# TRACING PERSONAL ORNAMENTS

## A MINERO-PETROGRAPHIC STUDY TO SOURCE THE MANUFACTURE AND DISTRIBUTION OF STONE BANGLES FOUND AT BAN NON WAT, THAILAND

***Thesis submitted by Ashlee Litfin in April 2014***

**In partial fulfilment of the Degree of Bachelor of Arts with Honours in Archaeology, in the School of Arts and Social Sciences, at James Cook University.**

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# Acknowledgements

I would like to acknowledge the following people without which I never would have had the courage and commitment to continue on this path.

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***From Indiana Jones to Lara Croft, archaeologists have become popular movie heroes. The irony is that the reality of archaeology is much closer to movie making than to the exploits of a movie hero. Like making a movie, archaeology involves the logistics of working with a team on location, for long hours, and with an eye toward pragmatic compromise. Like filmmakers, archaeologists do a great deal of unglamorous pre- and post-production work. Archaeology calls less for bravery in battle then it does for courage to take creative leaps based on intuition. The result of archaeological research is not triumphantly grasping a trophy, but rather reaching conclusions that open an entirely new vista of questions.***

(Chazan 2007)

# Abstract

Marble bangles are a type of personal ornament characteristic of the Bronze Age in Southeast Asia. They are generally recovered from contexts dating c. 3000-2500 years ago. While common finds, many questions remain: where did they come from, how were they made, and by whom? Determining the provenance of geological artefacts involves many elements, each of which has their own importance. The aim of this study is to determine a route for bangle stone between Ban Non Wat, Thailand, and the closest geological source. Through analysis of the visible characteristics of a selection of 'marble bangles' from Ban Non Wat, the material type of the stone bangle is first determined to be either marble or limestone. These are then compared with the results from previous chemical analysis undertaken on the bangles. Chemical analysis of the bangles determined that the stone was all from one source, and analysis on samples from local quarry sites showed the possibility of the stone originating from Ban Rai quarry in the southwest corner of the Khorat Plateau. The analysis from the visible characteristics of this quarry further established the possible link between Ban Rai and Ban Non Wat as most samples from this site were identified as marble. This analysis made it possible to rule out certain areas of Thailand, or South East Asia, from which the bangle stone may have been sourced. This data in combination with relevant palaeoenvironmental, geological and archaeological data was used to create a model of potential areas in Southeast Asia and southern China from which the bangles could have been sourced. The results of this analysis showed that there are three possible sources of bangle stone within reach of the Khorat Plateau. Each of these sources had potential trade routes either overland or by waterways. Control and manufacture of the trade is dependent on which of these sources the bangle stone came from.

# Chapter 1: Introduction

Knowledge of prehistoric stone bangle trade in Southeast Asia and south China is limited. The lack of published material and emphasis on the Southeast Asian mainland has diminished our archaeological and prehistoric knowledge in this area (Stark 2006:408). In particular, the lack of research on determining the provenance of geological artefacts makes any provenance study an important addition to the archaeological record. The archaeological site for this pilot study is Ban Non Wat, located in the Mun Valley region of the Khorat Plateau (Higham, 2011:367). This area is well-known for a dense concentration of prehistoric settlements encircled by moats and banks (Higham, 2011:367).

The aim of this study is to construct a model for the origin of trade of bangle stone found at Ban Non Wat, Thailand. A minero-petrographic pilot study combined with the study of palaeogeography, palaeoenvironment and archaeology is intended to help source the manufacture and distribution of stone bangles found at Ban Non Wat. The combination of a direct analysis of geological maps of Southeast Asia and south China in comparison with archaeological data from the same area, will lead to preliminary conclusions and models of possible trade and communication routes from Ban Non Wat.

Throughout this investigation a variety of points will be taken in to consideration. The background chapter starts with the palaeoenvironmental, geological and archaeological data for Southeast Asia and south China. Geological data of Southeast Asia and south China is relevant to locating the source of the bangle stone. Comprehensive geological and mineralogical maps of Southeast Asia and south China combined with palaeoenvironmental and archaeological data makes it possible to produce theoretical models of trade and exchange between Ban Non Wat and the most obvious resource or resources. A detailed and in depth look at the bangle find sites from the Khorat plateau, other bangle manufacturers, and known trade routes and modern or ancient quarries in Southeast Asia and south China, will be essential in the process of determining the model for trade and exchange from Ban Non Wat. This is followed by the second background chapter; a review of the archaeological site of Ban Non Wat, and the bangles. This is to gain context for the bangles. Within this final section relevant literature is reviewed.

As provenance studies for marble artefacts in Asia are rare, the outline for the methods has been determined from the more common European case studies. Experts in Europe tend to use an archaeometric approach, interrelated with processual archaeology (Vitali 1989:384). A multi-method analysis followed by discriminant function analysis is used explicitly for the provenance of marble according to multiple research papers (Attanasio et al., 2005; Attanasio et al., 2005; Brilli et al., 2010; Brilli et al., 2005; Ferrini et al., 2012 ; Ouazaa et al., 2012; Pensabene et al., 2012; Taelman et al., 2013).

In this dissertation, an analysis will first confirm what material was used to make the stone bangles, and identify any unique characteristics that would be helpful in determining the provenance of the bangles. An analysis of geological sources and bangle find sites combined with a discussion of the palaeoenvironment of Southeast Asia and south China will follow. Using the information gained from the bangle analysis, combined with the information already known from the previous research, a comprehensive examination of the produced geological and archaeological data will occur. From this models of provenance for the bangle stone and likely trade routes to and from Ban Non Wat will be developed. This also leads the discussion of the possibility of further research.

Chapter two is a detailed description of the relevant palaeoenvironment, geology and archaeology throughout Southeast Asia. The third chapter is a background on Ban Non Wat and the stone bangles. Chapter four is the theory and methodology chapter, which is followed by the first results chapter. These results are from the analysis of both stone bangles and the quarry samples. The second results chapter describes the analysis of the landscape and the potential trade routes for people. The next chapter is the discussion which includes understanding past connections throughout Southeast Asia. The final chapter concludes the dissertation and details further research opportunities prompted by this study.

## Summary:

To summarise, this is a pilot study that will help determine the origin of the bangle stone found at Ban Non Wat, and give further insight in trade and communication throughout southern China and Southeast Asia in prehistory. A background in geology, palaeoenvironment, and particular archaeological evidence will aid in the modelling process. The use of minero-petrographic analysis will further facilitate the process as it can be used to narrow information used to create the maps (i.e what type of rock formation needs to be recorded). The main aim is to develop various possible routes throughout southern China and Southeast Asia between Ban Non Wat and potential sources of bangle stone.

# Chapter 2: The Palaeoenvironment and Archaeology of Southeast Asia and South China

The dynamics of production, trade and exchange relationships in Southeast Asia during the Bronze Age (c.3000-2500 years ago) can be understood through knowing the landscape of that time. This includes palaeoenvironmental data such as landscape and coastline, geological data, archaeological evidence including known trade routes and other archaeological sites with stone bangles, and a background to Ban Non Wat and the bangles. Knowledge of the palaeoenvironmental data is important when deciphering how people moved through the region prior to and around the Bronze Age in Southeast Asia. The following two chapters will discuss these topics. The first will detail how palaeoenvironment, geology, and archaeology work together to build a map that can be used to study trade routes, while the second is a background in to Ban Non Wat and the subsequent bangle trade.

Not all of Southeast Asia is essential to the provenance study of the bangle stone found at Ban Non Wat. South China, Myanmar, Laos, Vietnam, Cambodia, and Thailand (as seen in figure 1) in particular, are the relevant countries considered.

Figure 1 Map of Southeast Asia and south China

The palaeoenvironmental landscape from the Bronze Age and the geological data of Southeast Asia and south China is the key to sourcing the bangle stone. When combined with other local archaeological sites and known trade routes, it is possible to generate hypothetical models of trade and exchange from Ban Non Wat to its most apparent source. This will be the main theme of this chapter.

## Palaeoenvironment

The palaeoenvironment of Southeast Asia and south China is crucial in identifying possible transportation and communication routes between regions. Unfortunately the palaeoenvironmental data from Southeast Asia is limited to the 'Origins of Angkor'/ 'Environment and Society Before Angkor' project in Northeast Thailand, and the 'Lower Mekong Archaeological Project' in southern Cambodia (Stark, 2006:412). These two areas are the only known regions from which current palaeoenvironmental research is in progress (Stark, 2006:412). Palaeoenvironmental changes in China, however, have been studied thoroughly from the last glacial maximum (LGM) to now (Jiao, 2006; Lapteff, 2010; Liu and Chen, 2012; Lui and Chen, 2006; Winkler and Wang, 1993). The palaeocoastline and landscape of Southeast Asia and south China are essential background to this study.

### Landscape

Southeast Asia is surrounded by the Indian and Pacific Oceans to the south, west, and east (Hall, 2009:148). The Alpine-Himalayan Mountains head south from the elevated plateau of Tibet in to Southeast Asia, and end at the Malay Archipelago {Hall, 2009:148}. The Chiang Muan Basin is located in north Thailand, 150km east of Chiang Mai (Suganuma, 2006:760). The Zomia mountain range runs from the Central Highlands of Vietnam to eastern India and over 300m elevation (figure 2) (Jon, 2013:560). The Chao Praya plains and the southern Mekong delta were swampland and uninhabitable until c.1500-1000BP, at the same time that a knowledge of water control techniques seemed to have appeared (Stark, 2006:412).

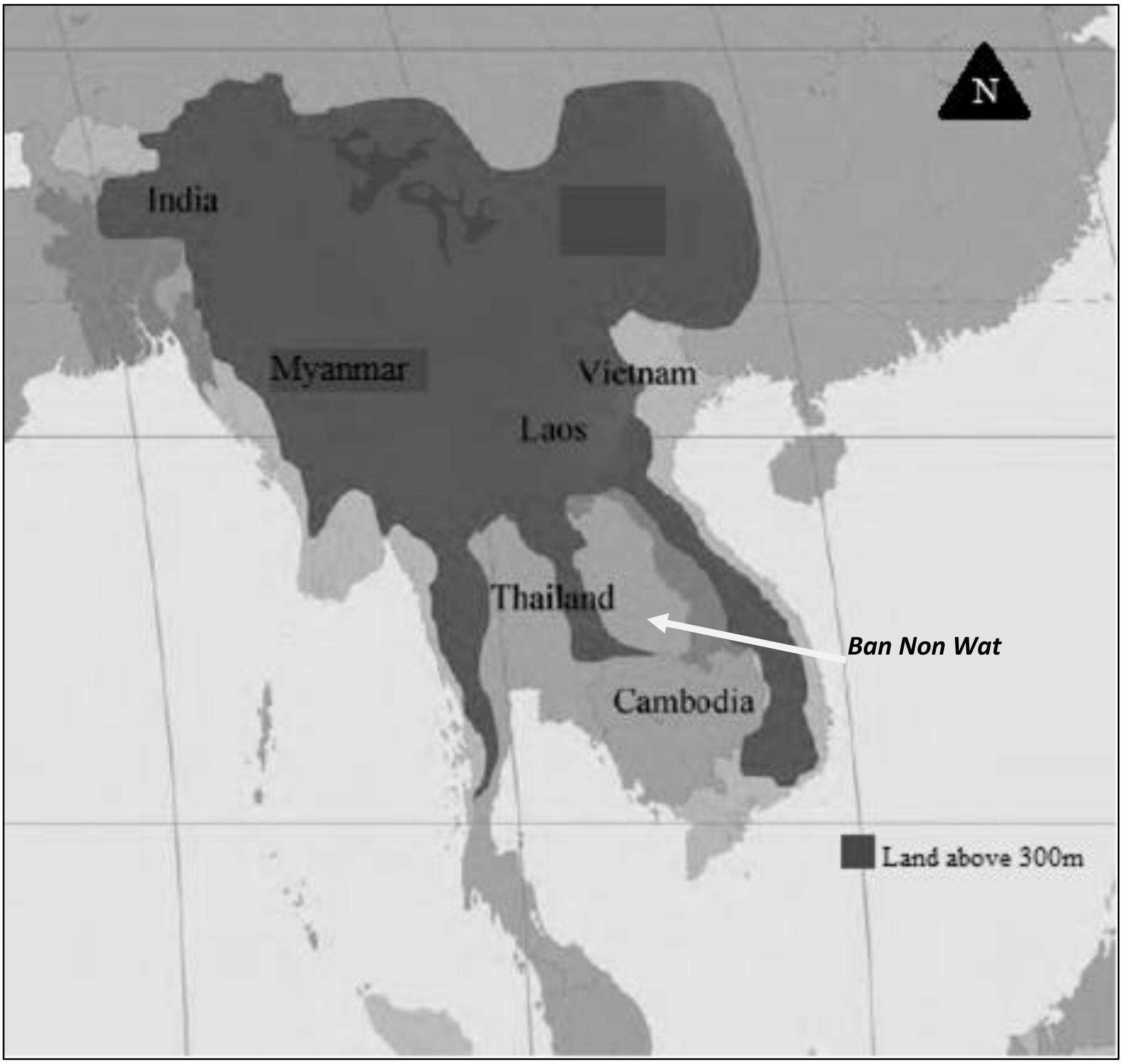


Figure 2 The geomorphology of Southeast Asia (after Jon 2013:561)

A localised study of the Khorat Plateau details the waterways in the area (Boyd and McGrath, 2001:309). During the Late Bronze Age (c.3000-2500BP) hydrology associated with sites began changing with the drier conditions of the climate (Boyd, 2008:15). During the Iron Age (c.2500-1700BP) there was a significant change to the hydrological conditions in the region as well as the landscape (Boyd, 2008:15; Boyd and McGrath, 2001:309). The Mun Valley, the main area of interest for this thesis, was characterised by an expanse of multi-channelled waterways (Boyd and McGrath, 2001:309). This can be seen in figure 3.

