being and how they would have continued to be used after the initiating cause. We need to examine what the routes were used for over centuries as well as their initial formalization.

Both the capital and the empire of Angkor would have required substantial resources in order to flourish. Scholars such as Georges. and B-P Groslier and Vickery have recognized the importance of the physical location of Angkor as a key element in its longevity as the capital. But this region could not provide everything required by the Angkorian elites or by the bulk of the populace of Angkor. Using this logic, the position of Angkorian sites connected and not connected to the road system showed that many were found in proximity to key resources. Land suitable for rice was essential for supporting Angkorian settlement. Interestingly, sites situated in the best rice-growing land, such as the Battambang group, are not connected to the road system. The fact that these sites are close to the river system and access to the Tonle Sap Lake suggests that bulk transport of rice was more efficiently distributed by water than by land. In the road system, there appears to be a dichotomy between those sites situated at the ‘end’ of the roads, such as Phimai, Preah Khan KS and Vat Phu, which have access to important economic resources such as salt, iron, and copper and those sites along the roadway, such as Koh Ker and Phnom Srok, that tend to have little or no economic potential and appear to be placed more as half-way points along geographic intersections such as catchment boundaries or rivers. Even from this broad cross-section of many of these resources we are still left with no clue as to why certain sites were positioned in the landscape. Koh Ker’s position in the Stung Sen catchment has no apparent value based on the criteria evaluated here. Overall, the evidence for settlement within the transportation system indicates that a varied set of priorities beyond the immediate requirements to meet local demands for food, water and shelter were involved. We must include the role of economic and other aspects of political and religious importance to our discussion of the military and pilgrimage functions of Angkorian roads.

Combining these data sets it is possible to evaluate specific aspects of how the Angkorian transport system operated. The resthouses, and particularly the *gîtes d’étapes,* have provided some of the most detailed debates about function in the past. Their inherent religious function, ascribed by scholars since the early 20th century, is not questioned by this study. The question, as Jacques already suggested, is whether their construction was directed toward imbuing the *roads* with religious importance or protection. He argues that nothing more can be known until we understand the function of Preah Khan KS; the same argument must also be extended to Phimai. Based on the analysis here, the most reasonable response are economic and political reasons – both sites are situated near an important resource(s) (i.e., iron; salt) and are on the edge of the Angkorian frontier (i.e., Staung River, Kuoy territory; Mun River, northern limit of land suitable for Angkorian agricultural practices). The resthouses therefore act as religious and political territory markers of a trade route to Angkor that became increasingly important at least by the early 12th century. By looking at the pragmatic role of these buildings as rest stops we get a more precise picture of their function in Angkorian society.

Following the point that the roads have an inherent plurality in their development, further investigation into the pre- and post-Angkorian periods is vital. For example, note the recent publication of 19th century Thai maps of Cambodia emphasizing rivers and that the preferred routes differ from the Angkorian system (see Phasuk and Stott 2004). This suggests that the Angkorian system was laid out specifically to meet the demands of the state; with its ultimate downfall, we see a return to the 'natural' routes across the landscape. The idea that the settlement plans of the pre- and post-Angkorian period are more similar to each other than the Angkorian period is an important guide for this investigation (Groslier 1986[1973]:42-43).

Future Directions in Angkor

This examination of the Angkorian transport system represents a small part of a larger investigation using the operational approach. Given the range of influences exerted by transportation and the methodologies and theories available to archaeologists the potential range of questions that can be addressed are vast. Within the context of Angkor this study has provided the foundation on which future work can be applied. It emphasized the role of GIS as a means of collating and evaluating archaeological, historical and geographic data sets individually and collectively. On the whole the emphasis of this study has focussed on identifying the location and comparing the visible transport components (e.g., roads, resthouses, bridges, tanks) and settlement at a regional level. This information has then been filtered through the transport concepts of planning, distance and development as a means of extracting the significance of results to the roads in a more direct fashion. As a result of this initial investigation we can now identify some important research initiatives of individual component and transport concepts for future research.

Components

The groundwork for future analyses lies within more detailed studies of the individual transport components. The following questions should be evaluated:

- Roads
  - Are there secondary roads, such as at Angkor and Banteay Chhmar, at other sites?
  - Can we identify the routes taken by Angkorian kings to Vijaya?

    - Is there evidence of resource movement along the Angkorian roads?
- Resthouses
    - Is there evidence of habitation around the *gîtes d'étape* and *temple d'étape* resthouses?
    - Are there traces of other *étape* structures on the other roads that we have missed?
    - Why are there no sandstone *gîtes d'étape* between Angkor and Beng Melea?
    - Is there evidence of the *éléphant d'étapes* along the Southeast Upper road?
- Bridges
    - Is there evidence of wooden bridges along the Angkorian roads within the region of the known stone bridges?
    - Can we find any evidence of the *elephant d'étapes* listed by Albrecht along the Southeast Upper road?
- Tanks
    - Can we find evidence that directly associates tanks with roads and resting places for travellers and animals?
- Traffic
    - Does the location of infrastructure correlate with the needs of particular types of Angkorian modes of transport?

The search for secondary routes embedded within the regional system is extremely important if we are to understand localized transport activities. Most Angkorian Khmer would not have used the regional roads, so an investigation of where smaller, more local routes will therefore provide insight into a different aspect of Angkorian society. Looking beyond Angkor to locate the connections between it and foreign states is equally important. It is in these hinterland regions that we will find the limits of formalized transport infrastructure but also the extent to which the Angkorian settlement plan was extended along these routes. An important part of this type of research is that site-level information collected from excavations of resthouses or along road surveys be integrated into its broader context.

Concepts

This thesis explored a few of the concepts of transportation such as planning, development, and distance within the Angkorian period. Each of the remaining concepts could and should be addressed through the following individual questions:

- Seasonality – Examine how transportation is affected by seasonal changes by looking at the 19th century accounts and patterns of movement/activity in rural Cambodia today
    - How would the roads and rivers function throughout the year?
- Distance
    - Does the spacing of resthouses (and possibly tanks) represent the logistical requirements of particular types of traffic (e.g., elephants)?
- Navigability - Undertake surveys of the river systems to determine the extent that they could be used as travel routes
    - How navigable are each of the modern rivers?
    - Was it possible to reach the Angkorian sites away from the Tonle Sap by river?
- Decay and Re-Use – Survey the Angkorian roads to see what proportion are still in use today and assess the role of Post-Angkorian transportation
    - Why have particular sections of roadway fallen into disrepair
    - Investigate the issue of the buried bridges

A vital part of successfully examining these research questions is the introduction of new dating techniques to test the historically-based assumptions in the current literature. Obtaining dates for the construction or modification of buildings, tanks, and bridges will profoundly assist in the overall temporal association of the road system. In the Angkorian context, Carbon-14 (C-14) and Optically Stimulated Luminscence (OSL) techniques could be used, in combination with the development of a detailed ceramic chronology. The application of OSL is particularly appealing as the roads and tanks are made of piled earth with a substantial sand content which is ideal for this technique. Hyslop also raised the issue that the proper dating of a road system requires publication of associated material such as surface collections (1991:32). A similar practice within Angkor and throughout the Angkorian world needs to be pursued in the future.

The Operational Approach for Empires

Through the evaluation of Angkorian transport several key benefits of the operational approach can be identified for the study of states and empire. Overall, the daily requirements of these societies are heavily reliant on the development and proper functioning of transportation on all scales of interaction (e.g., local, regional, supra-regional). Within the parameters defined in Chapter 6 we can see that transportation provides an excellent means of evaluating the dynamics within borders and territories. As Smith pointed out, borders and territories are more effectively studied from an internal perspective rather than as areal extents. Identifying the evidence of transport and settlement within a state's extent allows us to see where, why and how elites focussed their attention within the territory. This provides a more useful perspective on why a 'border' is where it is in the archaeological record.

A second major benefit of transportation is in studying the core principles of control and power. As with early studies of trade, the discussion of control and how it is manifest in the landscape is often limited to identifying the mechanism, and its end results (e.g., control over resource, evidence of resource at imperial centres). By including transportation within this discussion of control and power, we can link the origin and destination in a more meaningful way with new research questions (e.g., where was it transported? what mode of transportation moved goods?). Political, religious and social questions of society can similarly be couched within the framework of transportation. The primary limitation to investigating control in this manner is the kind, amount and quality of information available for the empire in question.

The utility of studying dynamics and mechanisms of control are specific benefits of incorporating the operational approach into the study of imperial transport. A more generalized utility from this approach that is generally applicable to all levels of society is the collection and integration of theavailable data sets. It is from this basic procedure that an integrated analysis of the spatial, temporal, or functional character of transport can be undertaken. This thesis has demonstrated the importance of now including Angkor in cross-comparative discussions of other empires such as *Tawantinsuyu* (the Inka Empire), the Roman empire and the empire of Vijayanagara. It is argued that these empires would greatly benefit from a similar integrated study of the archaeological and historic evidence of transport and communication. By applying the operational approach to these empires it will be possible to connect daily activities in a single framework and gain a further perspective on particular historical viewpoints. We can move beyond discussion of the end points of activities and link together information to better understand *how* power is maintained, *where* goods were moved across the landscape, *what* methods of transport were available and *what* infrastructure was put in place to facilitate their regular movements. Each of these questions is itself essential in understanding empires in a more holistic perspective and as transformative entities that may remake themselves over time.

Conclusions

Through the integration and rigorous examination of the corpus of archaeological, historic and geographic information for the Angkorian empire this thesis has demonstrated an important plurality of development and function in the Angkorian transport system. The operational approach has enabled a re-assessment of particularist commentaries made about the roads themselves and created new research directions that will strengthen our understanding of the road system and its greater role in Southeast Asian archaeological inquiry.

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Appendix 1

Phlau Beng Excavation Report

Appendix 2

Location Methods

Remote Sensing Mapping Process

Selecting the type of remote sensing imagery to undertake mapping is based on the constraints of the research project. Issues considered in this study are the ability to incorporate the imagery into GIS, the extent of the study area, visibility of the transportation features, and ultimately, cost. Two forms of remote sensing imagery were used Advanced Spacebourne Thermal Emission and Reflection Radiometer (ASTER) imagery and 1992 FinnMap 1:25,000 black-and-white aerial photographs. The initial survey of archaeological features was completed using the ASTER imagery. This coverage defined the maximum study area and was directed specifically to locate the position of the roads, find new roads in other parts of the Angkorian territory, map the distribution of tanks and main Angkorian sites. Aerial imagery was purchased along the roads within Cambodia to identify tanks using a higher resolution imagery source. Overall, the ASTER imagery found between 1/10 to 1/5 of the total number of tanks mapped with aerial photographs. This being said, tanks mapped from the ASTER imagery were always confirmed in the aerial photographs, supporting its utility in identifying tanks components at a broader regional scale.

ASTER Data

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging instrument flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System (EOS). ASTER is a cooperative effort between NASA, Japan's Ministry of Economy, Trade and Industry (METI) and Japan's Earth Remote Sensing Data Analysis Center (ERSDAC). ASTER is being used to obtain detailed maps of land surface temperature, reflectance and elevation (taken from http://asterweb.jpl.nasa.gov/index.asp).

ASTER imagery records the thermal emissions along three separate wavelengths at different resolutions: Visible Near Infra-Red (VNIR) (15 m), Short Wave Infra-Red (SWIR) (30 m), and Thermal Infra-Red (TIR) (90 m). Each ASTER tile produces an area of 60 by 60 km. While commonly used in natural sciences, ASTER data has rarely been used as the primary data set for archaeological research but has appeared in the context of Peru (Jennings 2006) and northern Mesopotamia (Altawheel 2005). Neither of these studies undertook extensive mapping of their respective region, however.

ASTER Purchase, Processing and Georeferencing

Fifty ASTER tiles (1A Reconstructed Unprocessed Instrument Data) were purchased from the EOS gateway website http://edcimswww.cr.usgs.gov/pub/imswelcome/ . The tiles were taken by the ASTER sensor between 2001 and 2005, normally between December and March as any cloud cover obscures ground visibility.

The stages involved in processing the imagery to be spatially georeferenced and imported into ArcGIS 9.1 were as follows:

1. Raw RS imagery to processed A2 data with rectification in ASTER DTM extension of ENVI 4.2
2. Images were transferred from native format to TIF images within ENVI 4.2

3. Each image was corrected by rubbersheeting to fit with the base layers of rivers derived from data of the Japanese International Cooperation Agency and Mekong River Commission in ArcGIS 9.1

By comparison with the AirSAR and SPOT imagery the ASTER data was found to vary from these higher resolution and accurately georeferenced data sets by 10-30m. This error was deemed acceptable as the object of this study was to examine the spatial proximity within the ASTER set.

ASTER Mapping

Only the VNIR (15m) bands were used in this study as they had sufficient resolution to map roads, larger tanks and main sites. The mapping process involved the following stages in ArcGIS 9.1:

1. ASTER image added to ArcGIS 9.1 mapspace
2. At a scale of 1:24,000, the following features were recorded as drawn as objects in individual shapefiles:
    a. Roads – mapped as polylines, each section of road was defined according to the following type of visibility:
        i. Visible – segment clearly visible
        ii. Partially – segment is partially visible and or obscured in sections
        iii. Estimated – segment not visible; this line represents a connection of end points from Visible or Partially identified roads, clusters of archaeological features (i.e., tanks, sites), or historic accounts.
    b. Tanks – mapped as four-sided polygons[8], only those tanks that had four visible sides were recorded. Only rectilinear tanks were recorded.
    c. Enclosures – mapped as four-sided polygons, only those enclosures that had four visible sides were recorded.

Lengths, perimeters, central points (centroids of polygons) and geographic coordinates were calculated using the X Tools Pro for ArcGIS Desktop program. Azimuth data for the long axis of the tank was completed by Damian Evans within ArcView 3.1. Detailed metadata was also recorded for each feature based on its relationship to archaeological (i.e., site name), geographic (i.e., catchment) and political (i.e., province, country) data from existing data sets (JICA, Mekong River Commission).

Aerial Photograph Georeferencing

A total of 119 FinnMap 1992 b/w aerials were purchased along the lengths of the roads mapped from the ASTER imagery survey. These photographs were scanned at 300dpi as tif files for importing into ArcGIS. The images were not used in stereo pairs. The georegistration process for this imagery in ArcGIS 9.1 involved the following stages:

1. Aerial photo Image added to ArcGIS 9.1 mapspace
2. Using Georeferencing tool, points were made connecting visible axes of rivers and roads of the aerial photographs with comparable digital data sets from JICA and MRC

[8] Since Angkorian tanks are generally rectangular or square in shape it was only necessary to map the internal corners of each structure. The important variable at this resolution is size, rather than exact shape. Further study may reveal important differences relating to state or local construction, however, this would require detailed topographic survey of each tank to determine the actual construction. This way not required in this study.

3. Further rubbersheeting connections were made with visible features (e.g., river crossings, forest) of ASTER data for the same location

Aerial Photograph Mapping

The process for mapping road, tanks and sites was similar to the ASTER data process listed above. The most significant difference is that mapping was completed at a scale of 1:5000.

Appendix 3

Data for Historical Analysis and GIS Methodologies

Historic Data Sets

Architectural modification and inscriptions with evidence of a king's presence or mention in a contemporaneous context from the site are used to assess the historic distribution of each Angkorian king's influence over his territory. The sources used to create this table include information from published works by Lunet de Lajonquière (1902-1911), Parmentier (1948), Briggs (1951), Jacques and Lafond (2004), Snellgrove (2004) and also the inscription database developed by Lustig (2006). The data used to analyse the historic routes of the Angkorian period are presented in the table in Appendix 3.1.

Historic Methodology

The process of generating communication zones for each king involves the following stages in the GIS:

1. In ArcGIS 9.1, select the temples that were built/modified by or associated with (i.e., inscription erected at the site) a particular king.
2. Create a maximum extent, or 'communication zone', for each king by drawing a polygon that connects the most distant temples of his reign.

To create shared communication zones the following steps were undertaken using MapInfo and ArcGIS 9.2.

1. Import the shapefile of communication zones into MapInfo.
2. Select all communication zones and create a new layer by 'cutting out' any zones that overlap with zones held by one or more kings.
3. Export this data set into ArcGIS 9.2.
4. Calculate the areas of overlapping zones using X Tools Pro for ArcGIS.
5. Group overlapping zones and label the shared communication zone with the number of kings that shared that region (i.e., 2-12 kings).

Main Site	JII	YI	JIV	RII	JV	UI	SI	UII	HIII	JVI	DI	SII	YII	JVII	InII	JVIII	Total
Banon	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2
Banteay Chhmar	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Beng Melea	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	3
Koh Ker	0	0	1	1	1	1	0	1	0	0	0	0	0	1	0	0	6
Muang Tam	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0	4
Neak Buos	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	4
Phimai	0	0	0	0	0	0	1	0	0	1	1	1	0	1	0	0	5
Phnom Chisor	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2
Phnom Rung	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	1	5
Phnom Srok	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	3
Prasat Andet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Preah Khan of KS	0	0	0	0	1	0	1	0	0	0	0	1	0	1	1	0	5
Preah Vihear	1	1	1	1	1	0	1	1	1	1	0	1	0	0	0	0	10
Sambor Prei Kuk	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Sdok Kok Thom	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Ta Prohm of Tonle Bati	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	2
Vat Baset	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	3
Vat Ek	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Vat Nokor	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Vat Phu	1	1	0	1	0	0	1	1	1	1	0	1	0	1	0	0	9
Total	3	3	3	5	6	1	12	8	2	3	1	8	1	12	2	1	

Type of Evidence

- Architectural modification attributable to the king by style
- Inscription from Lustig database
- Inscription from summary text
- Inscription (database) and inscription (text)
- Inscription (text) and architectural modification
- Inscription (database) and architectural modification
- Inscription (database), architectural modification and Inscription (text)

Appendix 3.1 Influence of each Angkorian king on the main sites and the type of evidence supporting this interaction

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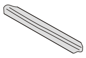
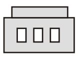
10.13 Number of geographic resources accessible for the main sites



Road	Width (m)	Source
Han dynasty (China) imperial highways	23.0	Pirazzoli-t'Serstevens 1982:74
Romano-British main road (max)	17.0	Margary 1967:20
Romano-British main road (min)	13.0	Margary 1967:20
Romano-British important	10.0	Margary 1967:20
Romano-British lesser (max)	4.0	Margary 1967:20
Romano-British lesser (min)	2.5	Margary 1967:20
Roman country road (max)	7.0	Chevallier 1976:89
Roman country road (min)	5.0	Chevallier 1976:89
Roman Nubia road	10.0	Hester et al. 1970:385
Indian rajamarga (max)	30.0	Sarkar 1914:34
Indian rajamarga (min)	15.0	Sarkar 1914:34
Indian marga	10.0	Sarkar 1914:34
Indian beethi	5.0	Sarkar 1914:34
Dahomey Royal Road (max)	30.0	Alpern 1999:15
Dahomey Royal Road (min)	20.0	Alpern 1999:15
Venezuelan raised earthen causeway (max)	8.0	Spencer and Redmond 1998:95
Venezuelan raised earthen causeway (max)	1.0	Spencer and Redmond 1998:95
Xochichalco thoroughfare (max)	5.0	Hirth 1982:323
Xochichalco thoroughfare (min)	3.0	Hirth 1982:323
La Quemada causeway (max)	14.0	Trombold 1991:159
La Quemada causeway (min)	2.0	Trombold 1991:159
Teotihuacan ceremonial avenue (max)	50.0	Charlton 1991:193
Teotihuacan ceremonial avenue (min)	40.0	Charlton 1991:193
Mayan sacbe (max)	20.0	Folan 1991:222
Mayan sacbe (min)	3.0	Folan 1991:222
Inka highway - cleared	6.3	Beck 1991:76
Inka highway - graded	17.1	Beck 1991:76
Inka highway - curbed	34.2	Beck 1991:76
Inka highway - low walls	9.0	Beck 1991:76
Inka highway - high walls	20.7	Beck 1991:76
Inka highway - causeway	6.6	Beck 1991:76
Egyptian cleared road (max)	11.0	Fenwick 2004:883
Egyptian cleared road (min)	2.0	Fenwick 2004:883
Mean road width	13.8	

Table 2.1 Road widths from historical contexts



Rest Stop	Distance apart (km)	Source
Mughal sarai	32.2	Farooque 1977:96
Han Chinese small station	2	Pirazzoli-t'Serstevens 1982:74
Han Chinese postal relay	4	Pirazzoli-t'Serstevens 1982:74
Han Chinese large station	12	Pirazzoli-t'Serstevens 1982:74
Roman Town spacing (Antonine Itineraries) (max)	28.9	Laurence 1999: 90
Roman Town spacing (Antonine Itineraries) (min)	16	Laurence 1999: 90
Roman Gaul posting stations	19.5	Berry 1987:552
Roman African wells	32.2	Hindley 1971:39
Roman Nubia	32.2	Hester et al. 1970:385
India wooden salas in 14th c. CE	0.8	Deloche 1993a:142
Mayan sacbe distances (max)	26	Bell and Church 1985:361
Mayan sacbe distances (min)	13	Bell and Church 1985:361
Inkan tampu (max)	25	Hyslop and Rivera 1984:39
Inkan tampu (min)	15	Hyslop and Rivera 1984:39
Inkan tampu (Atacama desert)	42	Hyslop and Rivera 1984:39
Mean space between rest stops	20.1	

Table 2.2 Spacing between rest stops along road from historic contexts

Type of Traffic	Dist per day (km)	Dist per hour (km)	Dist per 8hr day (km)	Source
India Mughal army (min)	5.2		5.2	Deloche 1993a:284
Indian Imperial army	12.4		12.4	Deloche 1993a:284
India Mughal army (max)	18.7		18.7	Deloche 1993a:284
India Commercial traffic	20		20	Deloche 1993a:284
Saxon land travel	24		24	Dobson 2005:8
Roman postal wagon		3.2	25.6	Kendal 1996:143
Persian army	28.9		28.9	Forbes 1964:80
India Cart/Saddled/Palanquin (av.min)	35		35	Deloche 1993a: 286
Pre-Hispanic Bearer	36	4.5	36	Drennan 1984:105
Roman pack mule		4.5	36	Kendal 1996:143
Roman postal carriage		4.8	38.4	Kendal 1996:143
India Cart/Saddled/Palanquin (av.max)	40		40	Deloche 1993a: 286
India qasid courier	40		40	Deloche 1993a:280
Roman cart		7	56	Kendal 1996:143
India Cart/Saddled/Palanquin (max)	60		60	Deloche 1993a: 286
Indian express courier (av.min)	60		60	Deloche 1993a:280
Roman 2-wheeler		8	64	Kendal 1996:143
Indian express courier (av.max)	80		80	Deloche 1993a:286
Indian relay	100		100	Deloche 1993a:280
Perisan Imperial messenger	289		289	Forbes 1964:80
Indian pilgrimage on panchakroshi road		13.3	13.3	Saraswati 1985:21

Table 2.3 Travel speeds of various types of land traffic from historical contexts

Water Travel	Mode of Traffic	Dist per day (km)	Dist per hour (km)	Dist per 8 hr day (km)	Source
India - Indus Steep Gradient - low water (av.min)	Boat		8	64	Deloche 1993b:171
India -Indus Steep Gradient - low water (av.max)	Boat		11	88	Deloche 1993b:171
India -Indus Steep Gradient - high water	Boat		20	120	Deloche 1993b:171
India -Delta - low water	Boat		6	48	Deloche 1993b:171
India -Delta - low water	Boat		12	96	Deloche 1993b:171
India -Ganga -dry season	Boat		5	40	Deloche 1993b:171
India -Ganga - monsoon season	Boat		12	96	Deloche 1993b:171
India -Winter Travel - highly sedimented river (av.min)	Boat	15		15	Deloche 1993b:171
India -Winter Travel - highly sedimented river (av.max)	Boat	30		30	Deloche 1993b:171
India -Ganges Tracking	Tracking	22		22	Deloche 1993b:173
India -Indus Tracking (av.min)	Tracking	27		27	Deloche 1993b:173
India -Indus Tracking (av.max)	Tracking	32		32	Deloche 1993b:173
India -Tracking speed 'content'	Tracking	16		16	Deloche 1993b:173
Mayan hand-propelled dugout - upstream	Boat	20		20	Drennan 1984:106
Mayan hand-propelled dugout - downstream	Boat	40		40	Drennan 1984:106
Northern England Rowing	Boat	66		66	Dobson 2005:8