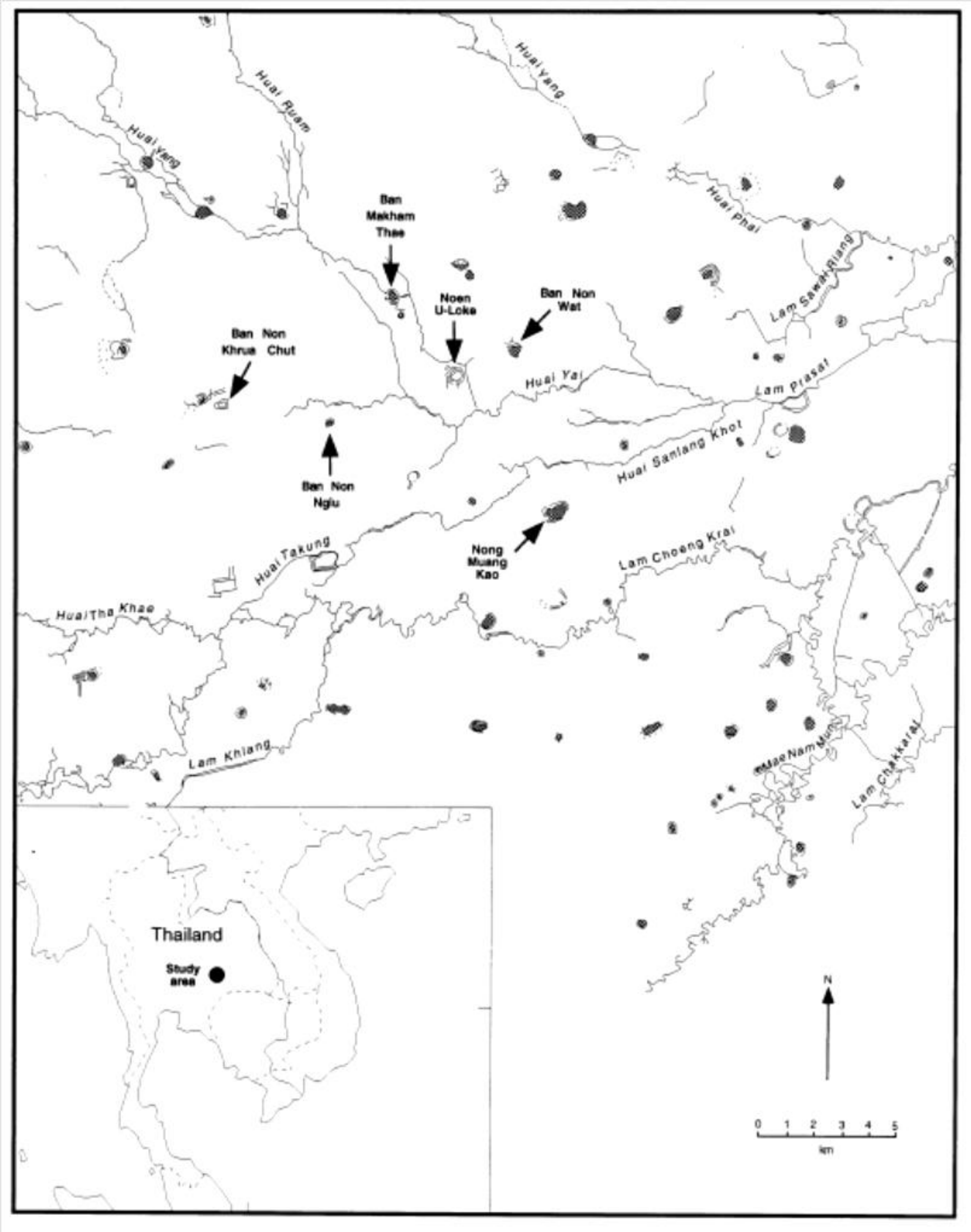


Figure 3 Complex system of waterways in the Khorat Plateau (from Boyd and McGrath 2000:308)

Around the LGM the dense forests became open grassland which was the peak of open grassland vegetation in the palaeoenvironment of Southeast Asia (Louys and Meijard, 2010:1443). Evidence suggests intensive land use increased after c.5000 BP (Bellwood, 2006:105). Research in to the palaeoenvironmental changes of Southeast Asia suggests that cyclical vegetation changes took place in several regions, between forest and open grassland, correlating with the increase in land use (Stark, 2006:412). Thailand, northern Vietnam, and southern Cambodia were inclusive of this (Stark, 2006:412). It has been suggested that most of Southeast Asia was forested with the exception of areas along major drainages and their branches, and the coastline, around 2000BP (Stark, 2006:412).

China is presently divided in to seven ecological zones based on certain factors: natural conditions, agricultural potential, and current provincial units (Liu and Chen, 2012:24). These zones will be used to determine the context of the study relevant to China. The areas associated with this study are Central China, South China and Southwest China as seen in figure 4.

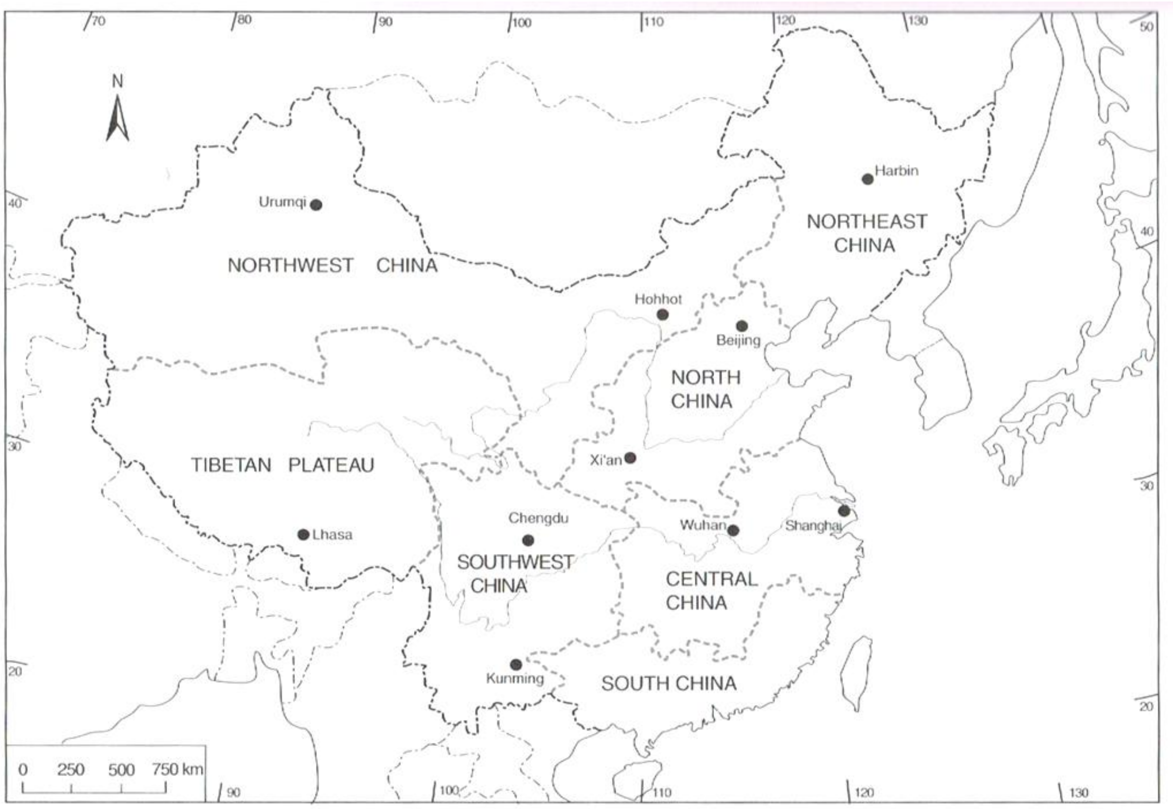


Figure 4 The division of China (from Liu and Chen 2012: 25)

The two latter areas are both humid subtropical and tropical zones. The Yangzi (Changjiang) River (in central China) and the Pearl (Zhu) River (in south China) along with their bordering plains compose the majority of the Chinese heartland (Liu and Chen, 2012:26). The Nanling Mountains separate south China from central China and part of the south-western region of China includes 'great upland subregions' separated by mountains (Liu and Chen, 2012:24, 26). These areas can be seen clearly in the following figure.

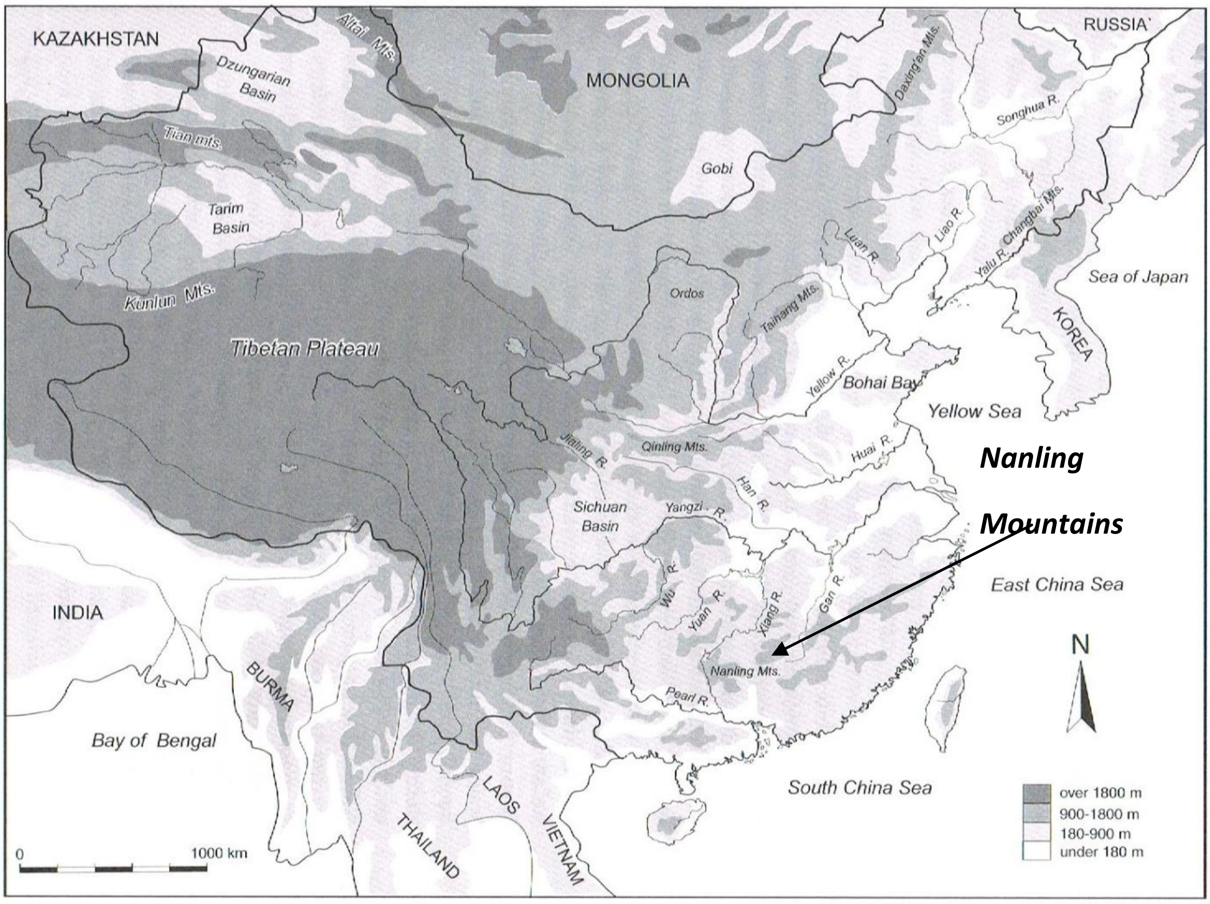


**Figure 5 The Geomorphology of China showing the Nanling Mountains (after Liu and Chen 2012:27)**

Similar to Southeast Asia, regions in southeast China which were densely populated with agricultural settlements causing forest decline. This started from the south-eastern Loess Plateau, continued to the southern Taihang Mountains, then progressed west to the North China Plain and extended from there (Liu and Chen, 2012:40). Deforestation in this area is therefore associated with intense agriculture (Liu and Chen, 2012:40). Soil erosion followed by more frequent floods are consequences of deforestation, which has been used

throughout prehistory and history (Liu and Chen, 2012:40). This change in landscape was accompanied by a fluctuating coastline of which shaped further changes to the landscape.

### Coastline

Sea level fluctuations have caused the coastline of Southeast Asia and China to change since the LGM consequently affecting human adaptations in those areas (Liu and Chen, 2012:34). The first fluctuation during the postglacial period caused sea levels of the East China Sea to vary therefore changing the coastal landscape dramatically (Liu and Chen, 2012:34). The sea level rose rapidly from 7500 BP until the highest most level of the sea was reached between 6000 and 4500 BP (Liu and Chen, 2012:35). Sea levels around the northern Vietnam coast stabilised at their current levels c.2000 BP and the Thai/Malaysia peninsula c.1500 BP (Stark, 2006:411). Landscape change was inevitable (Jiao, 2006:615), shifting ocean to land and

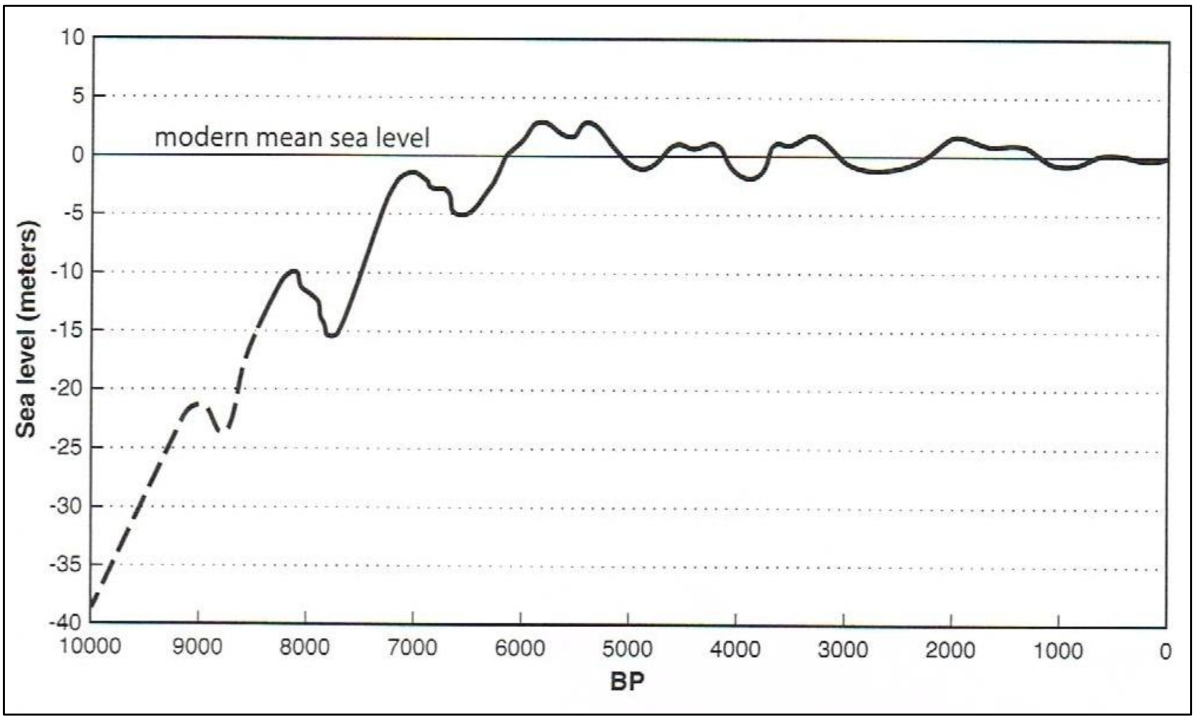


Figure 6 Holocene sea levels from 10000 BP to present (from Liu and Chen 2012: 35

land to ocean, and triggering population movement (Liu and Chen, 2012:34). The coastline changes can be seen in figure 6 and for China only in figure 7.

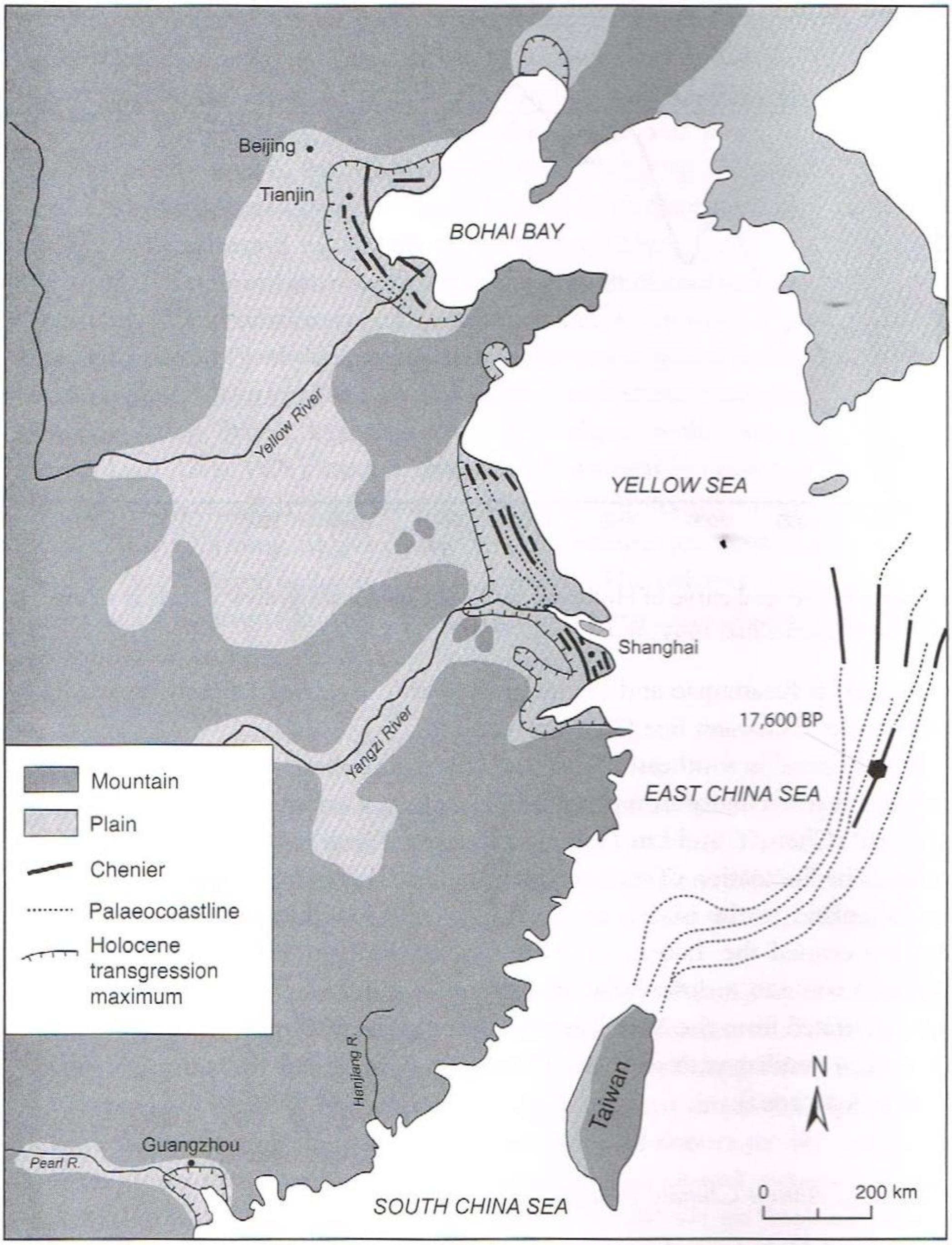


Figure 7 The changing coastlines of China from 17600BP (from Liu and Chen 2012:36)

People were forced to migrate from the Southeast Asian and Chinese coastline to islands in the Pacific Ocean (Liu and Chen, 2012:35; Soares et al., 2008; Winkler and Wang, 1993:237). In the late Pleistocene a migration of people from mainland China to Taiwan occurred on foot (Liu and Chen, 2012:35; Soares et al., 2008:1209). This was at a time when the sea levels were 120m below current sea levels and the Taiwan Strait was a land bridge (Liu and Chen, 2012:35). During the Neolithic (c. 6500 BP) another migration is thought to have

occurred, as a result of the sea level fluctuations, to Taiwan across the Taiwan Strait (Liu and Chen, 2012:35; Soares et al., 2008:1209). Sea levels were higher at this time causing inability to cross on foot which indicates people would have been familiar with seafaring techniques (Jiao, 2006:619; Liu and Chen, 2012:35).

During the Southeast Asian Bronze Age (c.3000-2200BP) the sea level fluctuated from between two metres below the current sea level and approximately one metre above sea level (as shown in figure 6). At its height the landscape would have looked like the following image.

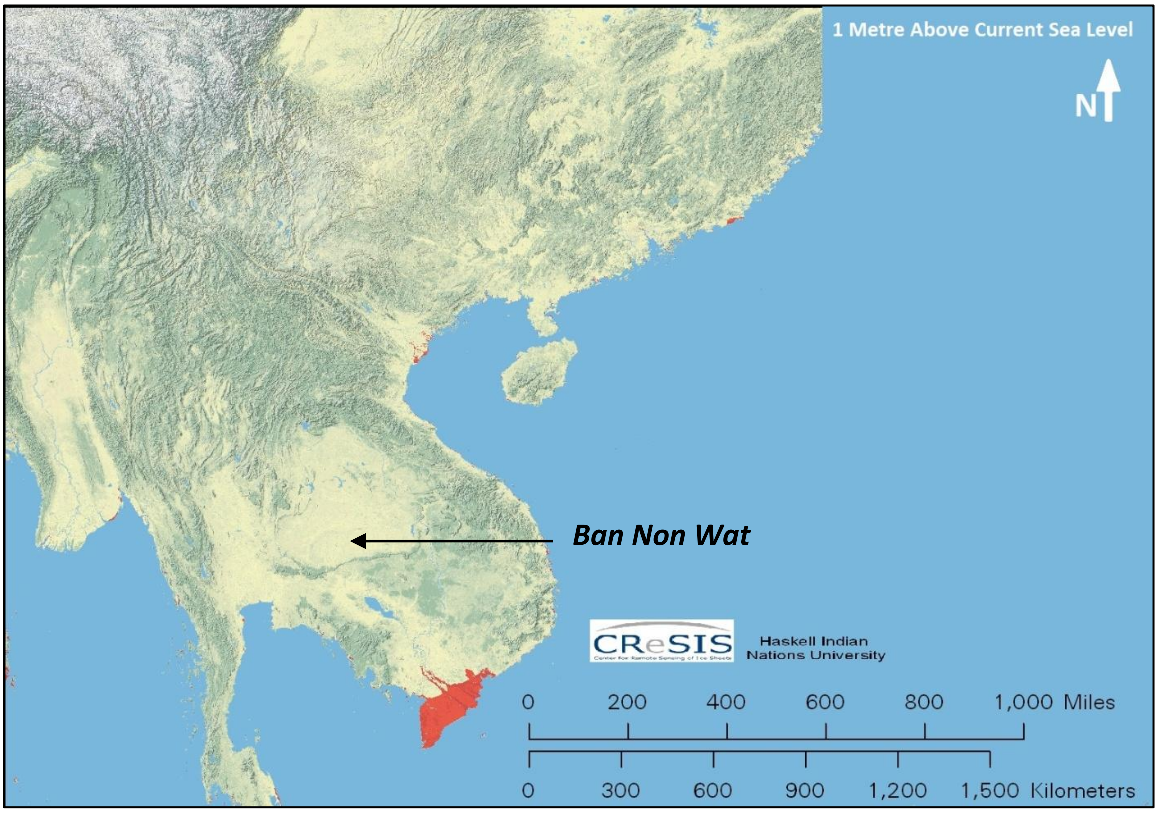


Figure 8 Map of Southeast Asia and south China 1masl. The red shows where the sea level would have been (after CReSIS (2013))

This information is important to understand the physical barriers to the trade at the time. Combined with the knowledge of prehistoric landscape, it possible create a map of the particular limits pertinent to understand how the landscape was used during the Bronze Age. When it is then merged with geological and archaeological data, GIS techniques can then be used in order to determine possible trade and communication routes throughout Southeast Asia and south China.

## Geology

Fontaine (2002:567), discusses the wide distribution of Permian rock on the surface of the Southeast Asian landscape. He mentions that as a result of the tropical environment, the rock is weathered deeply and covered by a dense layer of vegetation (Fontaine, 2002:567). An overview from Fontaine (2002) of the uppermost layer of the Permian rock establishes that one of the most widespread rock formations in Southeast Asia is limestone (table in Appendix A). According to Schumann (1993:284) limestones are widespread and form in mountain ranges. He mentions that limestone is often mistaken for marble as the distinction between the two rock types can sometimes be difficult, especially when particular cut and polished types of limestones are commonly called *marble* (Schumann, 1993:324).

The following map represents the limestone and marble distribution of southern China, Myanmar, Laos, Cambodia, Vietnam, and Thailand. The limestone and marble mineralogy from mainland Southeast Asia and south China is essential in interpreting the interregional communication of stone bangles throughout Indochina and south China. This is seen in figure 9.

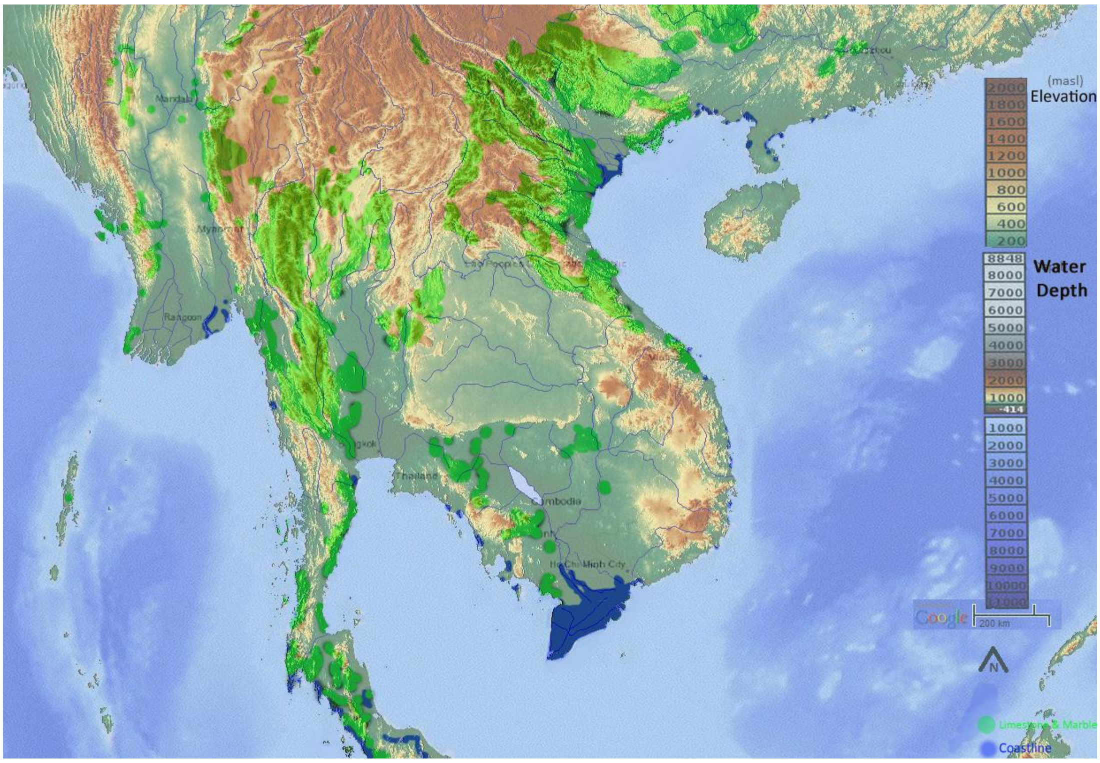


**Figure 9 A combined palaeoenvironment and limestone and marble distribution map from the Bronze Age. Dark blue areas are the palaeocoastline, fluoro green areas are limestone and marble distribution.**

Knowing the distribution of limestone and marble across Southeast Asia and south China is essential in the sourcing process of the bangle stone. This shows, as far as possible, all the possible sources of stone in the area, and when combined with the knowledge of landscape possible trade routes can start to be hypothesised. Once this information is combined with already known trade routes and other sites, improved theories can be developed.

## Archaeology: evidence from South East Asia and Southern China

Many ancient communities throughout Southeast Asia embraced the use of personal ornaments, particularly bangles, within their cultures. The abundance of bangles discovered throughout Thailand has been significant however the knowledge of manufacture and trade is limited. Craft production and trade is associated with the emergence of complex society and centralised control (Ray, 2003:214). In northern China this occurred during the transition from Neolithic to Bronze Age (Lui and Chen, 2006:149). Complex societies were characterised by bronze metallurgy and the long distance trade of valuable commodities (Lui and Chen, 2006:149). The commodities created facilitate communication across a shared cultural ethos (Ray, 2003:214). In order to gain a better understanding of the social complexity from the manufacture and trade of the bangles from Ban Non Wat it is important to gain background knowledge of the stone bangle sites from Thailand. It is equally important to understand the routes already used within the region.

### Known Trade Routes

Southeast Asian prehistoric settlements settled predominantly at coastlines, floodplains, or areas close to freshwater lakes (Stark, 2006:413). Waterways have been perceived to be the only communication and transportation routes throughout Southeast Asia since studies began. Regional communication, however, integrated the use of roads, rivers, and seaways (Stark, 2006:414). There is a great deal of information which supports the theory that seafaring was the sole means of communication. Areas of coastal settlement were situated near fresh water sources and potential harbours (Stark, 2006:414).

The 'boat nomads' of Southeast Asia are a cultural adaption which still survives in the Indian Ocean (Ray, 2003:43). These nomads move in accordance with the seasons, and are grouped together on the basis of geography, culture, and linguistics (Ray, 2003:43). There are three primary groups of 'boat nomads': the Moken and Molken of the Mergui archipelago in

Myanmar and southwest Thailand; the Orang Laut of the Riau-Lingga archipelagos in Indonesia; and the Sama-Bajau of south central Phillipines, eastern Borneo, and Sulawesi, to east Indonesia and the southern Moluccas (Ray, 2003:43-44). The control of the sea and sea trade is often associated with such 'maritime hunter-gatherer' communities {Ray, 2003:46}. In the Indian Ocean, a range of diverse communities (such as the Nabateans, Sabeans, Homerites, Arabs and Indians) were involved in various maritime activities (Ray, 2003:52). Marine fishing (in both the ocean and inland waterways), exploitation of the resources of the ocean, sailing, and piracy are examples of these activities (Ray, 2003:52).

The Mekong Delta, Cambodia, and Vietnam canals have been studied thoroughly for traces of interregional communication (Stark, 2006:414). Canals recorded in the Thai peninsula (Satingpra area) may have been used for interregional communication and transportation as well as irrigation (Stark, 2006:414). Lack of chronometric data at this point, however, makes the dating of the canals difficult (Stark, 2006:414). Using the morphology and locations, such canals in the Mekong delta and Thai peninsula were likely to be designed for interregional communication and transportation instead of irrigation (Stark, 2006:414).

Regional geographical contexts in China and Southeast Asia have influenced the development of cultures and civilisations (Liu and Chen, 2012:40). Natural barriers such as mountain ranges facilitated the primary use of rivers and other such waterways for interregional communication (Liu and Chen, 2012:40). Returning to Southeast Asia, one of these ranges, the Petachabun Range was a major communication route for people living on the Khorat Plateau to communicate with other regions (Higham, 2011:365). These large ranges also encouraged the development of seafaring and navigating technologies throughout China, examples of which include 8000 year old canoes from Kuahuqiao, Zhejiang; a 7000-5300 year old paddle and rudder from Chengtoushan, Hunan; and 6800-6100 year old boat-shaped pottery from Beishouling, Shaanxi (Liu and Chen, 2012:40-41; Stark, 2006:414). These discoveries suggest the use of rivers and other waterways as a means of travel and communication (Liu and Chen, 2012:41). In the mid-late first millennium BCE, the trade activity of the Malacca Straits and the Java Sea accelerated and adapted to include Southeast Asia; particularly the Dong Son region of Vietnam (Liu and Chen, 2012:41). These networks continued in to the third century CE as iron and tin trade throughout

Southeast Asia was documented by Chinese representatives (Liu and Chen, 2012:41). Figure 10 shows the maritime trade routes of Southeast Asia and south China.


Figure 10 The interregional seafaring trade networks of Southeast Asia and south China (from Stark 2006:146)

Similarities in material culture from southern China and Southeast Asia are observed from the Neolithic (Lapteff, 2010:94). This represents communications between the Yangtze River Valley and Indochina (Lapteff, 2010:94). An example of this is the rectangular and shouldered axes found throughout both regions (Lapteff, 2010:94). These can be seen in

figure 11. Pictures 1 and 2 are from Beiyinyangying, Yangtze Valley, and picture 3 and 4 are from Cambodia (Lapteff, 2010:95).