Table 2.4 Travel speeds of various types of water traffic from historical contexts

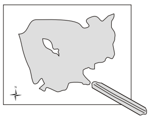
Traffic	Load (kg)	Source
Roman codex Post-wagon	490	Kendal 1996:142
Roman codex Post-carriage	325	Kendal 1996:142
Roman codex Cart	200	Kendal 1996:142
Roman codex Two-wheeler	65	Kendal 1996:142
Indian ox carts (max)	560	Deloche 1993:266
Indian ox carts (min)	300	Deloche 1993:266
Indian ox carts - rice (max)	700	Deloche 1993:266
Indian ox carts - rice (min)	500	Deloche 1993:266
Tucano cargo dugout canoe w/4 paddlers	750	Drennan 1984:106

Table 2.5 Loads of various vehicles from historic contexts

King	Reign (years)
Jayavarman II (c.770 - c.830)	60
Jayavarman III (c.839 - 877)	38
Indravarman I (877 - 889)	22
Yashovarman I (889 - c.910)	21
Harshavarman I (c.910 - 922)	12
Jayavarman IV (921 - 944) [at Koh Ker]	23
Isanavarman II (922 - 928) [at Angkor]	6
Harshavarman II (941 - 944) [at Koh Ker]	3
Rajendravarman II (944 - 968)	24
Jayavarman V (968 - 1000)	32
Udayadityavarman I (1001 - 1002)	1
Jayaviravarman (1002 - 1006?)	4
Suryavarman I (1002 - 1050)	48
Udayadityavarman II (1050 - 1066)	16
Harshavarman III (1066 - 1080)	14
Jayavarman VI (1080 - 1107)	27
Dharanindravarman (1107 - 1113)	6
Suryavarman II (1113 - c.1150)	37
Dharanindravarman II (c.1150 - ?)	8
Yashovarman II (? - 1165)	7
Tribhuvanadityavarman (1165 - 1177)	12
Jayavarman VII (1181 - 1220)	39
Indravarman II (1220 - 1270)	50
Jayavarman VIII (1270 - 1295)	25
Shrindravarman (1295 - 1307)	12
Shrindrajayavarman (1307 - 1327)	20
Jayavarman Parameshvara (1327 - ?)	?

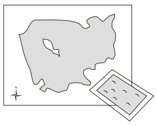
(source: Dagens, B. 2003: 36-44, and Jacques, C. 2006)

Table 5.1 List of Angkorian kings and their reign length



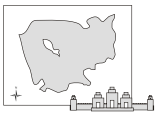
Roads	Total (km)	Aerials (km)	(% Total)	Visible (km)	(% Total)	Partial (km)	(% Total)	Estimated (km)	(% Total)
West	138.2	71.8	52.0	86.1	62.3	0.0	0.0	52.1	37.7
Northwest	268.0	122.9	45.9	60.1	22.4	27.1	10.1	180.9	67.5
Northeast	245.6	140.9	57.4	168.8	68.7	28.4	11.6	48.3	19.7
East	104.3	104.3	100.0	90.9	87.1	9.6	9.2	3.9	3.7
Southeast Upper	164.1	136.9	83.5	137.6	83.8	6.8	4.1	19.8	12.0
Southeast Lower	114.3	114.3	100.0	85.7	75.0	17.7	15.5	10.9	9.5
All Roads	1034.4	691.2	73.1	629.2	66.6	89.6	8.4	315.8	25.0

Table 8.1 Total distances and visbility of Angkorian roads mapped using ASTER and aerial photographs



RS Data	Total	Mean (m)	Max (m)	Min (m)	Bearing (°)
ASTER	3626	525.2	7017.7	142.2	83.2
Aerials	2610	273.3	3237.5	65.4	90.5
Road Survey (w/in 1000 m)	1371	309.7	2612.5	67.0	89.4
Road Survey (w/in 100 m)	369	515.3	2285.9	154.3	89.5

Table 8.2 Comparison of tanks mapped from ASTER, aerials, and within 100m of roads



Main Site	Road System	Perimeter (m)	Bearing (°)	Perimeter (m)	Bearing (°)
Banon[1]	Non	140	90	3698.3	86.8
Banteay Chhmar	Non	3424.5	86.6	4761.0	89.8
Beng Melea	Connected	3747.3	89.3	4294.9	90.0
Koh Ker	Connected	895.7	78.6	2809.7	163.4
Muang Tam	Connected	962.2	76.2	2991.2	78.1
Neak Buos[2]	Connected	268.0	11.0	2295.6	109.7
Phimai	Connected	3470.1	162.1	4810.8	159.1
Phnom Chisor[3]	Non	180.0	90.0	1167.6	91.5
Phnom Rung[4]	Connected	240.0	na	2337.8	88.6
Phnom Srok	Connected	4255.6	90.0	na	na
Prasat Andet	Connected	1324.3	82.0	1152.7	82.1
Prasat Don An	Non	1970.9	82.0	3671.1	84.4
Preah Khan KS	Connected	18253.5	62.0	7017.7	60.5
Sambor Prei Kuk	Connected	3142.3	88.9	na	na
Sdok Kok Thom	Connected	769.0	90.0	1190.8	88.2
Ta Prohm Bati	Non	3430.6	90.7	4613.3	91.5
Vat Baset	Non	1747.7	87.7	1325.8	90.3
Vat Ek	Non	668.8	89.5	na	na
Vat Nokor[5]	Non	1594.0	na	2742.3	88.0
Vat Phu (North)	Connected	1577.0	95.1	na	na
	Total Mean	2657.1	85.1	3180.0	96.4

[1]enclosure from Aymonier 1901:287, [2]enclosure from Lunet de Lajonquiere 1901(2):4

[3]enclosure from Aymonier 1900:186, [4]enclosure from Aymonier 1999b:160, [5]enclosure from Cunin 2004:168

Table 8.3 Summary of main Angkorian sites and characteristics of construction features

Road	Total Rd Length (km)	Total Length w/in last bridge (km)	Crossing	Total	Crossing Type Catchment	Permanent	Intermittent	Levee	(%) w/bridges
West	138.2	80.8	Bridges	9	0	6	0	3	64
			Potential	5	0	1	2	2	
Northwest	268.0	102.2	Bridges	16	3	3	3	7	70
			Potential	7	0	0	6	1	
Northeast	245.6	114.3	Bridges	5	0	1	4	0	14
			Potential	31	1	0	30	0	
East	104.3	104.3	Bridges	17	3	1	10	3	38
			Potential	28	0	0	26	2	
Southeast Upper	164.1	67.3	Bridges	19	1	1	5	12	73
			Potential	7	0	0	7	0	
Southeast Lower	114.3	0	Bridges	0	0	0	0	0	0
			Potential	21	1	3	16	1	

Table 8.4 Summary of stone bridge distribution and potential crossing locations within extent of furthest recorded bridge

Road	Crossing	Total	Crossing Type Main River	Permanent	Intermittent	Levee
West	Potential	9	1	0	8	0
Northwest	Potential	4	0	0	2	2
Northeast	Potential	34	1	8	25	0
Southeast Upper	Potential	7	0	3	4	0

Table 8.5 Number of potential bridge location along Angkorian roads past last known bridge

Table 8.6a Gîtes d'étape (East road)	Spacing Distance (km)	River and Bridge Proximity Dist to River (m)	River Type	Bridge w/in 500m	Tank Proximity Tank w/in 500 m	Closest Tank Dist (m)	Num Tanks w/in 500 m
Angkor (Royal Palace)*	0	na	na	na	na	na	na
Kuk Top Thom	45.6	500	P	Spean Thnot Ta Dev	Yes	200	2
Teap Chey (JVII)	14.4	500	I	No	No	>500	0
Prasat Ta En	13.5	>500	I	No	Yes	500	1
Prasat Sup Tiep A	15.4	500	I	No	Yes	500	1
Gîtes d'étapes (Preah Khan KS)	15.8	>500	I	No	No	>500	0
Mean Dist (KTT to G [PKKS])	14.8						
Mean (KTT to Pr STa)	14.4						

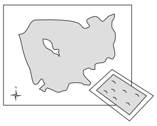
Table 8.6b Gîtes d'étape (NW road)	Spacing Distance (km)	River and Bridge Proximity Dist to River (m)	River Type	Bridge w/in 500m	Tank Proximity Tank w/in 500 m	Closest Tank Dist (m)	Num Tanks w/in 500 m
Angkor (Royal Palace)*	0	na	na	na	na	na	na
Sampeou	8.7	100	I	No	No	>500	0
Seman Teng	16.4	200	L	No	Yes	200	1
Kok O Chrung	17.7	500	P	Spean Preah Changer	No	>500	0
Kok Mon	13.3	100	I	Spean Krabon	Yes	100	1
Prohm Kel	9.9	>500	P	Spean Thbong	Yes	100	2
Ta Muan	62.4	>500	I	No	No	>500	0
Thamo	20.6	100	I	No	No	>500	0
Ban Bu	19.3	200	I	No	No	>500	0
Nong Kong	16.3	500	P	No	Yes	500	1
Nong Plong	11.5	>500	P	No	No	>500	0
Nong Ta Plaeng	12.2	500	I	No	No	>500	0
Samrong Kao?	15	200	I	No	No	>500	0
Huai Khaen	6.8	200	I	No	No	>500	0
Ku Sila	17	500	I	No	No	>500	0
Mean Dist (14 Gîtes)	17.7						
With 3 missing Gîtes (247.4 km length)	14.6						

Table 8.6c Temples d'étape (East road)	Spacing Distance (km)	River and Bridge Proximity Dist to River (m)	River Type	Bridge w/in 500m	Tank Proximity Tank w/in 500 m	Closest Tank Dist (m)	Num Tanks w/in 500 m
Angkor (Royal Palace)*	0	na	na	na	na	na	na
Chau Sey Tevoda	2.6	200	M	Spean Thma	No	>500	0
Thommanon	2.6	200	M	Spean Thma	No	>500	0
Banteay Samre	8.8	500	I	No	No	>500	0
Chao Srei Vibol	8	>500	I	No	No	>500	0
Banteay Ampil	7.7	500	I	No	Yes	500	1
Prasat Chrei	19.1	>500	I	No	Yes	200	3
Teap Chei (SII)	11.9	200	I	Spean Teap Chei	Yes	500	1
Prasat Pram	14.2	>500	I	No	No	>500	0
Prasat Sup Tiep B	15	500	I	No	No	>500	0
Prasat Chambok	12.4	>500	I	No	Yes	500	1
Temple de L'Inscription PKKS (?)	3.3	>500	I	No	No	>500	0
Mean Dist (TC to Pr C)	13.4						
Mean Dist (CSV to Pr C)	13.4						
Mean Dist (CST to PKKS)	12.1						

* denotes proposed start point

(?) denotes connection not certain

Table 8.6a-c Summary of resthouse spacing, proximity to rivers/bridges and tanks



Road	8.7a Distrubution Total Tanks	Num of Tanks	Road Length (km)*	8.7b Spacing Mean (km)	Max (km)	Min (km)
West -Aerials	27	21	52.6	2.3	6.4	0.1
Northwest - Aerials	60	42	111.3	2.3	8	0.1
Northeast - Aerials	74	59	141.2	2.4	14.2	0.0
East - Aerials	57	57	81.4	1.4	8.6	0.1
Southeast Upper - Aerials	78	71	114.7	1.3	6.4	0.0
Southeast Lower - Aerials	73	73	98.3	1.3	18.6	0
Total Aerials	369	323	599.5	1.8	18.6	0.05
West-ASTER	27	6	67.2	10	31.3	2.2
Northwest-ASTER	60	18	139.5	6	19.8	0.1
Northeast-ASTER	74	15	103.8	6.9	22	1.4
Southeast-ASTER	78	7	27.2	6.4	16.4	0
Total ASTER	239	46	337.7	7.3	31.3	0.0