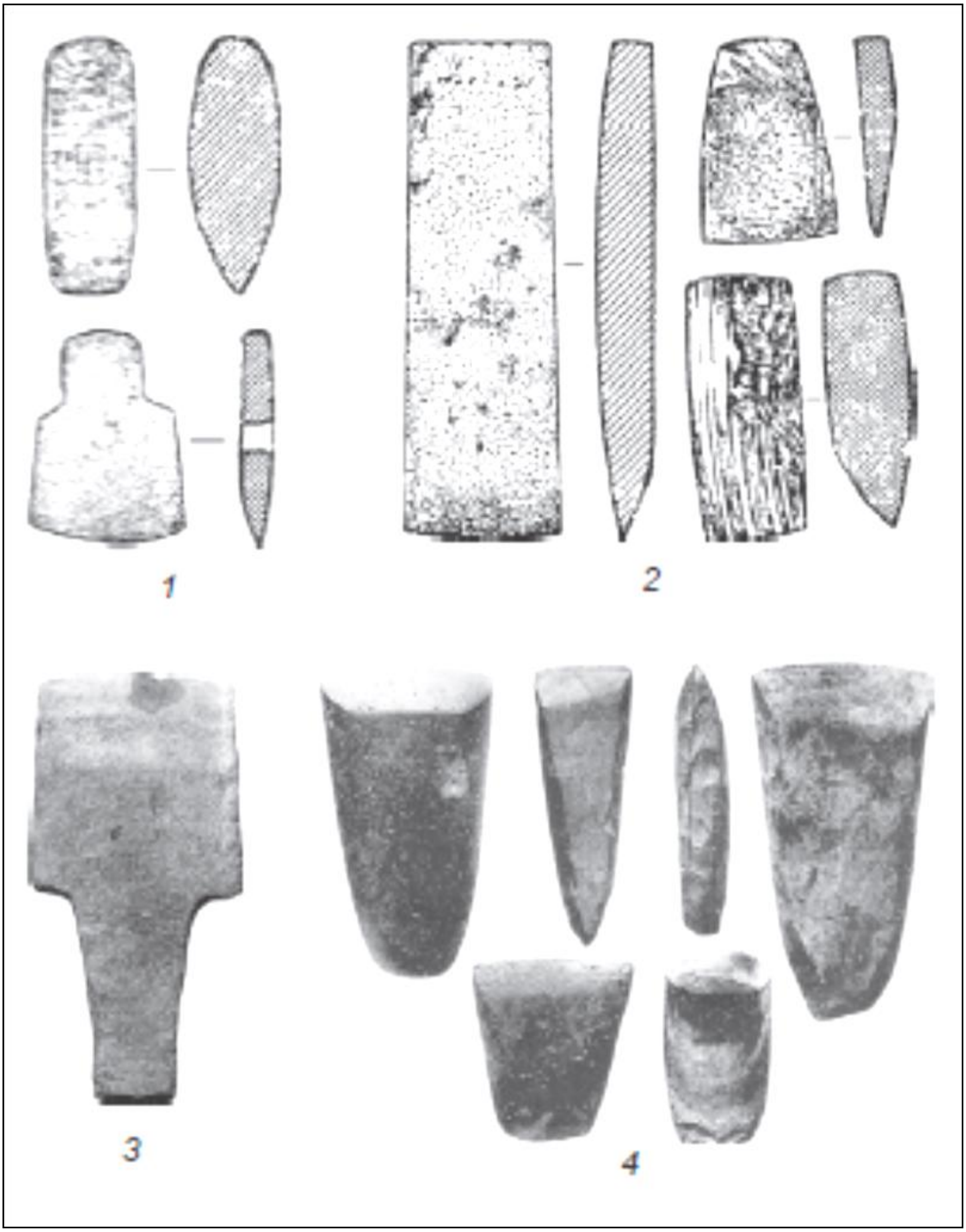


Figure 11 Rectangular and Shouldered Axes from southern China and Southeast Asia (from Lapteff 2010:95)

During the first millennium BCE the spread of bronze-iron bimetallic artefacts throughout South, Southeast, and East Asia indicates a widespread exchange of metallurgical knowledge (Ray, 2003:122). The use of this rare combination is found at Ban Chiang in Thailand, Yunnan, Gilimanuk in Bali, Prajekan in east Java and Dong Son in Vietnam, where spearheads and daggers have been discovered with iron blades and bronze hilts or sockets (Ray, 2003:122).

Areas of inland river settlements were located on the boundary between floodplains and upland areas, while settlements on floodplains were found raised on mounds (Stark, 2006:414). Intraregional communications are poorly researched and documented (Stark, 2006:418). Widespread relationships developed at Ban Non Wat between the Bronze and Iron Ages (Boyd and Chang, 2010:283-284). Trade networks between the Khorat Plateau and the coastline are indicated by the large quantities of marine-shell jewellery found in the area which includes *Tridacna sp.* in early Bronze Age burials, and armbands and bangles made of *Trochus sp*. in the later Bronze Age burials (Boyd and Chang, 2010:283-284). Two possible routes have been indentified for this particular trade network: (1) either over land to the Chao Praya River and west to the west coast, or (2) following the Mun and Mekong Rivers to the east coast (Boyd and Chang, 2010:284). The T-section stone bangles in particular, among numerous archaeological sites across Southeast Asia during the Bronze Age, have been said to indicate communications with China (Boyd and Chang, 2010:284). The potential trade routes for this artefact have not been discussed in detail.

In order to make assumptions about potential routes, used for the transportation and trade of bangle stone, it is important to know which other sites in the Khorat Plateau contain these particular stone bangle artefacts.

## Archaeological Sites in Thailand

Already known archaeological sites across Southeast Asia can help determine possible trade routes of bangle stone. These artefacts are evident in most Bronze Age archaeological sites in NE Thailand and the rest of Southeast Asia. In order to make the information useful it is important to look at the location of the sites; whether or not they are alongside a river or stream or any other patterns that may arise. The sites in the following image are those only from the area immediately surrounding Ban Non Wat, Thailand. Potential routes of trade

and communication, through following the distribution of bangle stone, should be determined when combined with the other palaeoenvironmental and archaeological evidence.

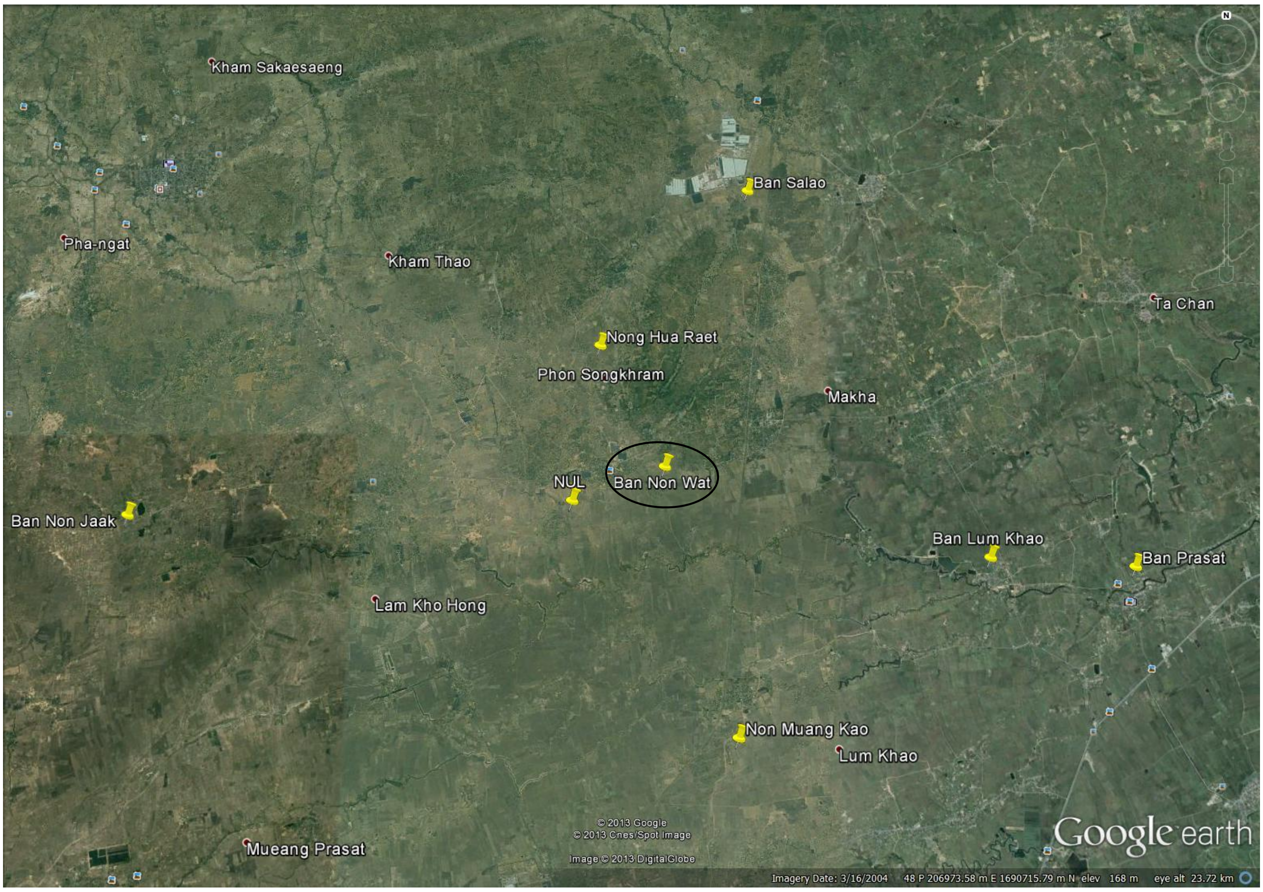


Figure 12 A map of the distribution of sites surrounding Ban Non Wat (prepared by Nigel Chang)

## Summary

The palaeoenvironment and geology of Southeast Asia and south China is an important link to understanding the manufacture and trade patterns from Ban Non Wat. With the information gathered it is possible to establish locations where stone may have been sourced for the manufacture and trade of the stone bangles. Palaeoenvironmental data describes what the prehistoric environment and landscape was like, creating the limitations of potential interregional communication routes. Through understanding the landscape trade may have occurred via waterways or overland travel, but more likely a combination of the two. The changing landscape constantly affects the limits of trade routes throughout the area. The limestone and marble distribution throughout Southeast Asia and southern China provides details which help determine where the bangle stone came from. The

archaeological site distribution gives insight on the sites throughout Thailand that may have been trading with Ban Non Wat, and the known trade routes provide possible routes which could have been used. A combination of the knowledge from this chapter with that of the following chapter provides a detailed description of landscape and gives ideal boundaries for the potential bangle trade of Ban Non Wat, Thailand.

# Chapter 3: Insight into Ban Non Wat and Bangles

## Ban Non Wat: an archaeological site


Figure 13 Map of Southeast Asia depicting where Ban Non Wat is located (after Higham 2011: 366)

The village of Ban Non Wat is located in the upper Mun River valley region of northeast Thailand on the Khorat Plateau as seen in figure 13 (Boyd and Chang, 2010:276; Chang, 2009:40; Higham, 2009:1; Higham and Thosarat, 2012:98). The Khorat Plateau lies to the southwest of the biggest bend of the Mekong River, which divides the area in to two major drainage basins (Higham and Thosarat, 2012:98). The Mun River flows through the Mun River valley in an easterly direction until it meets with the Mekong River, a vital link for communication and trade (Higham, 2011:365). The upper Mun Valley is located at the eastern entrance of the Petachabun Range; a major prehistoric communication route (Higham, 2011:365). A defining characteristic throughout the Mun River valley sites is the

presence of moats, clearly evident at Ban Non Wat (Boyd and Chang, 2010:276). In addition to this, the sites are large, with 3-5m mounds over hundreds of hectares and have a substantially long-lived settlement (Boyd and Chang, 2010:277). Three key excavation sites are present in the Mun Valley area; Ban Prasat, Ban Lum Khao, and Ban Non Wat (Higham and Thosarat, 2012:124-125). Each of these sites are located on slightly elevated terrain and are in reach of a river or stream (Higham and Thosarat, 2012:124). They are also near soils suitable for the cultivation of rice (Higham and Thosarat, 2012:124).

Excavations at Ban Non Wat began in January 2002 and are still continuing (Chang, 2009:40). The project has been split in to two series of excavations. From 2002-2007 was the 'Origins of Angkor' project (series 1) which then changed to the 'Environment and Society before Angkor' project (series 2). It remains one of the most significant sites in Southeast Asia for several reasons. It is one of a few Neolithic sites in Thailand (Chang, 2009:40), the size and extent of the excavation is unusual for mainland Southeast Asia (Chang, 2009:40), and there is a clear sequence of periods which can be unambiguously explored (Boyd and Chang, 2010:276; Chang, 2009:40; Higham and Thosarat, 2012:130;). The stratigraphic and cultural development of Ban Non Wat is shown in figure 14.

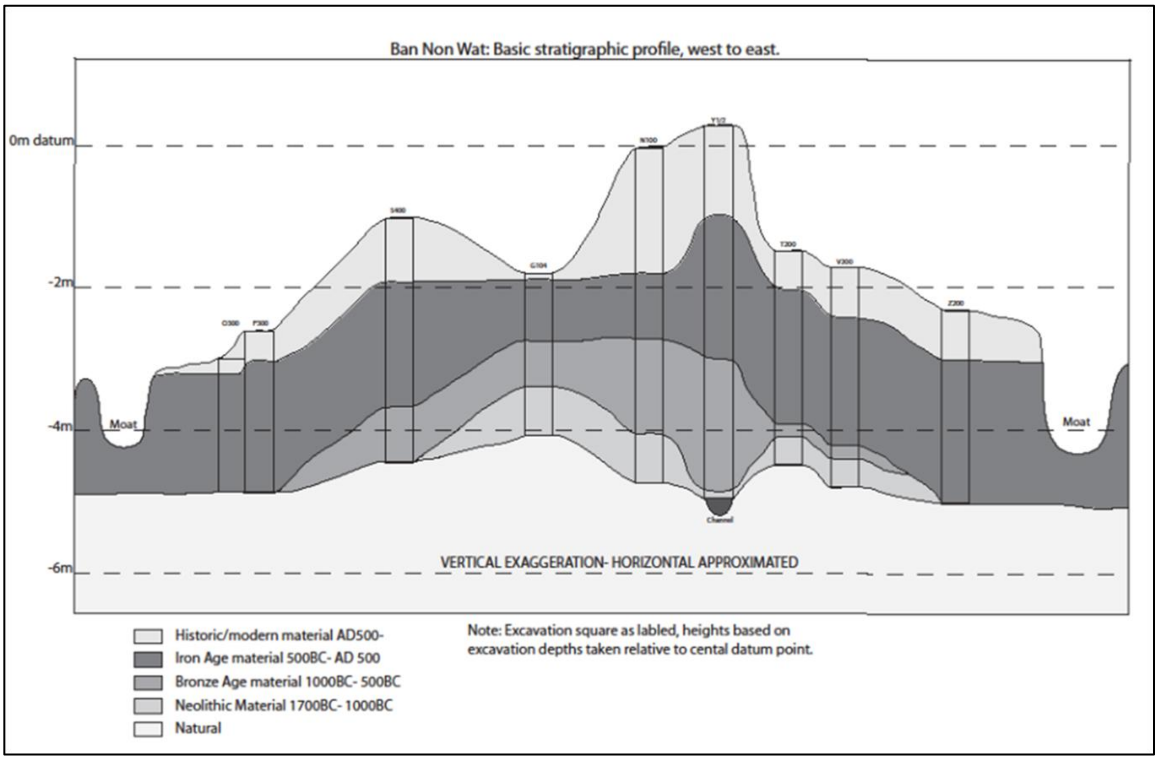


**Figure 14 Stratigraphic and cultural development of Ban Non Wat (prepared by Belinda Duke and Nigel Chang)**

A large number of Bronze Age burials are found here (Higham and Thosarat, 2012:130). Establishing a chronological framework was the original aim of this excavation (Higham, 2011:368). As a prehistoric site containing burials and middens, there is evidence of continuous use for a possible 4000 years (Boyd and Chang, 2010:276; Higham and Thosarat, 2012:98). According to Higham, the prehistoric chronology of Ban Non Wat has twelve stages based on the differing mortuary practices (2009:17-25; 2011:368). The following figure shows the chronology of Ban Non Wat.

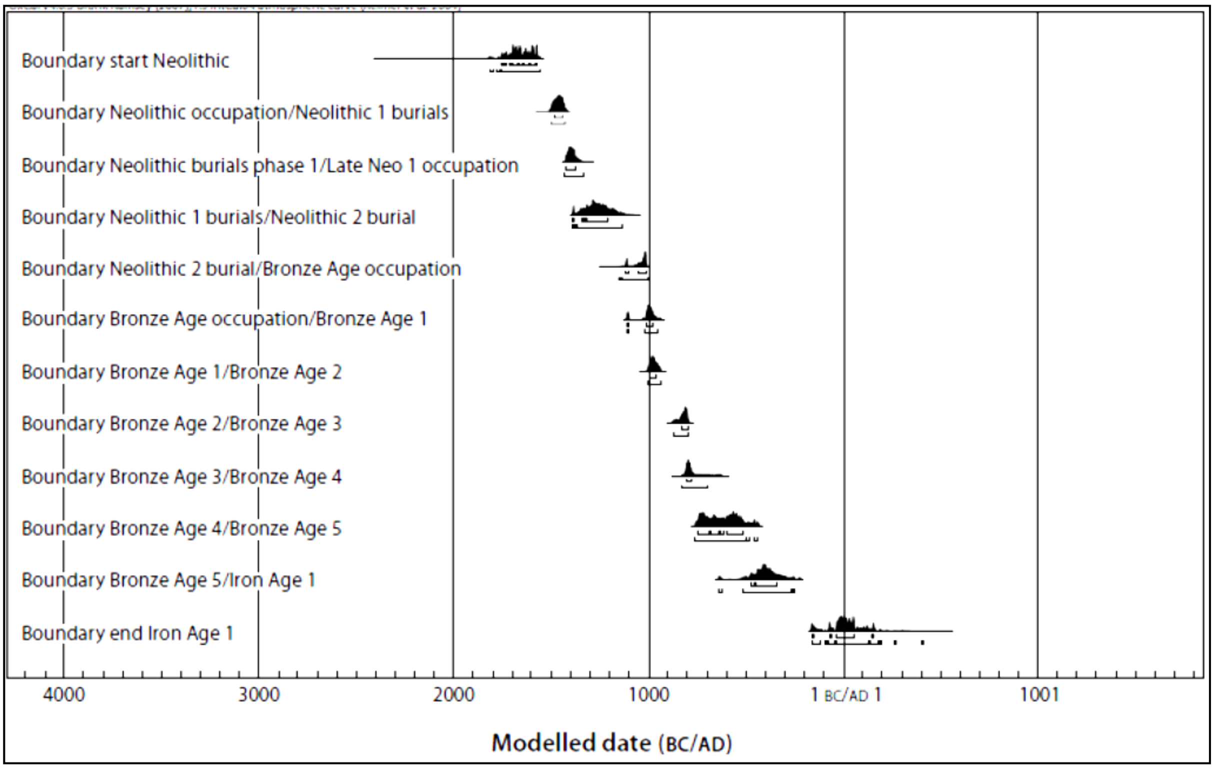


Figure 15 Modelled chronology of Ban Non Wat (from Higham 2011:368)

Three broad embanked moats surrounding Ban Non Wat have been dated to the Iron Age due to their association with Iron Age pottery (Boyd and Chang, 2010:276-277; Higham, 2011:368; Higham and Thosarat, 2012:98). The initial interpretation of the moats was their possible association with the development of chiefdoms in the region (Boyd and Chang, 2010:276-277). Burial practices and patterns reveal there were a distinction between the various and widely dispersed burial practices of the Neolithic and the more conventional burial practices of the Bronze and Early Iron Age (Boyd and Chang, 2010:282). A long list of material culture has been discovered through the excavation of burial sites at Ban Non Wat. Over 9000 artefacts were discovered in the series 1 excavation alone.

Results from work at Ban Non Wat show "new discoveries have been made that significantly change interpretations of life in the past" (Chang, 2009: 40). These new discoveries are more specifically two things: (1) our interpretation of the level of social complexity during the Bronze Age of Northeast Thailand is significantly altered as levels of social hierarchy and complexity are seen to be higher than proven before in the Bronze Age (which can be altered again with the addition of a bangle trade theory), and (2) the use of new dating techniques and subsequent new date sequence encourage mainland Southeast Asia to reassess their dating techniques (Chang, 2009:40). In order to gain further knowledge about the village of Ban Non Wat during its peak in the Bronze Age, it is important to understand the palaeoenvironment.

## Palaeoenvironment and Geology

Boyd and Chang (2010: 278) describe the geoarchaeological environment of archaeological sites from the upper Mun River valley region. The following figure shows the geological context of these sites from the upper Mun River valley region. Detailed field observations and published regional geological history combine to create a model of the palaeogeographic phases from the upper Mun River valley region (Boyd and Chang, 2010:278).

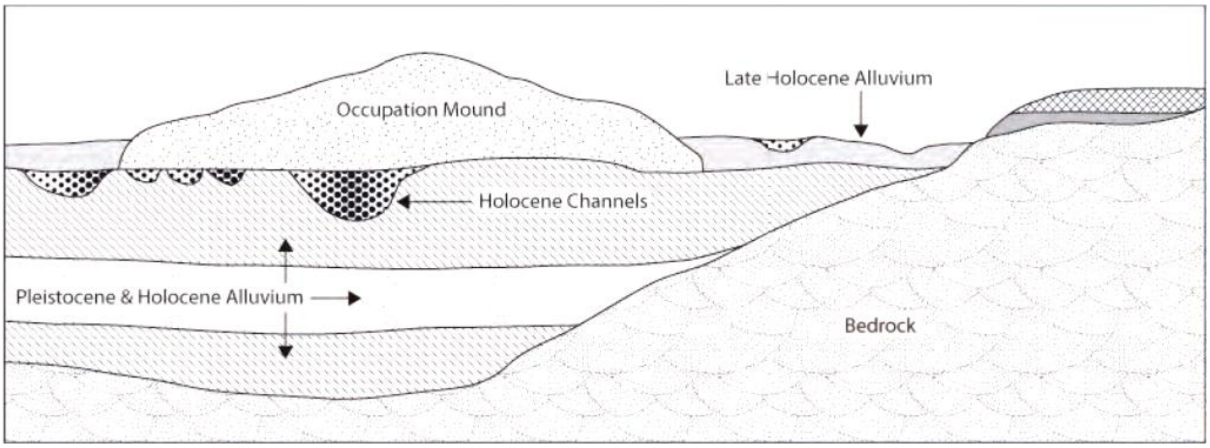


Figure 16 Geology of archaeological sites in the upper Mun River valley region (from Boyd and Chang 2010: 278)

Higham and Thosarat (2012) give a vague description of the palaeoenvironment of Ban Non Wat, identifying it as rich in game and heavily forested. Boyd and Chang (2010:279-280) extend the description of the palaeoenvironment further by including an in depth report of the geology, vegetation and palaeohydrology of the Mun River valley region. They

determined six phases of palaeogeographic landscape periods (Boyd and Chang, 2010:278). The following table illustrates the key geological processes, vegetation cover, and palaeohydrology from each of the palaeogeographic landscape periods.

| Palaeogeographic Phase | Key Geological Process | Vegetation Cover | Palaeohydrology |
|---|---|---|---|
| **Phase 1: Mesozoic-Tertiary** | Bedrock formation and weathering | | |
| **Phase 2: Mid to Late Pleistocene (to 12,000 BCE)**<br><br>***Established landscape for human settlement.*** | Regolith stripping; Coarse sandy river channels | | |
| **Phase 3: Late Pleistocene (12,000 - 6,000 BCE)** | Hiatus | | |
| **Phase 4: Early to Mid Holocene (6,000 - 1,500 BCE)**<br><br>***Environmental stability and richness.*** | Floodplain deposition; Braided channels to single-string channels, back swamps & lakes | Gradual vegetation change | |
| **Phase 5: Mid to Late Holocene**<br><br>***Critical environmental*** | **Phase 5A (1500-500 BCE)**<br><br>Channel Infilling | **Early Iron Age (c. 200 BCE – 1 CE)** natural forest had been disturbed and was now partially open | **Phase 5A & 5B**<br><br>Settlement beside rivers, gradual |

| | | | |
|---|---|---|---|
| ***change.*** | **Phase 5B (500-200 BCE)**<br><br>Anastomosing channels & reduced runoff; Drier floodplain | **Mid Iron Age (c. 300 CE)** forest clearance, rice cultivation, and woodland management, followed by woodland regeneration and the resumption of rice cultivation | change – river channels became increasingly managed |
| | **Phase 5C (200 BCE – 500 CE)**<br><br>Increasing dryness & seasonality | **Late Iron Age (c. 300-500 CE)** decline of agriculture and arboriculture | **Phase 5C**<br><br>Adaptive engineering – cutting of channels across oxbow cut-offs to produce bodies of water fully encircling the settlements & periodically cleaning out the sediments at the bottom of the channels |
| | | | Constructive engineering – demand for reliable water supply was increasing/supply of water was declining |
| **Phase 6: Late Holocene (500 CE-present)**<br><br>***Modified environmental stability due to new landscape equilibrium.*** | Alluvial conditions include single channels & sheet wash; onset of modern climatic conditions | Post Iron Age transition – agricultural landscapes were replaced by dry woodlands and grasslands | Modern conditions |

Table 1 Key geological processes, vegetation cover, and palaeohydrology from each of the palaeogeographic phases (after Boyd and Chang 2010: 278-280)

Major trends from these phases in the upper Mun River valley region during the last 4000 years are then outlined in appendix B. Through the analysis of Ban Non Wat geology, it has been determined that there are no sources of marble or limestone in the immediate area of Ban Non Wat.

The previous information on Ban Non Wat is essential in gaining a comprehensive overview of what life was like at Ban Non Wat in prehistory. Through understanding these details, assumptions can be made on how certain aspects of the area affected everyday life and in particular, whether manufacturing of bangles occurred at the site. This can be further determined through the history of stone bangles at Ban Non Wat and other archaeological sites.

## Bangles

The bangles being used in the pilot study are from both series of excavations and are dated to the Bronze Age. The bangles worn at Ban Non Wat are between Bronze Age 2 and Bronze Age 4 periods (Higham, 2009:225). This sets boundaries for determining the palaeoenvironment and geology of the area at that time. Bangles were either found complete, or in fragments; fragments being the more common of the two. Higham argues that marble bangles are associated with wealth, as individuals of 'wealth' from both sexes were found with one on marble bangle on each wrist (2009:225). Infants and children were also found in association with the marble bangles (Higham, 2009:225). His argument uses Ban Na Di in the Udorn Province as evidence, where the value of marble bangles are expressed through the mending of broken ones, as well as other ornaments, by boring holes near the break and pouring molten bronze through them (Higham, 2009:225). This type of repair is also found in burials and occupation layers at Ban Non Wat, showing similar practices took place there (Higham, 2009:225).

## Former Research

Three particular pieces of literature are essential to the foundation of this study. These are "Stone, Bone, Skin, and Black Boxes: towards a theory of personal ornament" (Kiernan, 2006), "Assessing the Potential of ICP-MS based elemental characterisation in the sourcing of Thai Bronze-Age Marble Bangles" (Theunissen and Chang, 2012), and "Personal Ornaments in Thai Pre-history: Nong Nor, Ban Lum Khao and Noen-U-Loke" (Chang, 2001).

"Chapter 4: Style and Typology - Khok Phanom Di and beyond?" in "Personal Ornaments in Thai Prehistory: Nong Nor, Ban Lum Khao and Noen U-Loke" was a thesis written by Nigel Chang in 2001. This particular piece of literature is important in understanding the styles and

typologies of the bangles found at Ban Non Wat. The classes of personal ornaments are determined both by use and form (Chang, 2001:29). A *bangle* is described as a closed or open circlet made of continuous homogenous material or as long firm ornaments worn on the arm (Chang, 2001:30). Terminology explaining bangles is shown in figure 17.

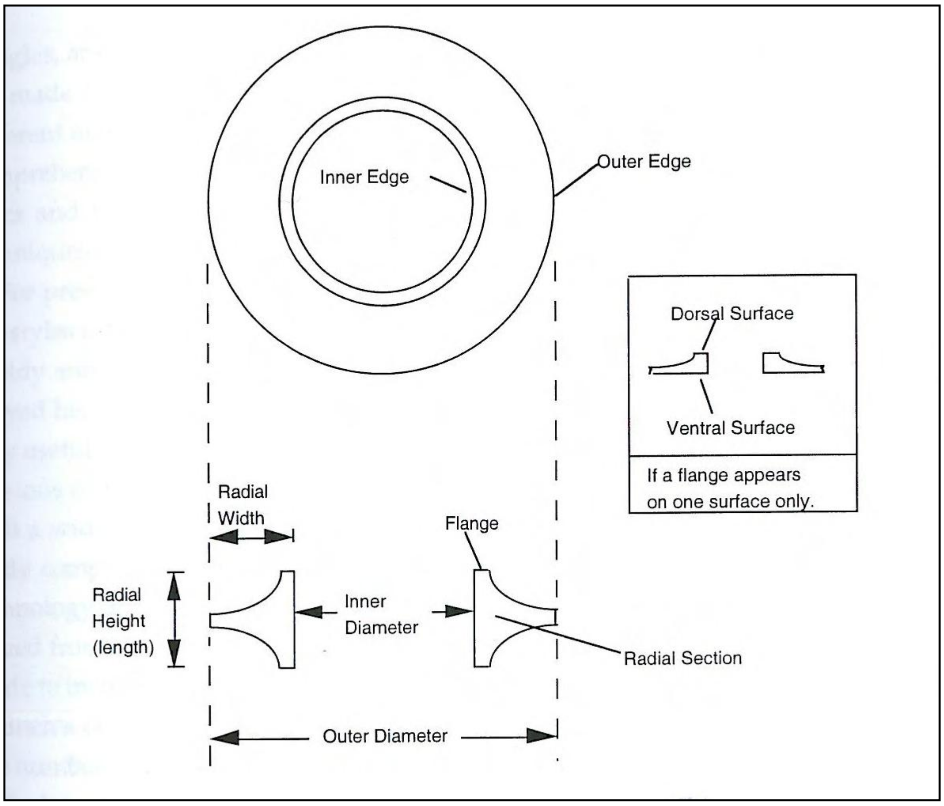


**Figure 17 Terminology for the description of bangles (from Chang 2001:31)**

There are 29 possible styles of bangle which can be classified (Chang, 2001:32-35). Style 2 is the most common style of bangle type, described as having T-shaped radial sections caused by the formation of concentric flanges on either side of the inner edge (Chang, 2001:32). This style is used as the example in the previous image. An overview of the types of stone used for bangles is also given. Of most interest is the material "soft stone". "Soft stone" include stones which are easily worked such as marble, serpentine and slate (Chang, 2001:36). It is possible that this type of stone was worked similarly to that of shell, using techniques of chipping, grinding, and trepanning (Chang, 2001:37). Each of the previously described features is important to the physical analysis of the bangle.

"Stone, Bone, Skin, and Black Boxes: towards a theory of personal ornament", an unpublished thesis by Trina Kiernan in 2006 was the first research on the stone bangles from

Ban Non Wat that was undertaken. She did ICP-MS analysis on a selection of sixteen bangles from Ban Non Wat, Thailand (Kiernan, 2006:39). Analysis concluded that shell bangles were sometimes being miscategorised in the field as stone, and that the actual stone bangles derived from a uniform source (Kiernan 2006:43). This deduction makes the search for the source of the bangles much simpler.