* length of road based on route distance to last tank within 100m, not entire mapped length of road

Table 8.7a-b Summary of tank distribution and spacing on each Angkorian road

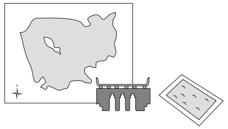
Road	Perimeter Mean (m)	Max (m)	Min (m)
West -Aerials	378.9	1195.8	118.7
Northwest - Aerials	445.5	1366.2	98.1
Northeast - Aerials	295.7	1184	94.7
East - Aerials	290.5	1116.9	86.6
Southeast Upper - Aerials	248.1	1056.8	122.3
Southeast Lower - Aerials	283.2	603.6	141.4
West-ASTER	607.2	994.4	371.6
Northwest-ASTER	778	2337.8	300.9
Northeast-ASTER	480.1	875.4	243.2
Southeast-ASTER	419.6	825.1	289.8

Table 8.8 Summary of tank perimeter on each Angkorian road

Road	Total	8.9a Orientation E-W Orient*	(%) EW	8.9b Road Alignment Long Axis	(%) LA	Short Axis	(%) SA	8.9c Catchment Position Downstream	(%) D
West -Aerials	21	11	52	3	14	0	0	14	67
Northwest - Aerials	42	20	48	5	12	7	17	24	57
Northeast - Aerials	59	26	44	28	47	5	8	42	71
East - Aerials	57	37	65	38	67	1	2	28	49
Southeast Upper	71	35	49	16	23	2	3	39	55
Southeast Lower - Aerials	73	35	48	17	23	1	1	61	84
West-ASTER	6	4	67	5	83	0	0	4	67
Northwest-ASTER	18	11	61	7	39	2	11	11	61
Northeast-ASTER	15	10	67	1	7	3	20	9	60
Southeast-ASTER	7	1	14	3	43	0	0	4	57

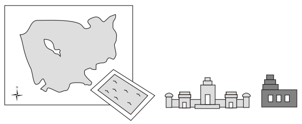
*orientation is +/- 5 degrees off 90

Table 8.9a-c Summary of tank orientation, road alignment and catchment position on each Angkorian road



	Number of Bridges w/in 500 m of tank			Type of Crossing				Tank Distance			Number of Tanks within 500 m of Bridge				
Road	Bridges nr Tanks	Total Bridges	(%) nr Tanks	Main	Permanent	Intermittent	Levee	100 m	200 m	500 m	One	Two	Three	Four	Five
West	3	9	33	0	1	0	2	0	0	3	1	1	1	0	0
Northwest	7	16	44	1	1	3	2	1	0	6	7	0	0	0	0
Northeast	2	5	40	0	0	2	0	0	1	1	0	2	0	0	0
East	10	17	59	1	0	2	7	4	1	5	5	1	4	0	0
Southeast Upper	14	19	74	0	0	4	10	3	5	6	8	3	0	2	1
Total	36	66		2	2	11	21	8	7	21	21	7	5	2	1

Table 8.10 Summary of bridge and tank relationship for each Angkorian road



			Spacing			Perimeter			Orientation	Road Alignment		Catch Position
Road	Tank Number	Rd Length (km)	Avg (m)	Max (m)	Min (m)	Avg	Max	Min	E-W Orient	Long Axis	Short Axis	Downstream
East (both resthouses)	57	81.4	1197.1	8582.0	41.2	290.5	1169.9	86.6	35	38	1	28
Northwest	43	101.4	2106.6	7930.1	21.2	475.8	1444.0	98.1	22	5	9	24

Table 8.11 Summary of resthouse and tank relationship on East and Northwest roads

8.12a

Northwest Road (40.9km section)			Perimeter			Orientation, Alignment, Position		
Gites	Total Tanks	Mean Spacing (km)	Mean (m)	Max (m)	Min (m)	Bearing (°)	Alignment	Catchm Pos
Kok O Chrung	8	2	431.2	1216.9	152.9	83.8	not	Downstream
Kok Mon	5	2.2	402.1	586.1	126.4	87.8	not	Downstream
Prohm Kel	1	4.9	340.0	340.0	340.0	76.0	not	Upstream

8.12b

East Road (72.6km section)			Perimeter			Orientation, Alignment, Position		
Temple	Total Tanks	Mean Spacing (km)	Mean (m)	Max (m)	Min (m)	Bearing (°)	Alignment	Catchm Pos
Prasat Chrei	6	2.7	286.6	537.9	124.1	85.2	not	Downstream
Teap Chei (SII)	3	3.0	326.6	570.7	175.6	98.7	Long	Downstream
Prasat Pram	14	0.9	302.6	1169.9	86.6	94.4	Long/not	Upstream
Prasat Sup Tiep A	18	1.1	245.6	523.4	106.1	91.2	Long	Downstream
Prasat Chambok	9	0.7	264.5	418.0	152.4	90.3	Long	Upstream

Table 8.12a-b Summary of tank and resthouse relationships

Temple	Road System	River Dist (km)	Catch River Dist (km)
Banon	non	0.5	0.5
Banteay Chhmar-N	non	4.0	40.0
Banteay Chhmar-W	non	4.2	13.7
Beng Melea-N	connected	1.6	23.9
Beng Melea-S	connected	2.6	22.3
Koh Ker	connected	0.1	38.9
Muang Tam-E	connected	0.4	26.2
Neak Buos	connected	1.4	65.8
Phimai	connected	0.8	0.8
Phnom Chisor	non	1.7	41.8
Phnom Rung-E	connected	1.5	24.8
Phnom Rung-W	connected	4.0	29.5
Phnom Srok	connected	4.6	16.8
Prasat Andet	connected	0.2	14.6
Prasat Don An	non	0.5	65.2
Preah Khan-E	connected	4.7	4.7
Preah Khan-S	connected	1.8	11.9
Preah Vihear-E	non	1.0	4.0
Sdok Kok Thom-W	connected	3.4	25.2
SPK	connected	0.6	6.2
Ta Prohm Bati	non	0.5	25.6
Vat Baset	non	0.9	57.3
Vat Ek	non	0.4	6.1
Vat Nokor	non	2.5	2.5
Vat Phu	connected	1.3	8.1
	Mean	1.8	23.1

Table 8.13 Main Angkorian site access to nearest river and catchment river

Main Site	River Dist (km)	Road Dist (km)	Difference (km)	Ratio River:Road
Beng Melea	118.7	45.7	73.0	2.6
Koh Ker	591.8	106.4	485.4	5.6
Muang Tam	1498.3	169.9	1328.4	8.8
Neak Buos	585.6	173.6	412.0	3.4
Phimai	1520.5	268.0	1252.5	5.7
Phnom Rung	1655.6	172.6	1482.9	9.6
Phnom Srok	168.0	66.9	101.1	2.5
Prasat Andet	179.8	127.0	52.7	1.4
Preah Khan KS	261.5	104.3	157.1	2.5
Sambor Prei Kuk	292.0	164.1	127.9	1.8
Sdok Kok Thom	273.3	136.6	136.7	2.0
Vat Phu	808.2	291.3	516.9	2.8

Table 8.14 Effect of Angkorian road on travel by river for sites connected to road system

				Potential Routes				
Event	Date (CE)	King	Century (CE)	West	NW	NE	East	SE (U&L)
Movement of capitol to Koh Ker	921	Jayavarman IV	10th			Yes	Yes	
Expedition to Champa, pillaging Po Nagar	950	Rajendravarman	10th				Yes	Yes
Civil war in northwest Cambodia	1002-1004	Suryavarman I	11th	Yes	Yes			
Interventions with Buddhist community	1022-1025	Suryavarman I	11th	Yes				
Rebellion in the south (possibly by the Cham)	1051	Udayadityavarman II	11th					Yes
Cambodian incursion into Champa (take Sambor)	1056	Udayadityavarman II	11th				Yes	Yes
Rebellion in the northeast	1060's	Udayadityavarman II	11th			Yes	Yes	
Rebellion of Prthusaila, Phnom Rung	1066	Udayadityavarman II	11th		Yes			
Campaign against Dai Viet	1128	Suryavarman II	12th			Yes	Yes	
Expedition against Haripunjaya	1100's	Suryavarman II	12th		Yes		Yes	Yes
Naval expedition to Dai Viet	1129	Suryavarman II	12th				Yes	Yes
Campaign against Dai Viet	1136	Suryavarman II	12th			Yes	Yes	Yes
Conquers Vijaya	1145	Suryavarman II	12th				Yes	Yes
First campaign against Champa	1190	Jayavarman VII	12th				Yes	Yes
Second campaign against Champa	1192	Jayavarman VII	12th				Yes	Yes
Attack on Champa (Annexes State?)	1203	Jayavarman VII	13th				Yes	Yes
Cambodian-Cham attack on Nghe-An	1216-1218	Jayavarman VII	13th				Yes	Yes
Total Potential Events along Route				2	3	4	13	11

Table 9.1 Historic events* and potential route involved
*(based on summary in Dagens 2003:38-42 and notes by Michael Vickery, pers comm. Nov. 2006)

Cambodian Products	Chinese Imports
Kingfisher feathers	Gold
Elephant tusks	Silver
Rhinoceros horn	Silk Fabrics
Beeswax	Tin wares
Laka-wood	Mercury
Cardamom	Iron pots
Gamboge	Copper trays
Lacquer	
Chaulmoogra oil	
Pepper	
Salt	

Table 10.1 List of important goods exported and imported into Cambodia based on the records of Zhou Daguan

Site	Soil	(%)
Angkor	Acrisol	82
	Fluvisol	9
	Gleysol	6
	Water	2
	Cambisol	1
Banon	Luvisol	58
	Cambisol	20
	Acrisol	18
	Fluvisol	2
	Leptosol	1
Banteay Chhmar	Acrisol	94
	Cambisol	4
	Slope Complex	2
	Arenosol	0
Beng Melea	Acrisol	86
	Cambisol	14
Koh Ker	Acrisol	87
	Cambisol	11
	Ferralsol	2
Muang Tam	Acrisol	83
	Slope Complex	4
	Arenosol	4
	Rock	3
	Vertisol	3
	Luvisol	2
	Gleysol	1
	Arenosol	0
	Water	0
	Cambisol	0
Phimai	Acrisol	41
	Gleysol	30
	Luvisol	23
	Solonetz	4
	Lixisol	1
	Arenosol	0
	Cambisol	0
	Water	0
Phnom Chisor	Acrisol	77
	Plinthosol	16
	Cambisol	3
	Water	2
	Gleysol	2
	Leptosol	0
	Fluvisol	0
	Arenosol	0
Phnom Rung	Acrisol	84
	Arenosol	5
	Luvisol	3
	Rock	3
	Vertisol	3
	Gleysol	2
	Slope Complex	1
	Water	0
Phnom Srok	Acrisol	60
	Plinthosol	33
	Gleysol	4
	Arenosol	2
	Cambisol	0
Prasat Andet	Acrisol	56
	Plinthosol	25
	Gleysol	18
	Water	1
Prasat Don An	Acrisol	80
	Gleysol	12
	Luvisol	7
	Fluvisol	2
Prasat Neak Buos	Acrisol	70
	Slope Complex	20
	Cambisol	9
	Rock	1
	Arenosol	0
Preah Khan KS	Acrisol	88
	Cambisol	12
Preah Vihear	Acrisol	53
	Cambisol	20
	Arenosol	12
	Slope Complex	11
	Ferralsol	3
	Fluvisol	0
	Water	0
	Luvisol	0
	Chernozem	0
	Lixisol	0
	Rock	0
Sambor Prei Kuk	Acrisol	93
	Leptosol	2
	Plinthosol	2
	Arenosol	2
	Cambisol	1
Sdok Kok Thom	Acrisol	70
	Arenosol	10
	Luvisol	9
	Slope Complex	4
	Cambisol	4
	Chernozem	3
	Ferralsol	1
	Water	0
	Lixisol	0
Ta Prohm Bati	Acrisol	77
	Cambisol	9
	Plinthosol	8
	Water	3
	Gleysol	1
	Fluvisol	1
	Residential	0
	Leptosol	0
	Arenosol	0
Vat Baset	Luvisol	53
	Gleysol	40
	Fluvisol	7
	Leptosol	0
	Cambisol	0
Vat Ek	Luvisol	69
	Gleysol	18
	Fluvisol	8
	Cambisol	4
	Leptosol	1
	Acrisol	0
Vat Nokor	Cambisol	31
	Acrisol	24
	Ferralsol	23
	Gleysol	10
	Water	7
	Fluvisol	4
	Leptosol	1
Vat Phu	Acrisol	53
	Cambisol	17
	Luvisol	11
	Rock	9
	Water	5
	Leptosol	3
	Gleysol	2
	Plinthosol	0