"Assessing the Potential of ICP-MS based elemental characterisation in the sourcing of Thai Bronze-Age Marble Bangles" is the final source of literature crucial to this study. This is an unpublished paper, by Nigel Chang and Robert Theunissen from 2012. It details a comparative analysis between the results from Kiernan and new ICP-MS analysis results on 14 quarry samples from quarries local to Ban Non Wat; Ban Rai and Ban Tha Chang Dai with the stone bangles from Ban Non Wat, using Cairns quarry marble as a control sample (Theunissen and Chang, 2012:4). Principal Components Analysis (PCA) determined that the Ban Non Wat bangle fragments were distinguishable from the quarry samples, however, they were very closely clustered together which suggests they did in fact come from the one source (Theunissen and Chang, 2012:10).It was considered that the samples may still come from Ban Rai Quarry as the bangle fragments grouped central to the chemical variation of that of Ban Rai (Theunissen and Chang 2012:10). These results can be seen in the following image.

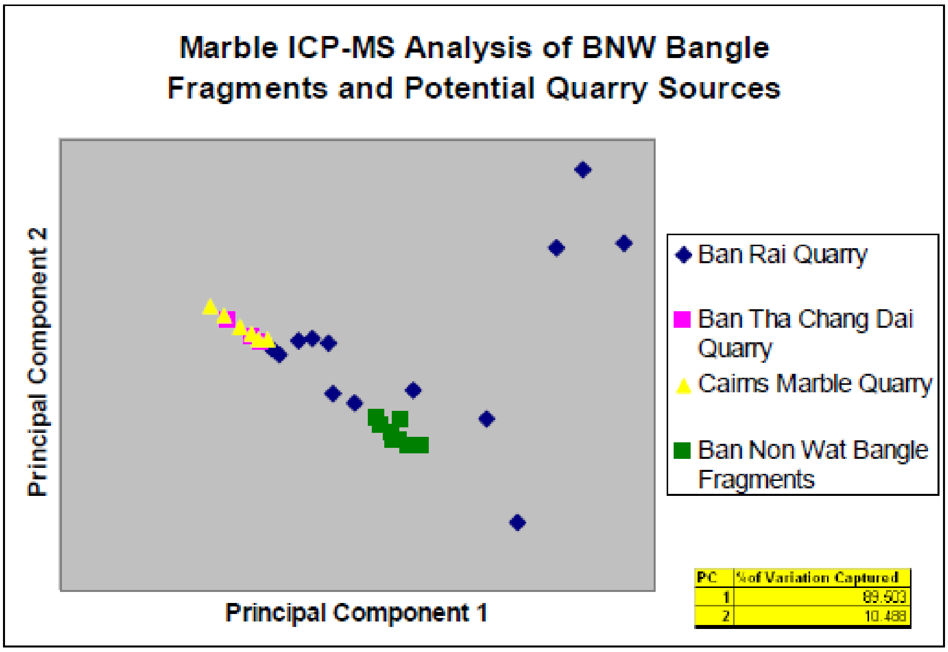


Figure 18 Principle Component Analysis of ICP-MS Results (Theunissen and Chang 2012: 10)

The Cairns Marble Quarry samples were used as a control sample. The results showed that the Ban Tha Chang Dai Quarry samples were extremely similar in composition to the Cairns Marble Quarry. This shows that both a quarry sample from Far North Queensland, Australia, and a quarry sample from Northeast Thailand are both very similar in composition or that this is an error and shows the importance of combining Principle Component Analysis with another type of analysis to minimise the risk of error.

Understanding these ICP-MS results enables researchers to focus on looking for the single quarry source with the potential source of the stone already discovered. This investigation will take a further look at the quarry samples in comparison with the bangle fragments to determine if that is the source and provide a model for the possible trade of the bangle stone from Ban Non Wat.

## Summary

Context is a very large part of this study. The background of Ban Non Wat and the former research all contribute to our understanding of the origin of the bangle stone from Ban Non Wat, Thailand. Understanding the background of Ban Non Wat reveals information on where the study originates, and when, who, why and how the bangles were used. It also determines that there is no limestone or marble geologically in the immediate area, which means the stone for the bangles, had to have come from an outside source. Researching previous studies provides further important information for the analysis. The theory and methods behind the research is necessary before analysis can begin.

# Chapter 4: Theory and Methods

Three main methods are used to complete the research; ethnographic analysis, stone analysis, and understanding the landscape through Geographic Information Systems (GIS) techniques. Ethnographic analogy, a middle-range theory approach, provides a theoretical component to this study.

## Ethnographic Analysis

A modern culture identifying as the Naga tribes live in the mountains of the area bordering Myanmar and India. Strictly speaking, the Naga tribes do not comprise of a homogenous ethnic identity, instead they have a number of distinct ethnic groups (Kumar, 1995:3). There are at present thirty major Naga tribes living in the eastern hill frontiers of Nagaland, Manipur, Assam, and Arunachal Pradesh (Kumar, 1995:1). There are four different categories of classification of the Naga tribes based on ethnological and linguistic data: Southern Nagas, Western Nagas, Central Nagas, and Eastern Nagas (Kumar, 1995:2). Konyak Nagas are one of the fourteen major tribes in Nagaland (Kumar, 1995:1). Nagaland stretches from $25^0$6’N to $27^0$4’N latitude and $93^0$20’E to $95^0$15’E longitude, and is bordered to the west by Assam, to the north/east by Arunachal Pradesh, to the east by Burma, and to the south by Manipur (Kumar, 1995:11). The mostly hilly region is made up of three mountain ranges: Patkai, Naga, and Barrail (Kumar, 1995:11). Villages in this area are built mainly on hilltops to be out of the malaria infection zone (Kumar, 1995:11; Furer-Haimendorf, 1969:7).

There is limited research on the Konyak Nagas and their use of the bangle (also known as Shuptet in Konyak (Mongro, 1999:101)) in their culture. It is said that during the Naga migration from Central and Southeast Asia, a variety of precious ornaments including bangles were brought with them, which are said to be the most original ornaments used by the Naga (Mongro, 1999:97). From ethnographic research it has been illustrated that Konyak men and women wore various shaped arm rings and neck ornaments made of several materials (Furer-Haimendorf, 1969:14). This is shown in the following image.

Figure 19 Konyak Naga men and women wearing a variety of personal ornaments (Furer-Haimendorf 1969:10)

Among the many personal ornaments seen in this image are stone bangles similar to those of this current study. Bangles are generally worn by women and was a popular personal ornament among the Konyak tribe (Mongro, 1999:97 and 101). They came in a variety of designs and colours, however they were mostly made of brass (Mongro, 1999:101). Bangles were used in two ways; for everyday wear, and for special occasions (Mongro, 1999:102). Although bangles were originally brought in from neighbouring countries for use, however they are now being made in individual tribes (Mongro, 1999:102). This information is used in comparison with Ban Non Wat to further the knowledge of bangle culture. Ethnographic analogy is understood through the framework of the Middle Range Theory.

## The Middle-Range Theory

*Middle-range theory* was first introduced by Lewis Binford in 1975 (Binford, 1975:255), followed by an explicit description in 1977 (Binford, 1977:6). The intention is to observe the past through the archaeological record (Tschauner, 1996). There are two conditions that are important for the fulfilment of *middle-range theory*: the independent development of general theory and the assumption that the past was similar to the present (uniformitarian

assumption) (Johnson, 1999:54-55). *Middle-range theory* research establishes a method that is independently tested and ingrained in the foundation of arguments, through studying the cause and effect relationships between dynamics and statics in the archaeological record as per figure 20 (Tschauner, 1996:4).

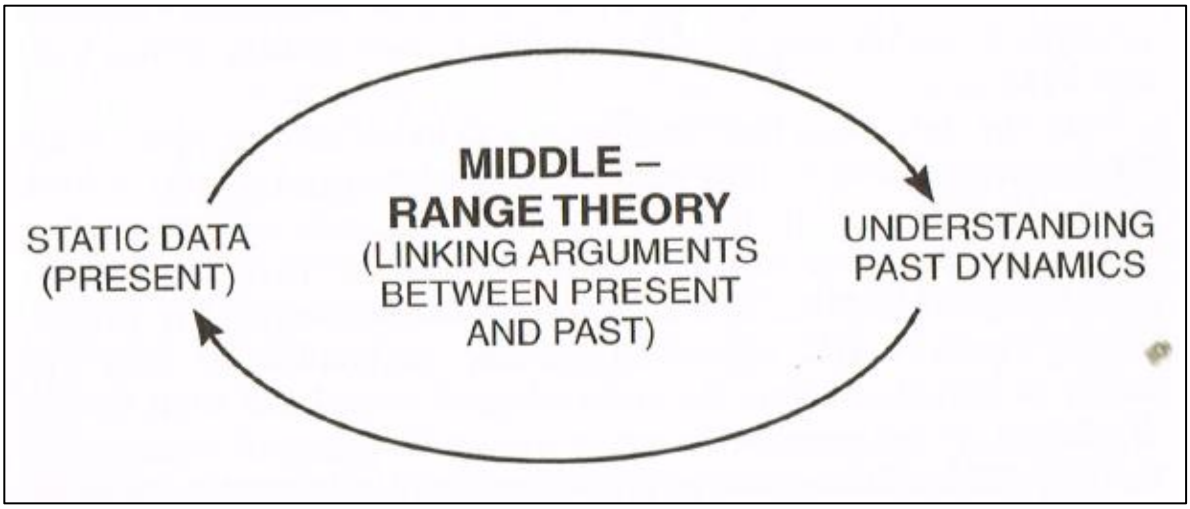


**Figure 20 Present statics and past dynamics (from Johnson 1999: 49)**

It is described as a:

> *body of knowledge about the relations between material culture and human activities within various behavioural settings, warranting translation of static archaeological data to cultural and cultural processual dynamics* (Watson, 2008:31).

To identify relationship properties, an understanding of how living, contemporary cultural systems work, how they differ, and what factors condition these differences, is needed (Tschauner, 1996:4). The *middle-range theory* model provides this understanding between the present and the archaeological domains by bridging the gap (see also figure 21) (Carr, 1995:108; Tschauner, 1996:4; Kosso, 1991:623; Watson, 2008:31). Connections are made between the records of the present, through the use of field and site reports, and the reconstructions of the past (Kosso, 1991:621). These claims are backed up through material evidence which is used to make the information link between the past and the present (Kosso, 1991:622). Tracking the flow of information from past to present is key to understanding the past (Kosso, 1991:623).

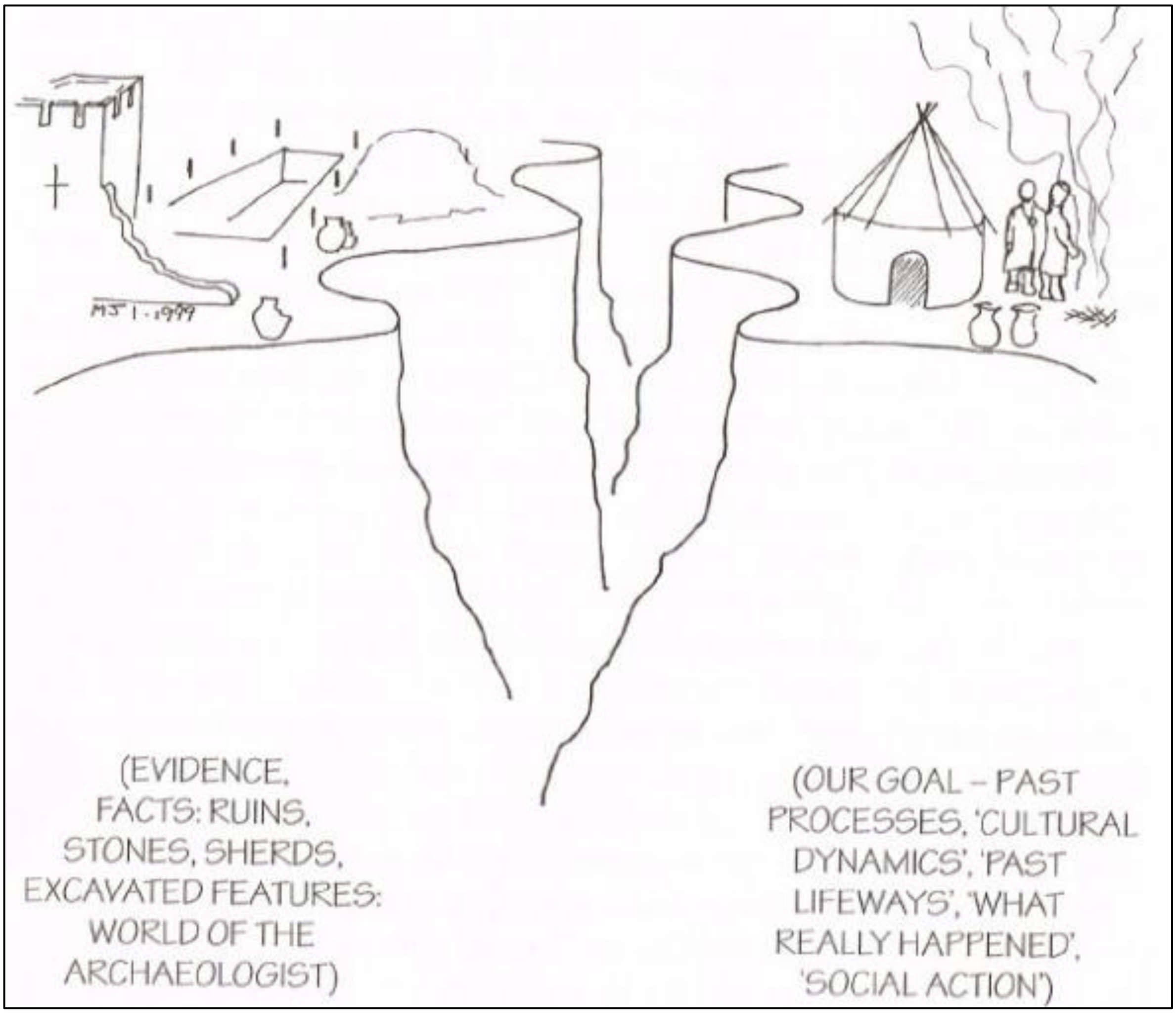


**Figure 21 The gap between the present and the archaeological record (from Johnson 1999: 14)**

Deposits of neglect, burial or intentional discard; alteration of deposited artefacts (through natural or cultural activity); specific claims about the area such as the tendency for erosion; and the local people, are all used to identify material evidence (Kosso, 1991:622). Theories linking the past and the present are used as a contribution to the lineage of the archaeological record as well (Kosso, 1991:622). Archaeologists make observations of present cultures relevant to the past through the archaeological record (Watson, 2008:31). Binford wanted *MRT* to be experimental, with the intent to make the process of observing the past through the archaeological record a normal occurrence in the natural sciences (Kosso, 1991:623; Tschauner, 1996:6; Trigger, 2006:405).

### *Applications within archaeology*

Binford described *middle-range theory* as a:

> *Rosetta Stone: a way of translating the static, material...found on an archaeological site into the vibrant life of a group of people who in fact left them there* (Binford, 2002:24).

Ethnoarchaeology is the most prominent application of *middle-range theory* within archaeology. It is one of the most significant characteristics derived from *middle-range theory* (Binford, 1979; Binford, 1991; Carr, 1995; Cunningham, 2003; Johnson, 1999; Kosso, 199; Roux, 2007; Trigger, 2006; Tschauner, 1996; Watson, 2008). Stark (2003:195) conveys that ethnological data provides the fabric for building archaeological conclusions which are stronger than the material culture modelling derived of commonsense explanations.