0 = <1%

Table 10.2 Major soil types within 25 km radius of main Angkorian sites

Economic Resources		Comestible		
Site	Road	Rice Growing	Fish	Salt
Angkor	All	Good	Yes	No
Phnom Srok	West	Good	Yes	No
Sdok Kok Thom	West	Good	No	No
Phnom Rung	Northwest	Good	No	No
Muang Tam	Northwest	Good	No	No
Phimai	Northwest	Good	No	Yes
Koh Ker	Northeast	Good	No	No
Neak Buos	Northeast	Good	No	No
Vat Phu	Northeast	Good	No	No
Beng Melea	Northeast/East	Good	No	No
Preah Khan KS	East	Good	No	No
Prasat Andet	Southeast Lower	Good	Yes	No
Sambor Prei Kuk	Southeast Upper	Good	Yes	No
Banteay Chhmar	Non	Good	No	No
Preah Vihear	Non	Good	No	No
Vat Nokor	Non	Not	Yes	No
Vat Ek	Non	Very Good	Yes	No
Vat Baset	Non	Very Good	Yes	No
Banon	Non	Very Good	Yes	No
Prasat Don An	Non	Good	Yes	No
Ta Prohm Tonle Bati	Non	Good	Yes	No
Phnom Chisor	Non	Good	Yes	Yes

Table 10.3 Summary of main site access to comestible economic resources

Site	Resource	Distance (km)	Days of Travel (25km/day)
Beng Melea	Iron	16.9	1
Angkor	Iron	17.7	1
Preah Khan KS	Iron	27.0	2
Preah Khan KS	Iron	36.5	2
Preah Khan KS	Iron	32.4	2
Preah Khan KS	Iron	33.3	2
Preah Khan KS	Iron	48.2	2
Banon	Iron	35.5	3
Phnom Srok	Iron	66.5	3
Neak Buos	Iron	60.6	3
Preah Khan KS	Iron	71.2	3

Table 10.4 Summary of main site access to iron sources

Site	Resource	Distance (km)	Days of Travel (25km/day)
Vat Phu	Copper	11.2	1
Phnom Chisor	Tin	25.3	2
Vat Phu	Copper	25.4	2
Preah Khan KS	Copper-Lead-Zinc	34.1	2
Vat Phu	Tin	40.7	2
Vat Phu	Copper	44.3	2
Vat Phu	Copper	45.1	2
Preah Khan KS	Copper-Lead-Zinc	45.2	2
Vat Phu	Copper	46.5	2
Neak Buos	Copper-Lead-Zinc	64.0	3
Vat Nokor	Copper-Lead-Zinc	69.5	3
Vat Phu	Copper	72.3	3
Vat Phu	Copper	74.5	3
Vat Phu	Copper	75.4	4
Ta Prohm Bati	Tin	86.0	4
Vat Phu	Copper	98.5	4
Vat Phu	Tin	113.5	5
Vat Phu	Copper	118.1	5
Vat Phu	Copper	122.8	5

Table 10.5 Summary of main site access to copper and tin sources

Site	Resource	Distance (km)	Days of Travel (25km/day)
Banteay Chhmar	Gold	1.9	1
Preah Khan KS	Gold	21.0	1
Preah Khan KS	Gold	21.2	1
Vat Phu	Gold	25.7	2
Preah Khan KS	Gold	30.1	2
Sdok Kok Thom	Gold	56.8	3
Phnom Srok	Gold	57.6	3
Banon	Gold	61.7	3
Sambor Prei Kuk	Gold	66.8	3
Sdok Kok Thom	Gold	79.7	4
Vat Nokor	Gold	80.7	4
Phnom Chisor	Gold	89.6	4
Vat Ek	Gold	92.3	4
Sdok Kok Thom	Gold	92.5	4
Prasat Don An	Silver	90.8	4
Vat Phu	Gold	98.6	5
Vat Phu	Gold	107.2	5
Vat Phu	Gold	123.0	6
Vat Phu	Gold	130.0	6
Vat Phu	Gold	135.8	6
Vat Phu	Gold	175.5	>6

Table 10.6 Summary of main site access to gold sources

Site	Resource	Distance (km)	Days of Travel (25km/day)
Vat Phu	Gem Sapphire-Ruby	7.1	1
Preah Vihear	Gem Sapphire-Ruby	24.4	1
Vat Phu	Gem Sapphire-Ruby	36.1	2
Preah Khan KS	Gem Sapphire-Ruby	53.9	3
Banon	Gem Sapphire-Ruby	58.1	3
Banon	Gem Quartz-Amethyst	58.3	3
Vat Phu	Gem Quartz-Amethyst	57.5	3
Sambor Prei Kuk	Gem Quartz-Amethyst	66.1	3
Preah Khan KS	Gemstones	64.9	3
Preah Khan KS	Gemstones	61.9	3
Prasat Don An	Gem Sapphire-Ruby	87.7	4

Table 10.7 Summary of main site access to gemstone sources

Site	Road	Iron	Copper	Tin	Gold	Silver	Gems
Angkor	All	Yes	No	No	No	No	No
Phnom Srok	West	No	No	No	No	No	No
Sdok Kok Thom	West	No	No	No	Yes*	No	No
Phnom Rung	Northwest	No	No	No	No	No	No
Muang Tam	Northwest	No	No	No	No	No	No
Phimai	Northwest	No	No	No	No	No	No
Koh Ker	Northeast	No	No	No	No	No	No
Neak Buos	Northeast	No	No	No	No	No	No
Vat Phu	Northeast	No	Yes	Possibly	Yes*	No	Yes
Beng Melea	Northeast/East	No	No	No	No	No	No
Preah Khan KS	East	Yes**	Yes	No	Yes	No	Possibly
Prasat Andet	Southeast Lower	No	No	No	No	No	No
Sambor Prei Kuk	Southeast Upper	No	No	No	No	No	No
Banteay Chhmar	Non	No	No	No	Yes	No	No
Preah Vihear	Non	No	No	No	No	No	Yes
Vat Nokor	Non	No	No	No	No	No	No
Vat Ek	Non	No	No	No	No	No	No
Vat Baset	Non	No	No	No	No	No	No
Banon	Non	No	No	No	No	No	Possibly
Prasat Don An	Non	No	No	No	No	No	No
Ta Prohm Tonle Bati	Non	No	No	Possibly	No	No	No
Phnom Chisor	Non	No	No	Yes	No	No	No

*Sdok Kok Thom and Vat Phu are closest Angkorian sites to several sources west and east of the study area

**PKKS near numerous iron sources within two days travel

Table 10.8 Summary of main site access to industrial economic resources

Site	Resource	Distance (km)	Days of Travel (25km/day)
Preah Vihear	Catchment	0.4	1
Beng Melea	Catchment	0.6	1
Neak Buos	Catchment	1.4	1
Banteay Chhmar	Catchment	1.9	1
Vat Ek	Catchment	2.0	1
Vat Baset	Catchment	4.4	1
Ta Prohm Bati	Catchment	4.9	1
Phnom Srok	Catchment	6.1	1
Banon	Catchment	6.8	1
Prasat Don An	Catchment	10.5	1
Prasat Andet	Catchment	10.6	1
Phnom Chisor	Catchment	11.4	1
Koh Ker	Catchment	14.2	1
Prasat Bakan	Catchment	16.4	1
Muang Tam	Catchment	24.4	1
Vat Nokor	Catchment	26.5	2
Sdok Kok Thom	Catchment	28.0	2
Phnom Rung	Catchment	29.9	2
Sambor Prei Kuk	Catchment	31.3	2
Phimai	Catchment	120.7	5

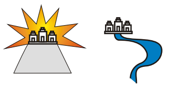
Table 10.9 Summary of main site access to catchment boundary

Site	Resource	Distance (km)	Days of Travel (25km/day)
Preah Vihear	Pass	0.0	1
Preah Vihear	Pass	5.1	1
Neak Buos	Pass	18.5	1
Preah Vihear	Pass	18.7	1
Vat Phu	Pass	26.6	2
Neak Buos	Pass	26.9	2
Muang Tam	Pass	27.8	2
Banteay Chhmar	Pass	30.3	2
Vat Phu	Pass	30.9	2
Vat Phu	Pass	33.1	2
Vat Phu	Pass	34.7	2
Muang Tam	Pass	38.5	2
Banteay Chhmar	Pass	38.7	2
Vat Phu	Pass	44.7	2

Table 10.10 Summary of main site access to Dangrek passes

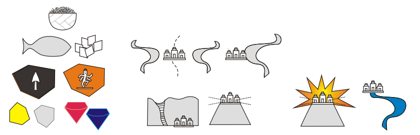
		River System		Topography	
Site	Road	Major River	Catchment	Dangrek	Hill
Angkor	All	No	Yes	No	Yes
Phnom Srok	West	No	Yes	No	No
Sdok Kok Thom	West	No	No	No	No
Phnom Rung	Northwest	No	No	Yes	Yes
Muang Tam	Northwest	No	No	Yes	No
Phimai	Northwest	Yes	No	No	No
Koh Ker	Northeast	No	No	No	No
Neak Buos	Northeast	No	Yes	Yes	No
Vat Phu	Northeast	Yes	No	No	Yes
Beng Melea	Northeast/East	No	Yes	No	No
Preah Khan KS	East	Yes	No	No	No
Prasat Andet	Southeast Lower	No	Yes	No	No
Sambor Prei Kuk	Southeast Upper	Yes	No	No	No
Banteay Chhmar	Non	No	Yes	Yes	No
Preah Vihear	Non	No	Yes	Yes	Yes
Vat Nokor	Non	Yes	No	No	Yes
Vat Ek	Non	No	Yes	No	No
Vat Baset	Non	No	Yes	No	No
Banon	Non	Yes	No	No	Yes
Prasat Don An	Non	No	No	No	No
Ta Prohm Tonle Bat	Non	No	Yes	No	No
Phnom Chisor	Non	No	No	No	Yes

Table 10.11 Summary of main site access to Political resources



Site	Road	Phnom	River Origin
Angkor	All	Yes	No
Phnom Srok	West	No	No
Sdok Kok Thom	West	No	No
Phnom Rung	Northwest	Yes	No
Muang Tam	Northwest	No	No
Phimai	Northwest	No	No
Koh Ker	Northeast	No	No
Neak Buos	Northeast	No	No
Vat Phu	Northeast	Yes	No
Beng Melea	Northeast/East	No	No
Preah Khan KS	East	No	No
Prasat Andet	Southeast Lower	No	No
Sambor Prei Kuk	Southeast Upper	No	No
Banteay Chhmar	Non	No	No
Preah Vihear	Non	Yes	Yes
Vat Nokor	Non	Yes	No
Vat Ek	Non	No	No
Vat Baset	Non	No	No
Banon	Non	Yes	No
Prasat Don An	Non	No	No
Ta Prohm Tonle Bati	Non	No	No
Phnom Chisor	Non	Yes	No