*Middle-range theory* has also been used as an application of analysis of mortuary practices (Carr, 1995). The case study from Carr (1995) has two objectives; (1) establish that philosophical-religious beliefs are an essential part of the study and interpretation of mortuary practices and remains, and (2) test with cross-cultural data to reconstruct social organisation from mortuary remains (Carr, 1995:106-107). The roles of social organisation and beliefs from an anthropological and archaeological viewpoint in determining mortuary practices are discussed, followed by the historical outline of how American mortuary archaeology began a focus on social organization (Carr, 1995:108). The subsequent development of middle-range theory due to restrictive circumstances then occurred (Carr, 1995:108). The focus for mortuary archaeology was on social organisation rather than beliefs and ideology (Carr, 1995:119). Social organisation such as age, vertical social position, horizontal social position, and burial practices such as body preparation and grave furniture were deemed fundamental to the study of mortuary practices (Carr, 1995:119). Binford argued against the few 'idealist' or 'rationalist' approaches of cultural analysis and directed mortuary practices toward social organisation by maintaining that mortuary practices are symbolic (Carr, 1995:117-118). Because mortuary archaeology was focussed on social organisation, conclusions in other fields about how beliefs impacted on mortuary practices were not integrated in to archaeology (Carr, 1995:119).

Through providing an understanding between the dynamics of the present bangle culture of the Naga and static past of Ban Non Wat, the gap between the two can be linked using analogies. The relative value of the artefacts in relation to how far away they came from or how hard they were to make is the analogy in this case. The stone bangles from Ban Non Wat are the evidence from the archaeological record that are analysed through scientific means. Through analogy, using the Naga as an example, theoretical conclusions about what the society of Ban Non Wat might have been like can be made. The relative values of stone bangles and conclusions on trade and exchange of those items in particular can be made.

## Sourcing Materials: a look at similar research

Provenance studies for marble artefacts in Asia are rare. The only known study is an unpublished thesis written in 2006 for James Cook University (Kiernan, 2006). These studies, however, are common place for archaeologists and geologists in Europe. They typically follow the method of an archaeometric approach, which is interrelated with processual archaeology; the most common theoretical framework used within provenance studies. Importantly, tests have been done to explore expert systems in the construction of archaeological interpretations when based on archaeometric data (Vitali, 1989). Results of such tests found that expert systems offered a “systematic and verifiable” way for interpretation and reasoning as well as a method, based on archaeometric information, to guide interpretive stages of studies (Vitali, 1989:383). It also found that understanding all disciplines in archaeological studies, and having sufficient knowledge in these disciplines, was involved in successful archaeological interpretation (Vitali, 1989:383). An expert system it seems is an important system to follow for such a study as this one.

Multi-method analysis followed by discriminant function analysis are used explicitly for the provenance of marble according to multiple research papers (Attanasio et al., 2005; Attanasio et al., 2005; Brilli et al., 2010; Brilli et al., 2005; Ferrini et al., 2012; Ouazaa et al., 2012; Pensabene et al., 2012; Taelman et al., 2013). These multi-method analyses are applied through the previously mentioned archaeometric approach; using scientific methods to obtain archaeological results (Vitali, 1989:383-384). Five types of scientific analyses were present overall out of seven articles relating to marble sourcing. Spectroscopic Electron Paramagnetic Resonance (EPR), oxygen and strontium isotopic analysis, minero-

petrographic analysis, X-Ray Diffraction (XRD) analysis and Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) analysis were the principal scientific techniques undertaken for the studies (Attanasio et al., 2005; Brilli et al., 2010; Brilli et al., 2005; Ferrini et al., 2012; Ouazaa et al., 2012; Pensabene et al., 2012; Taelman et al., 2013). Discriminant function analysis is then used in at least three of the research papers, in order to organise the results, for comparison and analysis (Attanasio et al., 2005; Brilli et al., 2010; Taelman et al., 2013). The following table is a description of the different methods available and how successful they were.

| Method | Use | Success |
|---|---|---|
| **Spectroscopic Electron Paramagnetic Resonance (EPR)** | e.g. Jasper sourcing | Multi-method needed |
| **Oxygen and Strontium Isotopic Analysis** | Time consuming<br>Expensive<br>e.g. Marble sourcing | Multi-method preferable |
| **Minero-petrographic Analysis** | Used in conjunction with chemical analysis<br>e.g. dacite sourcing | Multi-method needed |
| **X-Ray Diffraction (XRD) Analysis**<br>**X-Ray Fluorescence (XRF)** | Minimally destructive<br>Fast<br>e.g. Obsidian sourcing | Multi-method needed |
| **Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) Analysis** | Destructive<br>e.g. stone artefact sourcing | Multi-method preferable |

Table 2 The different analysis techniques, uses and successes

This table gives preference to multi-method analysis for accurate results. Isotopic analysis would be preferable for the instance of the bangle sourcing, however, that has been proven to be time consuming as well as highly expensive (Brilli et al., 2005:546) which is not suitable for this study. The next standard method used to provenance marble is petrography. Six out of the seven research papers used this method and as such is the principle method of choice for this project. This is combined with the visual analysis to determine physical characteristics of the bangles. A visual and petrographic analysis is then completed on 14 rock samples from quarries local to Ban Non Wat for comparison. The second step of the

study is to study the landscape through GIS techniques. This includes studying the landscape with a combination of information from palaeoenvironment, geological, and archaeological information. The analysis from the quarry samples and the stone bangles are then compared to previous chemical composition analyses. These steps will help determine a model for the trade and manufacture of bangle stone. The information gathered will then be compared to the present culture, Naga, who still use stone bangles today.

## Stone Analysis

As previously mentioned the overall aim of this project is to construct a model for the origin of trade of the bangle stone from Ban Non Wat (BNW), Thailand. Three important questions are derived from this overall aim: what is the bangle stone and where does it come from, where were the bangles manufactured, and how controllable was the trade? Minero-petrographic analysis is set to be completed on 3 bangle samples from Ban Non Wat, and 4 quarry samples. This is to confirm marble was the stone used to make the bangle. Previous chemical composition studies had been done on all the samples, with Principal Component Analysis (PCA) to analyse the data (Kiernan, 2006; Theunissen and Chang, 2012). Using the chemical composition and mineralogy of the rocks, the provenance of the stone bangles is to be carried out using GIS techniques.

Petrography is the most suitable and appropriate technique to use for the provenance of marble artefacts, as it is a popular choice amongst professionals undertaking that exact task (Attanasio et al., 2005; Brilli et al., 2010; Brilli et al., 2005; Ferrini et al., 2012; Ouazaa et al., 2012; Pensabene et al., 2012). This technique allows the mineralogical composition of the stone artefacts to be compared with the mineralogy of possible sources (Attanasio et al., 2005; Brilli et al., 2010; Brilli et al., 2005; Ferrini et al., 2012; Ouazaa et al., 2012; Pensabene et al., 2012), therefore making the provenance of artefacts easier; it enables the ruling out of any sites that do not match that mineralogical composition. Petrography is also used to determine rock type, and in this case to confirm that the composition of the bangle stone is that of marble or limestone. The following is a detailed method on the stone analysis and how each question is answered through this method.

The stone bangle analysis is recorded on excel in three sections; artefact context, physical characteristics, and thin section analysis. Artefact context is essentially the description of

where the artefact was found, written on the bag, and this is recorded first. Physical characteristics of the bangle samples are then determined. Bangle type or form, weight (g), estimated completion (%), estimated inner and outer diameters (mm), radial height and width (mm), and the flange connection to the body are analysed according to the 'Stone Bangle Typology' in Chang (2001) (see Appendix C). Colour, texture, grainsize, and effervescence are also analysed and recorded as per Pellant (2000). Once this process is complete and documented, three samples are sent for thin sectioning through Ingham Petrographics (seen in figure 22).

Figure 22 Stone bangles used for thin sections

Petrographic analysis involves looking for specific features of the minerals such as shape, habit, colour, pleochroism, cleavage, relief, birefringence, extinction angle, twinning, zoning, and alteration (MacKenzie and Adams, 1994; Schumann, 1993). Information gained from the identification of minerals is used in two ways. The first is to confirm the bangle stone is marble. The mineralogy and composition learned from this analysis is used in relation to the

geology of Southeast Asia, narrowing the search criteria down for potential provenance sites. This analysis leads to the second way, which is where the bangle stone comes from.

Two quarries local to Ban Non Wat have previously had samples obtained. There are 14 quarry samples; 12 from Ban Na Dai and 2 from Ban Ta Chang Rai. With these samples, the rock types are determined through the use of the Rock Identification Key (see Appendix D), and compared to the conclusions from the stone bangle identification. Four of these samples are then sent for thin sectioning through Ingham Petrographics for petrographic analysis. Once this is complete a chemical analysis comparison between both the quarry samples and bangles takes place. Chemical composition analysis was already performed on the samples, with comparative testing (derived from Principle Component Analysis) (Theunissen and Chang, 2012). The results showed that the bangles may have been sourced from one of the local quarries; Ban Rai (Theunissen and Chang, 2012). It also showed that all bangles were from the same quarry source (Kiernan, 2006; Theunissen and Chang, 2012) which indicates that the objective is to locate one potential source.

Using the minero-petrographic data in comparison with the data from the original chemical analysis, it is possible to determine the composition of the samples. Initial interpretations of a trade route are then made from an analysis via GIS techniques. This technique involves the use of geological maps of Southeast Asia and southern China, specifically including minerals, elevation, and palaeoenvironment, in relation with archaeological maps of the same area, including trade routes and relevant archaeological sites. Possible conclusions and models are made through this method and a detailed plan for further comprehensive analysis using a GIS program is outlined in the discussion and conclusion.

## Understanding the Landscape through GIS

Geographic Information Systems (GIS) is a spatial analysis tool that uses mapping and other visual methods for analysis; especially archaeological analysis (Gillings and Marttingly, 1999). When first introduced as a method of analysis, GIS had a systems based approach to understanding the past (Gillings and Marttingly, 1999). GIS in archaeology has three main uses: inventory (for survey and excavation), spatial analysis, and publication (Fisher, 1999). Spatial analysis can be broken in to three sections: contextual analysis, locational analysis,

and predictive modelling (Fisher, 1999). This particular study is done through locational analysis; attempting to test a hypothesis (Fisher, 1999).

There was not enough time for the spatial analysis to be computerised therefore GIS techniques are implemented in order to create the model for bangle stone trade from Ban Non Wat. Before this analysis is done, a map similar to a GIS database is created. The necessary parts for this study are determined via category. The location was narrowed down to Mainland Southeast Asia and south China. Geological and geographical outputs are reviewed and established and include minerals (limestone and marble), elevation, and palaeolandscape. Archaeological outputs are also reviewed and established as other known bangle sites and known trade routes.

Each of these individual sections is combined to make the final map. Through analysis, this map can be used to determine possible communication and trade routes by determining the quickest or easiest possible routes to get to the nearest limestone or marble outcrops. Three possible outcomes are set to be established through this method. Once the possible routes are determined how controllable the trade was can also be determined.

## Summary

This is a pilot study designed from a previous attempt to provenance the bangle stone from Ban Non Wat, Thailand, via chemical composition analysis. Alternatively, this study looks at the minero-petrographic aspect of the stone bangles as a point of origin. The ethnographic aspects of the study put this in the *middle-range theory* category, however the majority of the study is scientific based. A detailed and systematic methodology will help to create a clear theory in to the trade of stone bangles from Ban Non Wat. The results of these analyses demonstrate this.

# Chapter 5: Stone Analysis Results

This chapter reports on the results found from the stone analysis, from both the bangle and the quarry samples. The first section of results shows the analysis results of the series one excavations, followed by the series two excavations. Then the second section shows the analysis results of the quarry samples. These results are then compared in order to determine if there is a possible chance that the bangles could have come from either quarry.

## Personal Ornament Samples

### *Series 1:*

Personal ornaments comprise 29% of the material culture at Ban Non Wat as per the series one excavations seen in table 3. This 29% includes ~3000 artefacts of which 31 were stone bangles.

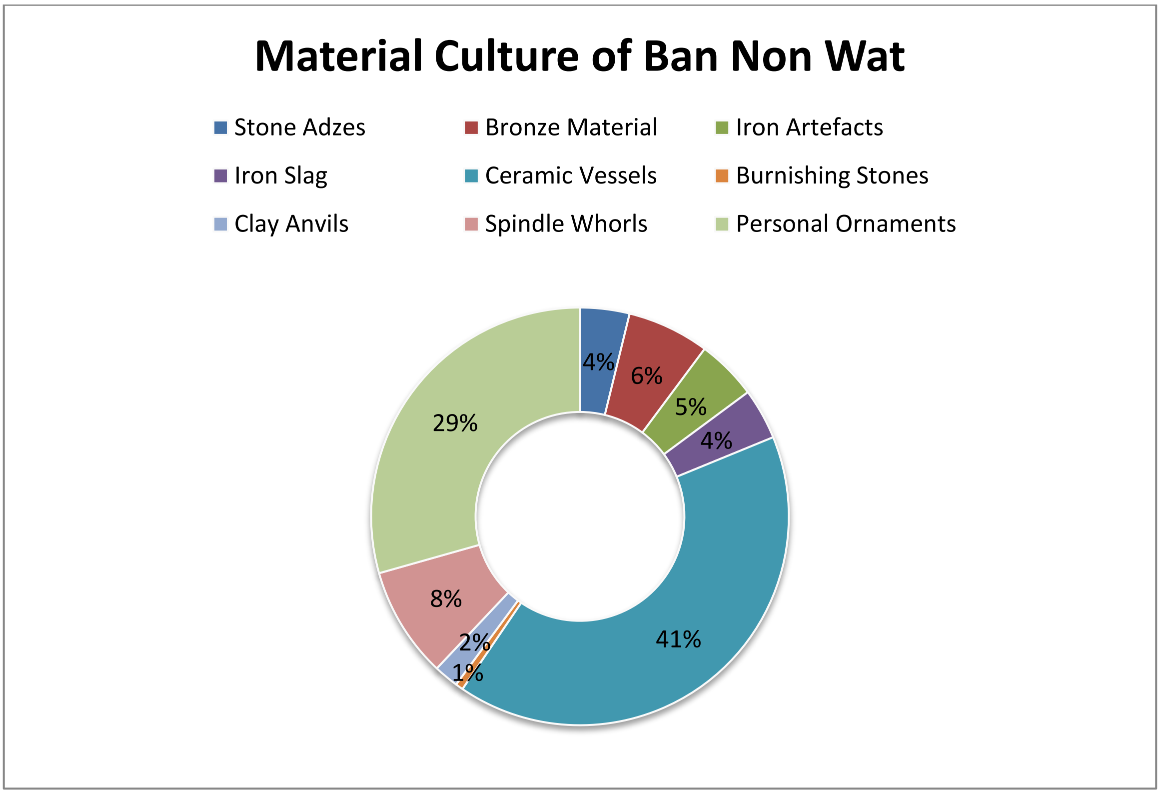


Table 3 Percentage of distribution of material culture at Ban Non Wat, Thailand (after Higham 2009: 187-249)

Six bangle fragments are analysed from this set. Only one of these fragments was removed from a feature, though they are all distributed widely across the first series of excavations.