Table 10.12 Summary of main site access to Religious resources



Site	Road	Economic	Political	Religious	Total
Vat Phu	Northeast	4	2	1	7
Preah Vihear	Non	2	3	2	7
Phnom Chisor	Non	4	1	1	6
Angkor	All	3	2	1	6
Preah Khan KS	East	4	1	0	5
Banon	Non	2	2	1	5
Vat Nokor	Non	1	2	1	4
Phnom Rung	Northwest	1	2	1	4
Banteay Chhmar	Non	2	2	0	4
Vat Ek	Non	2	1	0	3
Vat Baset	Non	2	1	0	3
Ta Prohm Tonle Bati	Non	2	1	0	3
Sambor Prei Kuk	Southeast Upper	2	1	0	3
Prasat Andet	Southeast Lower	2	1	0	3
Phnom Srok	West	2	1	0	3
Phimai	Northwest	2	1	0	3
Neak Buos	Northeast	1	2	0	3
Sdok Kok Thom	West	2	0	0	2
Prasat Don An	Non	2	0	0	2
Muang Tam	Northwest	1	1	0	2
Beng Melea	Northeast/East	1	1	0	2
Koh Ker	Northeast	1	0	0	1

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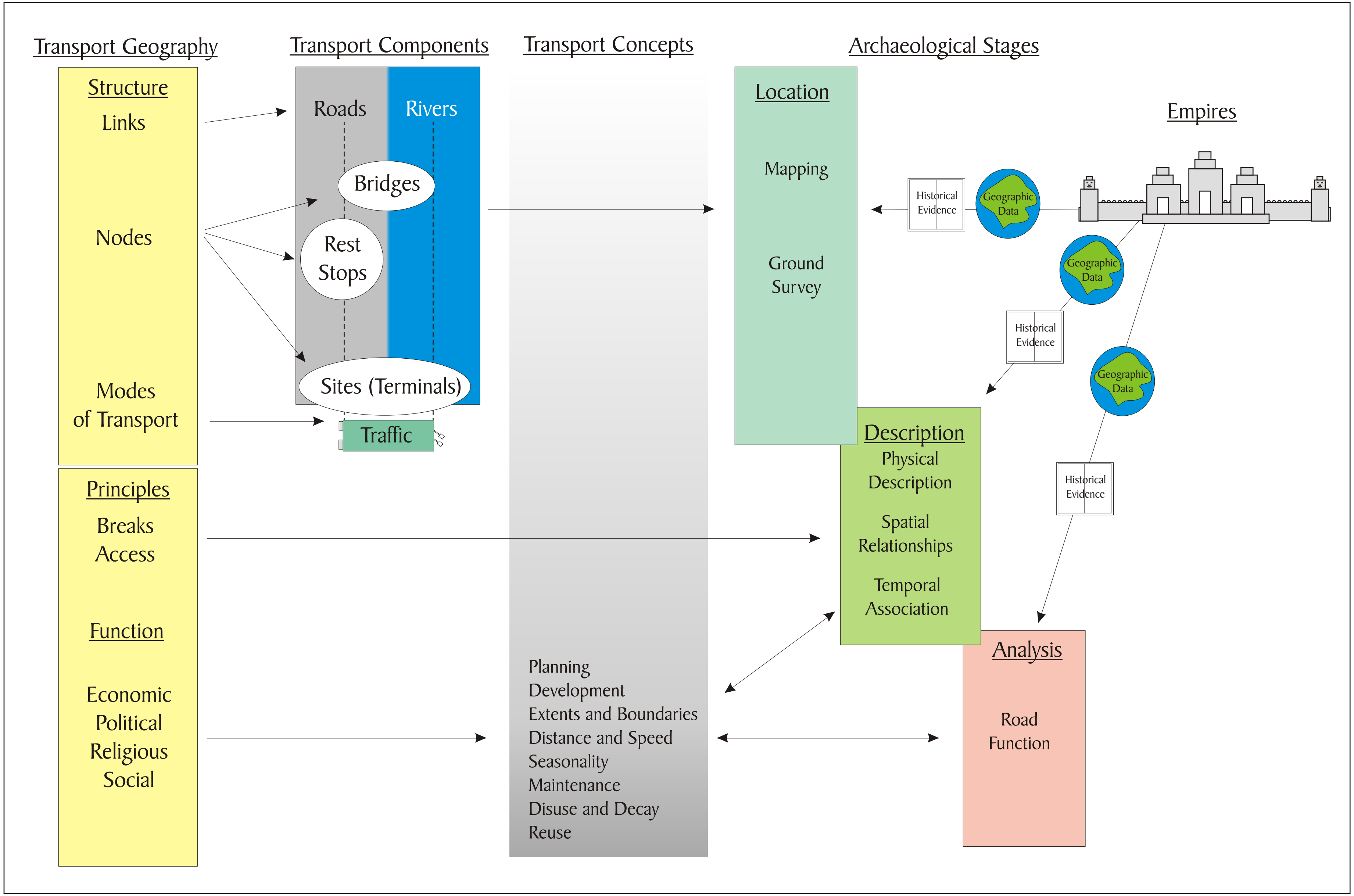

Figure 4.1 Schematic of the operational approach to archaeological transportation

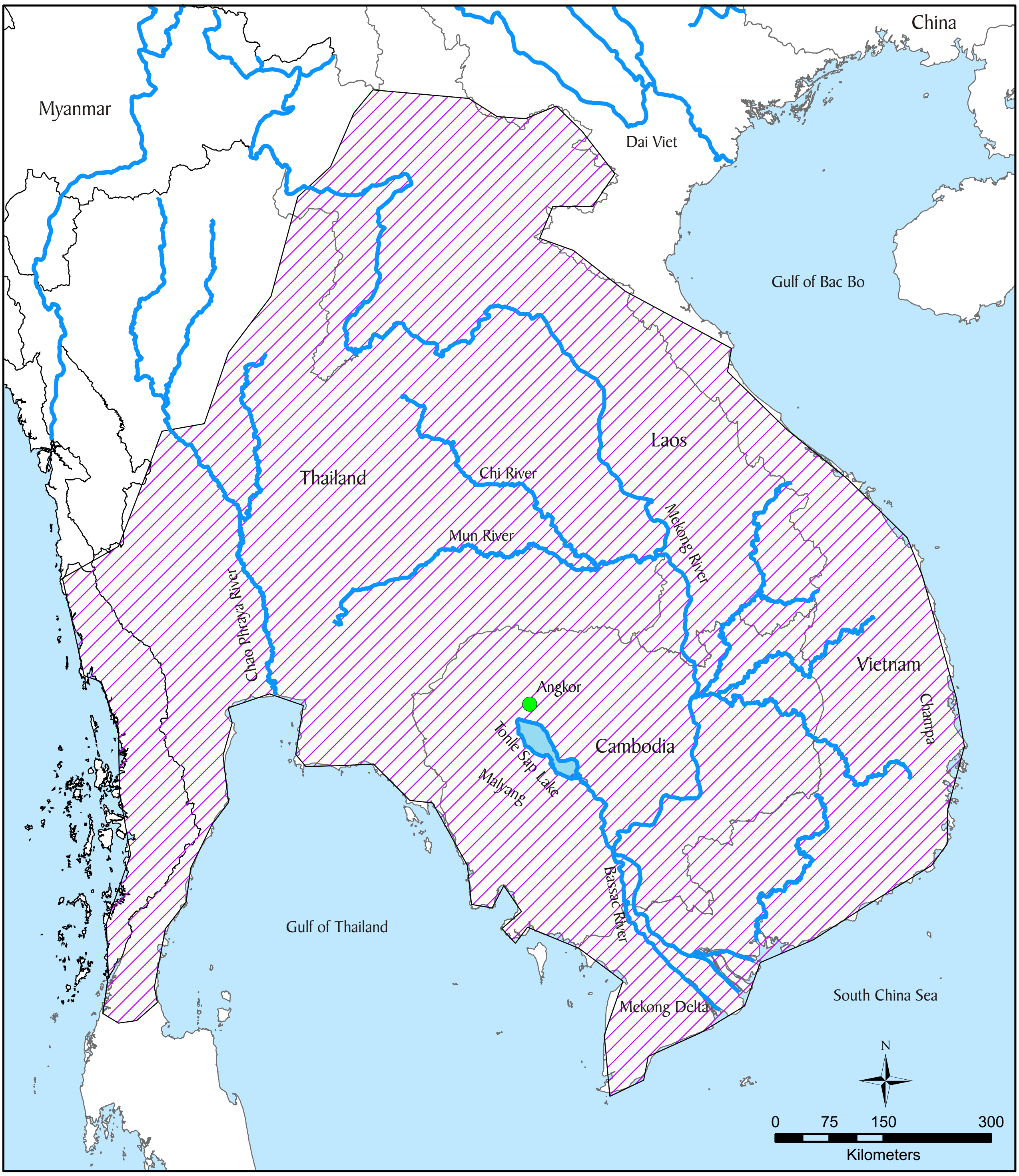

Figure 5.1 Map of geographic locations, sites mentioned in text and proposed maximum extent of the Angkorian Empire (late 12th-early 13th century)

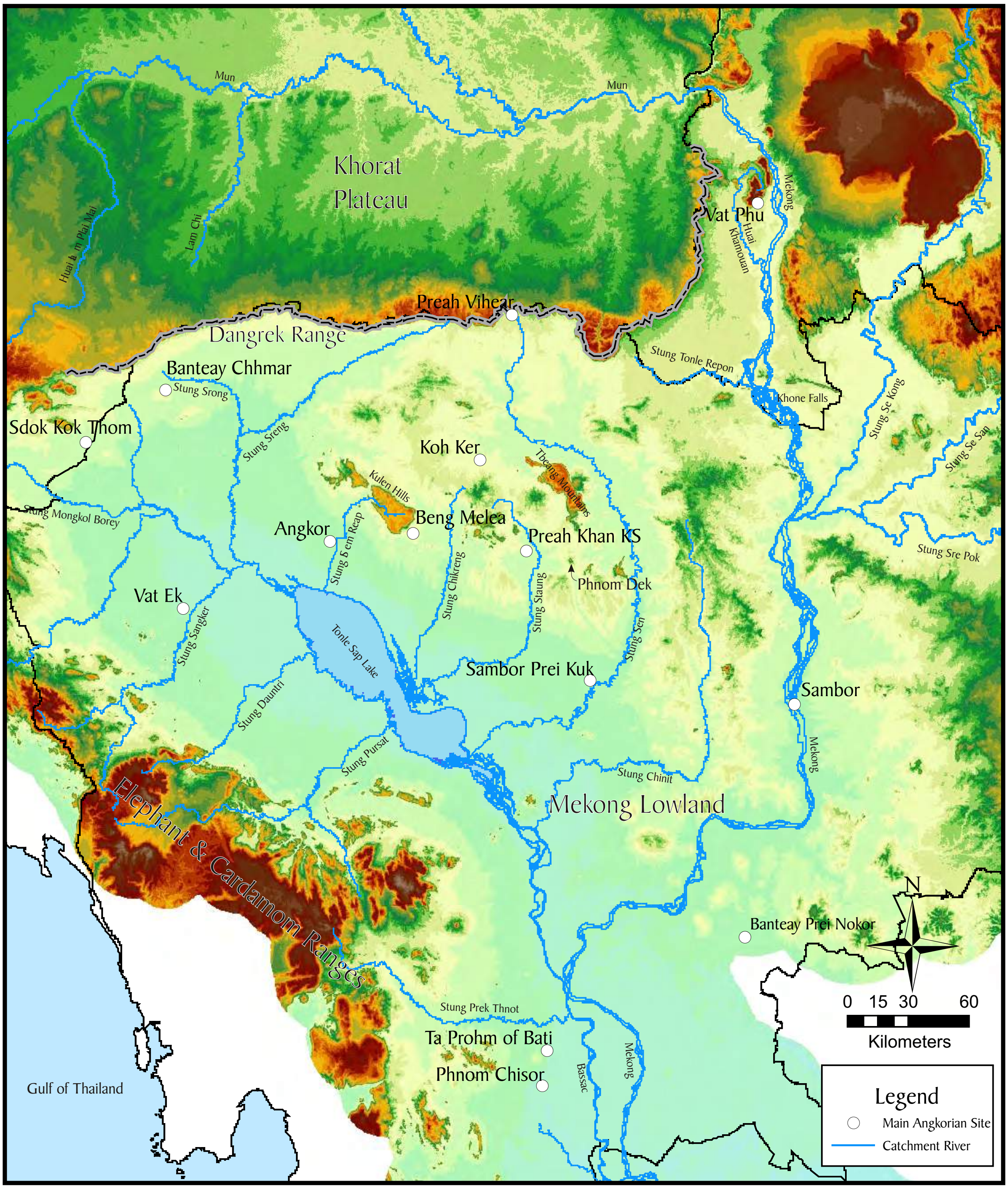

Figure 5.2 Map of geographic features in the Mekong Catchment and sites mentioned in the text

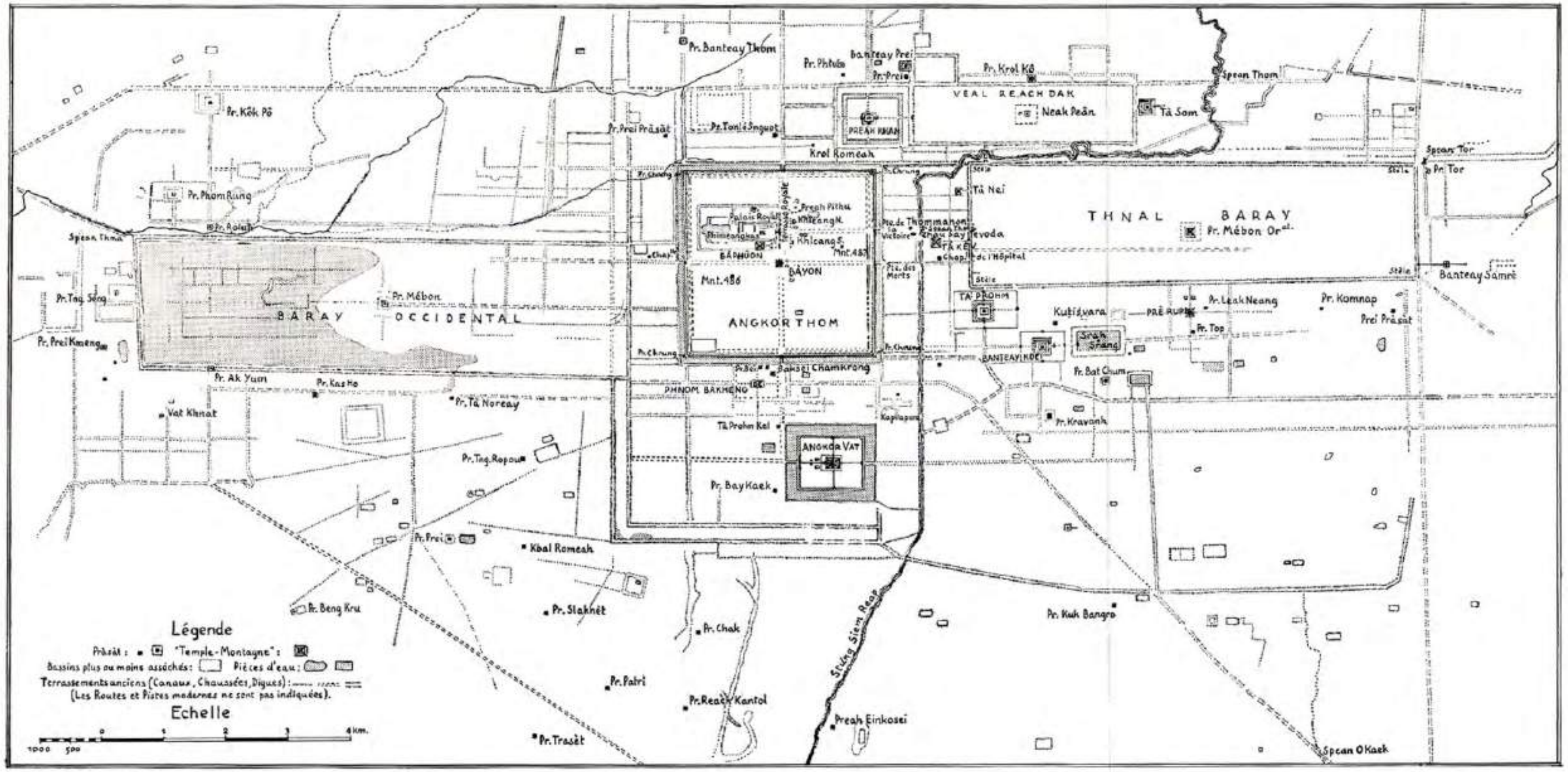

Figure 5.3 Map of temple sites in Angkor

Figure 5.4a Koh Ker (a) the Prang temple mountain and (b) example of large *shivalinga* at Prasat Thnoeng (I)

Figure 5.5 Bas relief from Angkor Wat depicting 'Thai' hill tribe militia in the Angkorian military procession

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Figure 5.7 Jayavarman VII resthouse building within enclosure of Preah Khan KS

Figure 5.8 Face towers built on temples attributed to Jayavarman VII (l) Banteay Chhmar (r) Preah Khan KS

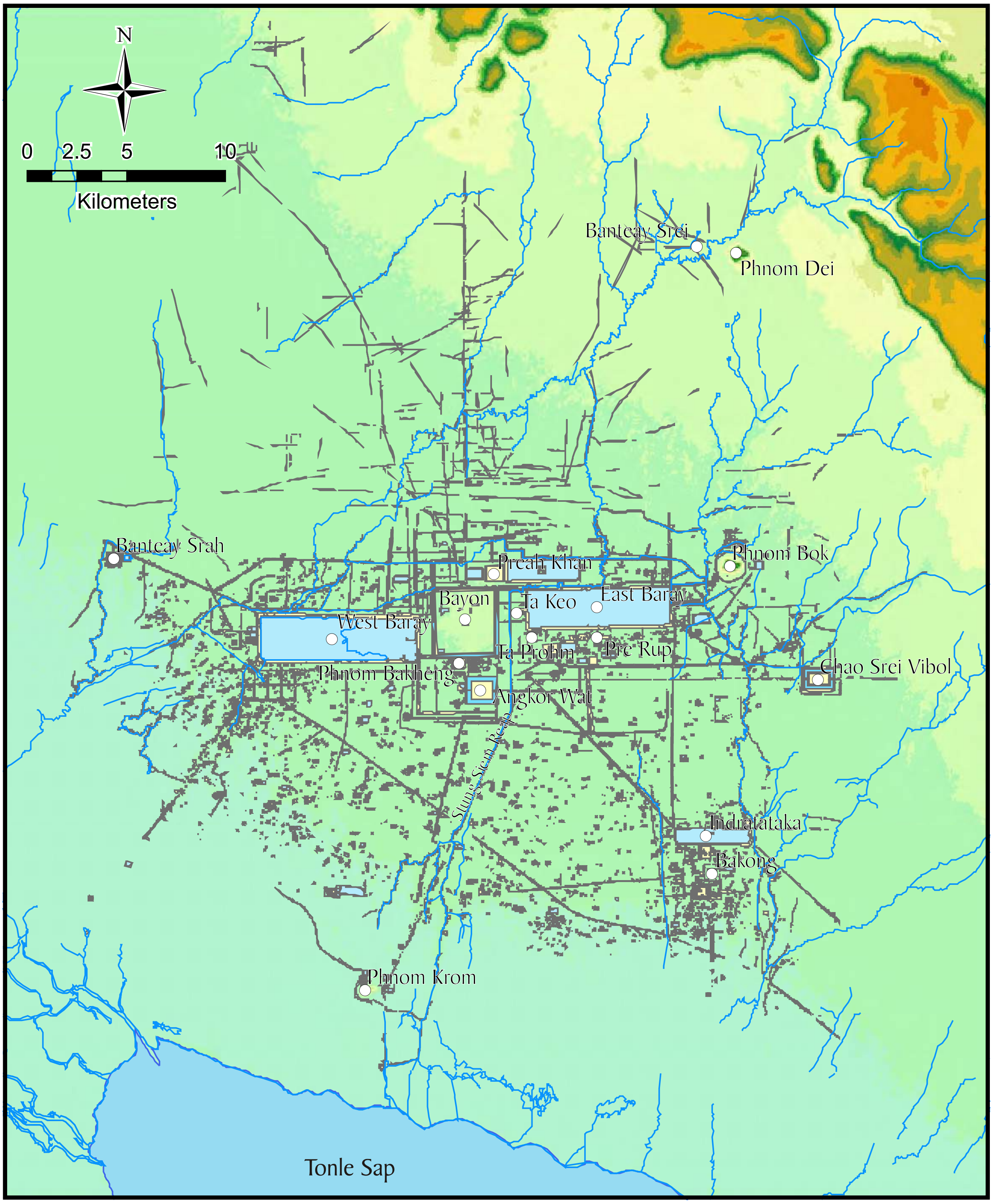

Figure 6.1 The city of Angkor. Extent of features mapped by Pottier (1999) and Evans (2002 and sites mentioned in the text

Figure 6.2a-b Angkorian landscape features (a) village-level temple with horseshoe-shaped moat and *trapeang* (pond) and (b) rice fields separated by bunds

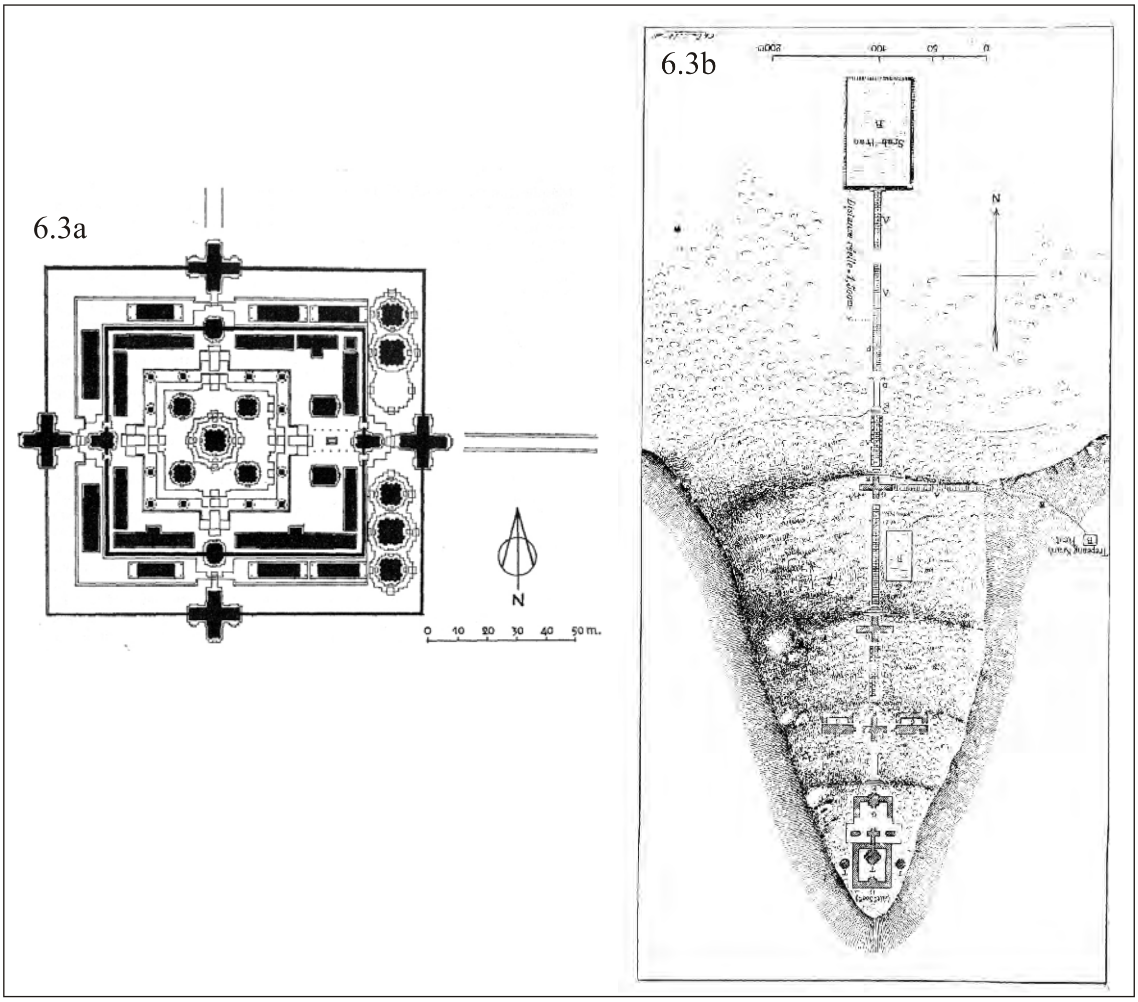

Figure 6.3a-b Architectural layouts of Angkorian temples (a) concentric enclosure of Pre Rup and (b) axial plan at Preah Vihear

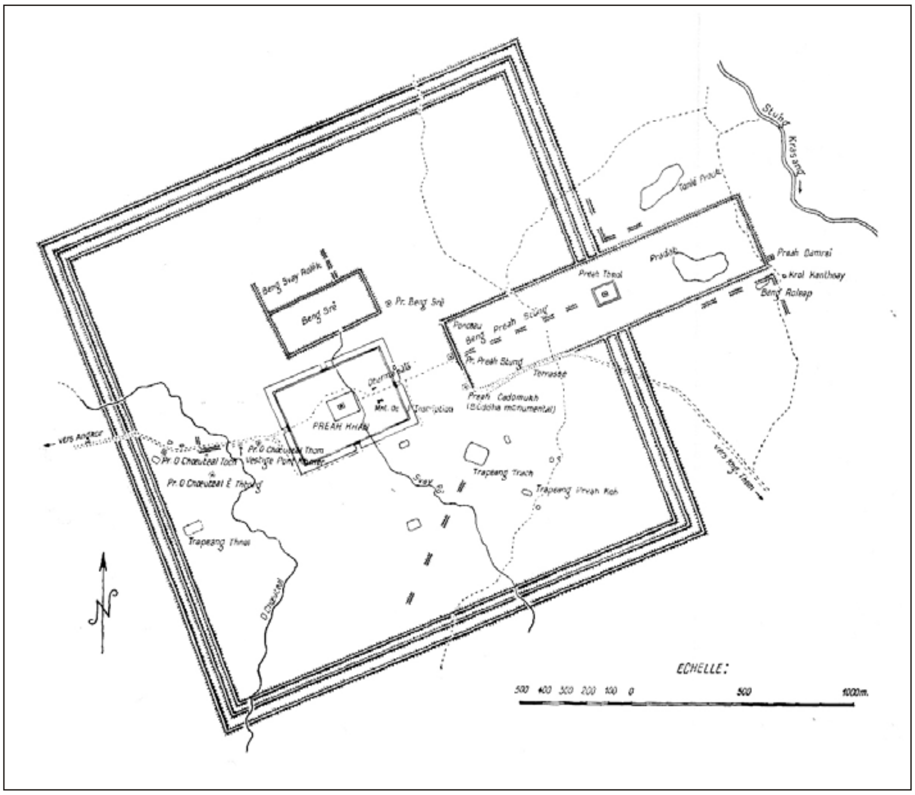

Figure 6.4 The city of Preah Khan of Kompong Svay

Figure 6.5a-b Different profiles of Angkorian temples (a) ‘temple mountain’ at Pre Rup and (b) single level at Phnom Krom

Figure 6.ba-b   Variation in number of towers (a) single tower at Prasat Neang Khmau, Koh Ker and (b) quincunx arrangement of Angkor Wat

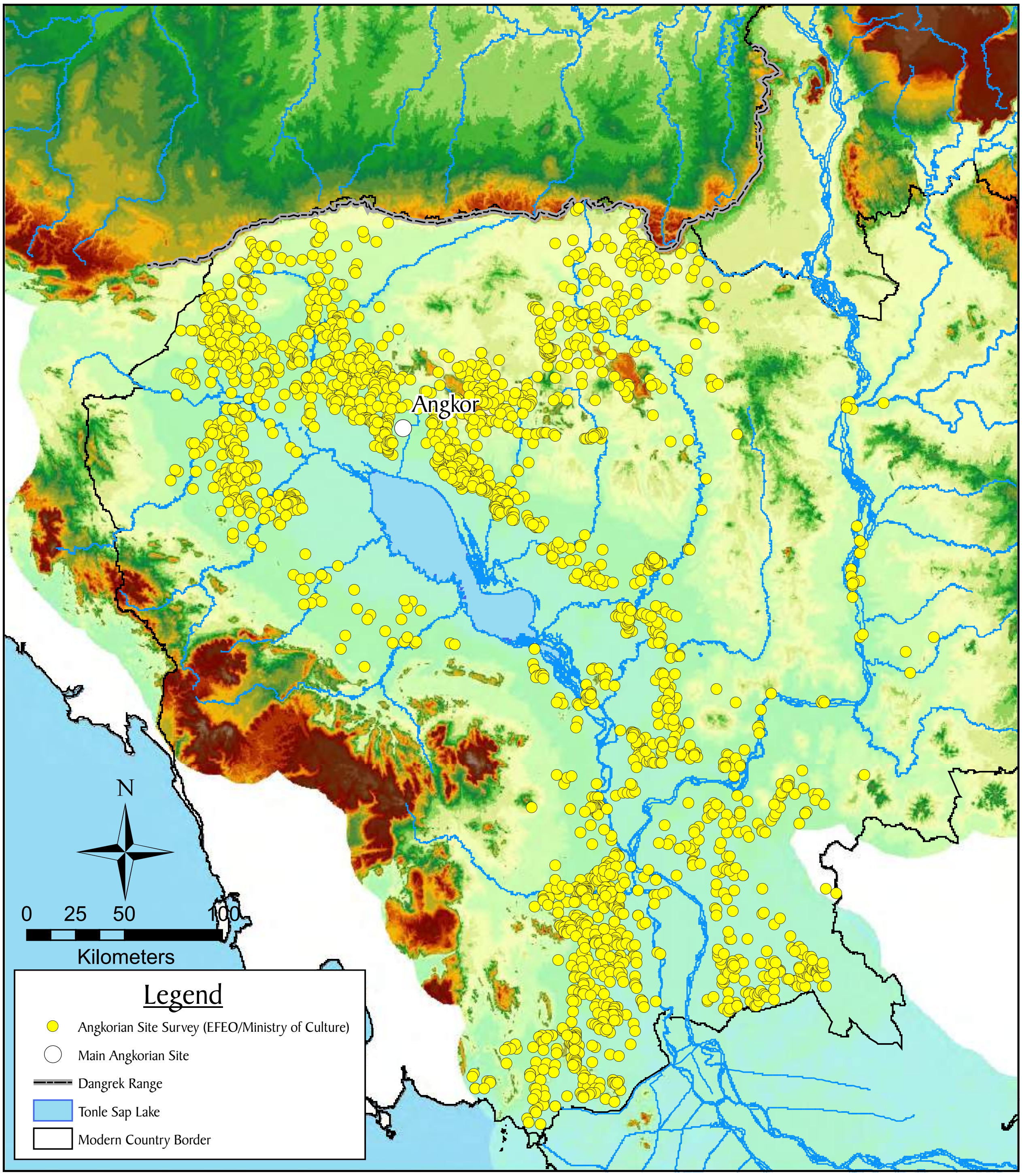

Figure 6.7 Distribution of Angkorian period sites in Cambodia mapped by the EFEO and Ministry of Culture (excluding Angkor region)

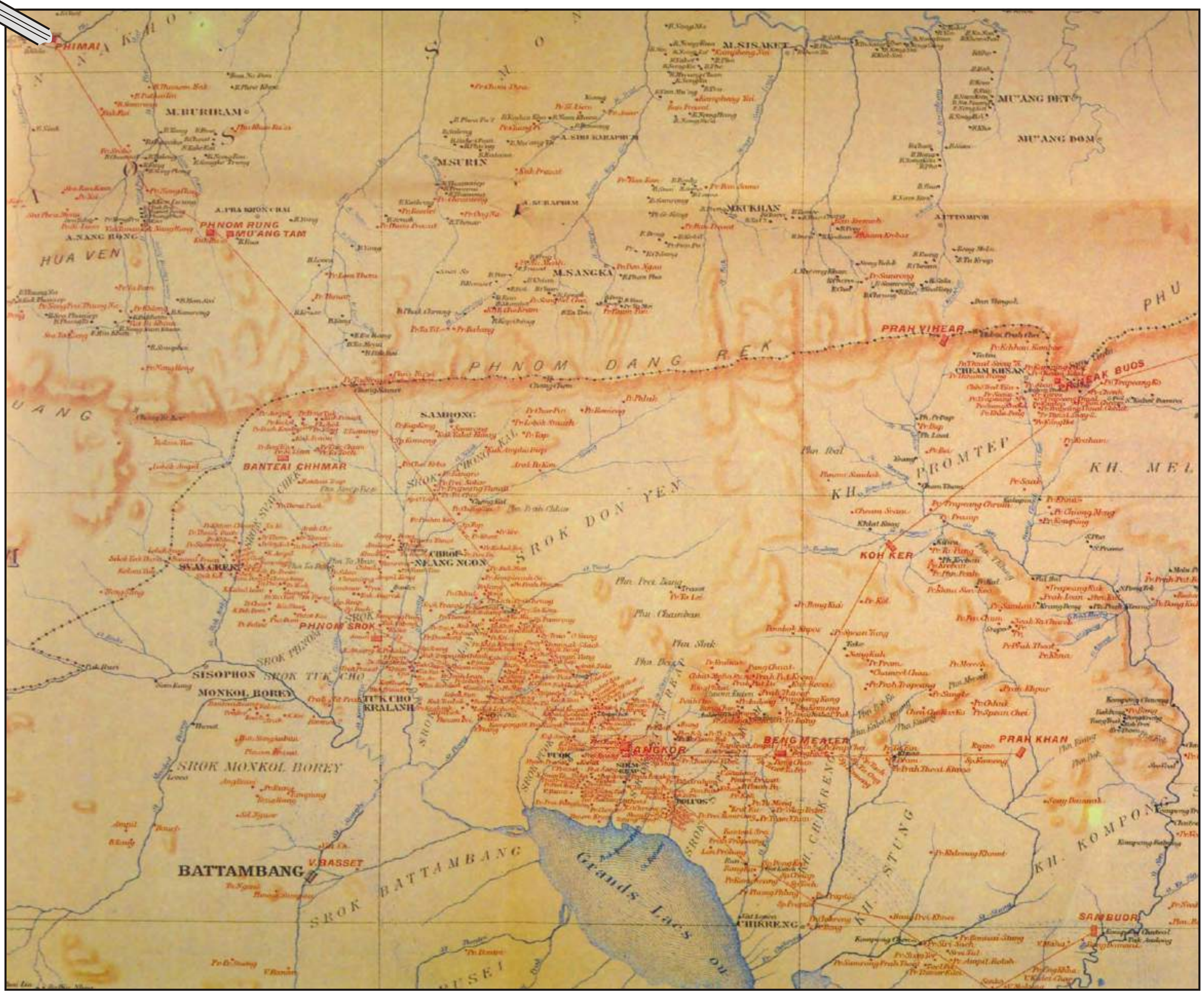

Figure 7.1 Lunet de Lajonquière's (1902) map showing the Angkorian road system (highlighted in red) and recorded sites