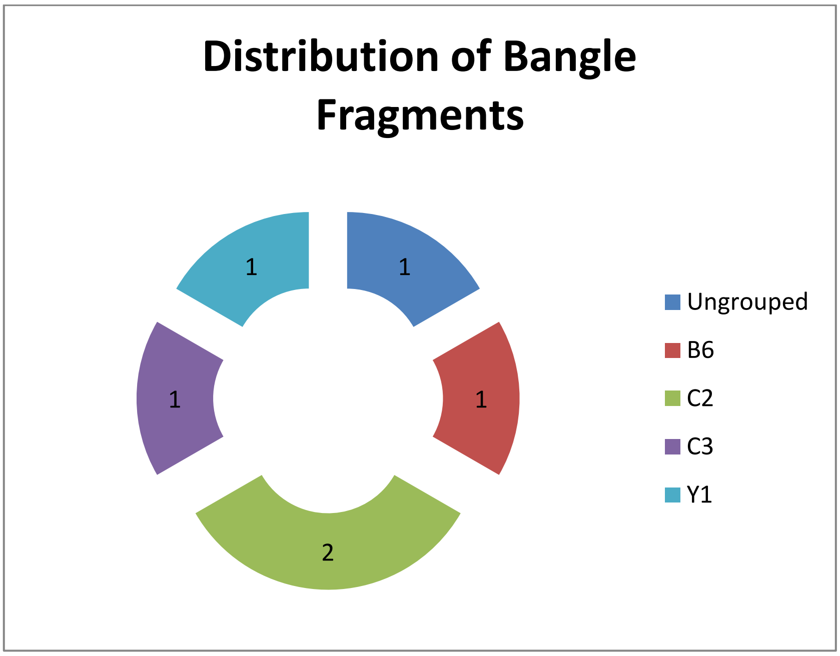


Table 4 The bangle fragment distribution across Ban Non Wat

The distribution of the sample of bangles throughout Ban Non Wat is shown in table 4 and figure 23. B6, C2, and C3 are from the large yellow excavation square shown, and Y1 is from the blue excavation that has been indicated. One of the fragments locations is not confirmed.

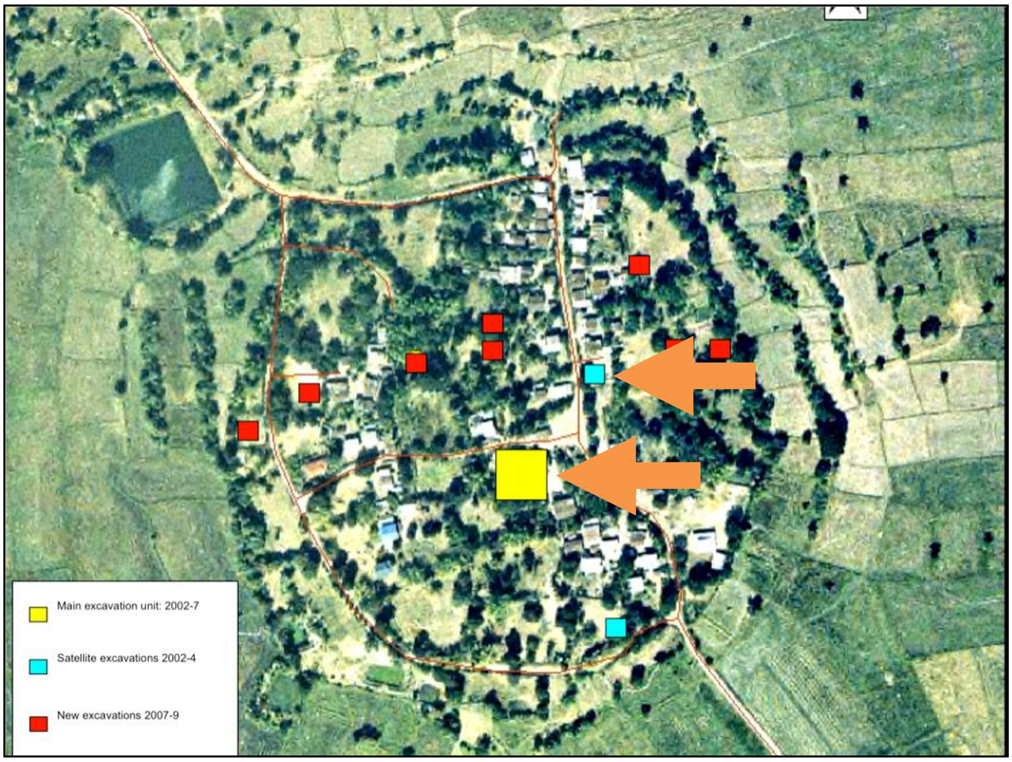


Figure 23 Distribution of excavation squares across Ban Non Wat (prepared by Nigel Chang and James Maloney)

Out of the six fragments, three were chosen for petrographic analysis. These were chosen based on the size and style of the fragment. Sample Y839, 6648, and 8639 were chosen with these criteria and sent for petrographic analysis. However, this is yet to take place due to unforseen difficulties.

Appendix E has the datasheets for these stone bangles. It illustrates the context of the artefacts as well as their physical descriptions. It shows that four out of six fragments had a marbled surface. This relates to the effervescence of the fragments. It shows that half of the fragments had no reaction to vinegar (a test to determine effervescence in rock, of which limestone is), and the remaining had mild reactions or higher. The fragments with marbled surfaces correlate to the fragments which show sign of effervescence. However, accretions on the surface of the fragments or a presence of talc may have also caused them to effervesce. The following table shows the comparative reactions of the fragment.

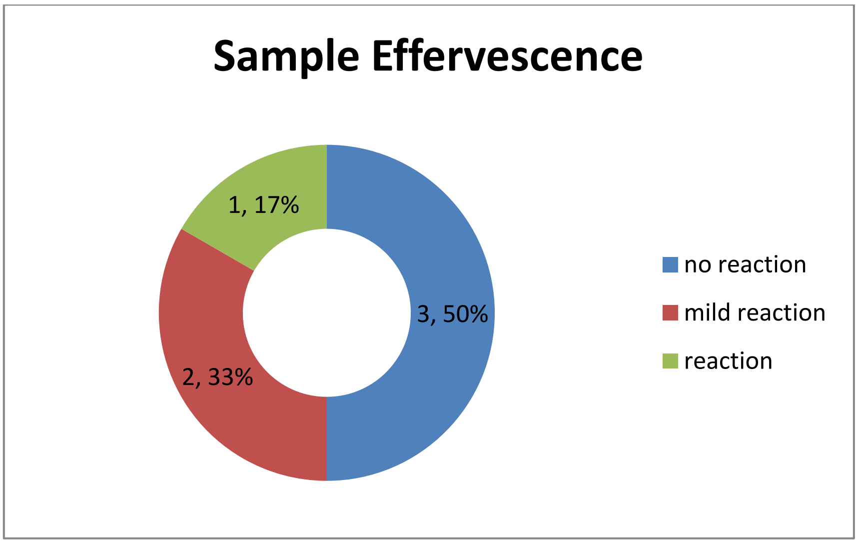


Table 5 Sample effervescence

Out of the six fragments analysed from series one, the most common bangle style was style 2 (table 6), according to Chang's Stone Bangle Typology (Chang, 2001:32-33). Style 2 bangles are discs with T-shaped cross-sections, as seen in figure 24.

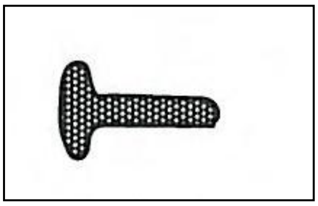

Figure 24 Style 2 bangle cross-section (from Chang 2001:34)

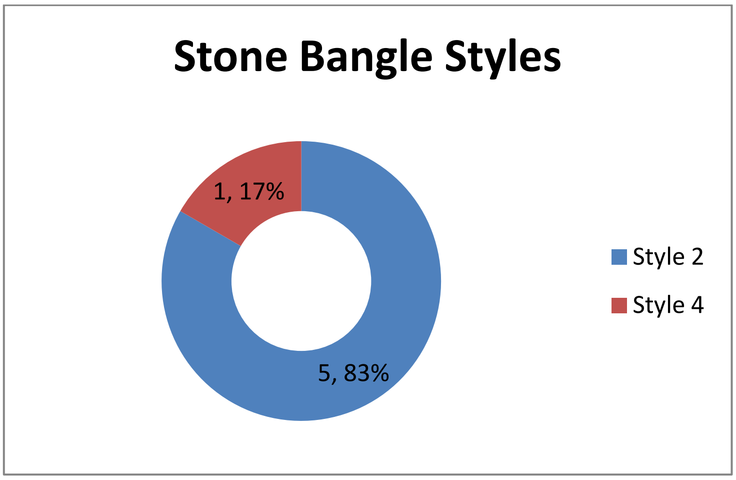


Table 6 The distribution of bangle fragments selected for the study

This style is also the most common from the series 2 excavation, which can be seen in the next section.

*Series 2:*

There are 344 (stone, shell and clay) bangles or bangle fragments from the series 2 excavations. Of this 344, only 28 were made of stone. The following table is the dispersal of bangle materials throughout Ban Non Wat. Bone and bronze bangles are not included in this particular analysis as the stone, shell and clay bangles are commonly confused with one another.

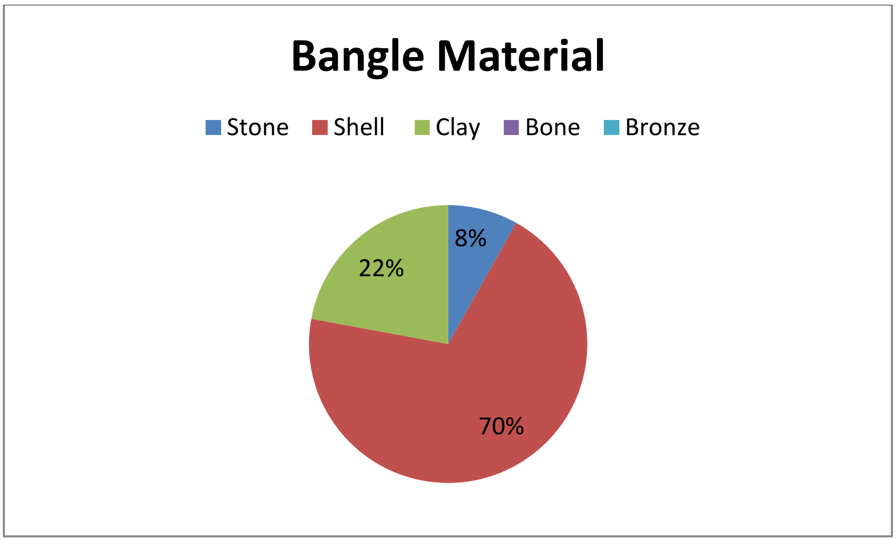


Table 7 The dispersal of bangle material from Ban Non Wat

Datasheets for each of the stone bangle fragments can be found in Appendix E. These show the context, style, material type, colour, grainsize, weight, flange, percentage of completion,

radial height and width, and inner and outer diameters. A majority of these 28 fragments are style 2 (figure 24). 36% of these fragments were too small or fragmented to be able to determine an indisputable style, shown in table 8.

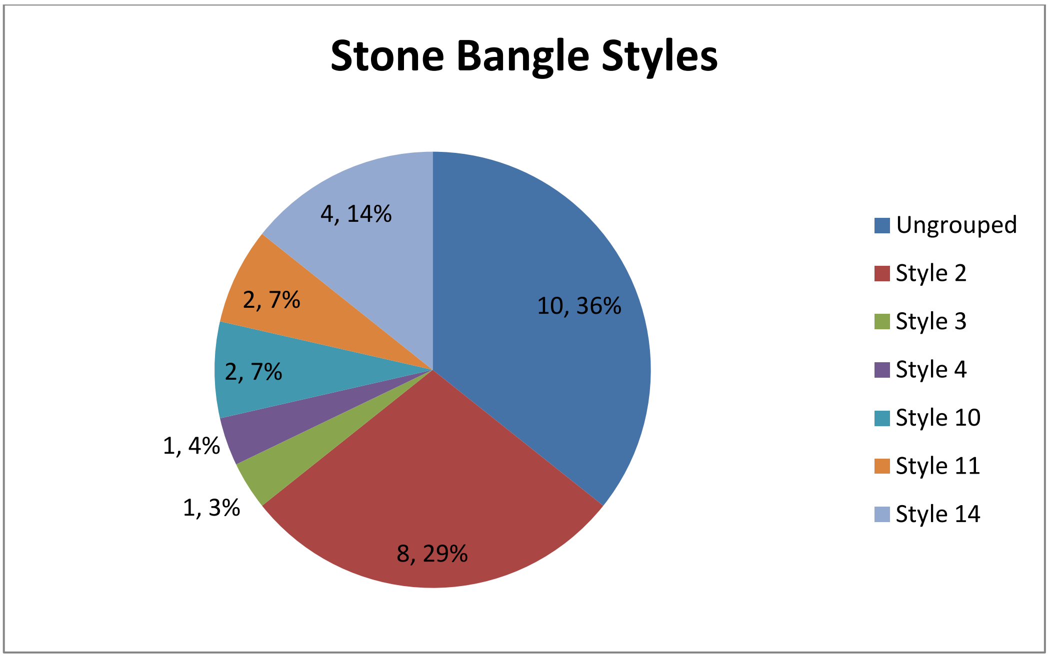


Table 8 The total distribution of bangle fragments from Ban Non Wat

17 or 61% of the fragments from this series have a marbled surface (table 9). None of these particular fragments showed any sign of effervescence when tested.

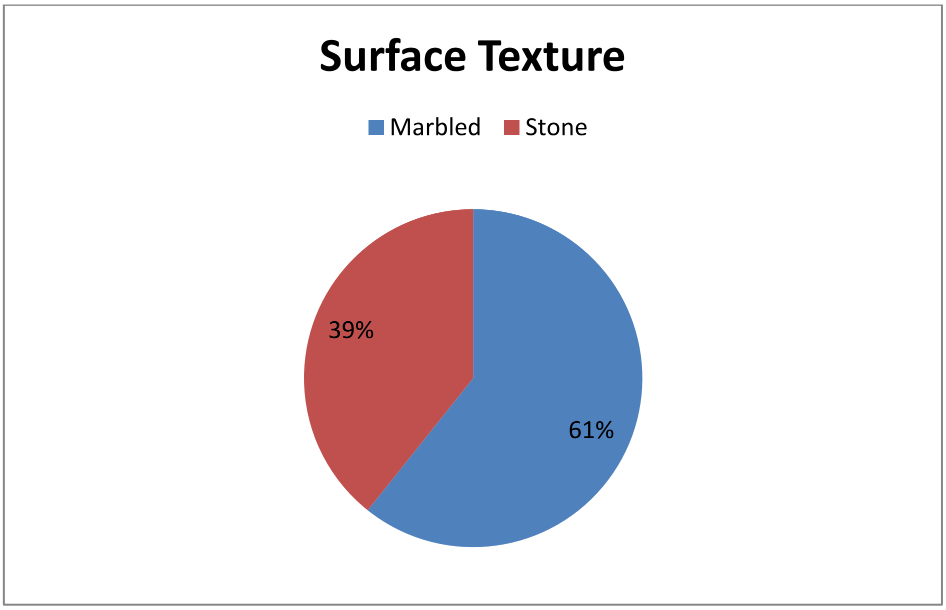


Table 9 The surface texture of the fragments

Only one fragment from the entire sample series shows signs of effervescence. When the surface texture of the fragments is compared with the effervescence, no effervescing fragments had a marbled surface. This is very different from the fragments from the series one excavations, of which half of the fragments showed signs of effervescence. These results are then compared to the analysis of the quarry samples.

## Quarry Samples

14 quarry samples are analysed.  These quarry samples are all sourced from an area that is close to Ban Non Wat in the southwest corner of the Khorat Plateau. 12 samples are from Ban Rai quarry and 2 are from Ban Tha Chang Dai quarry. The following image shows the location of these quarries within the Khorat Plateau.


Figure 25 The location of the two quarries, in comparison to Ban Non Wat, on the Khorat Plateau

It shows that the quarry locations are within 10km of one another. Appendix E has the context and description of the physical characteristics of the quarry samples.

This analysis led to the conclusion that the rock type from the Ban Rai quarry is grey marble, pink marble, migmatite, black slate or granulite, while both samples from Ban Tha Chang Dai

quarry were halleflinta. Marble is defined as a metamorphic rock (Schumann, 1993:324). The term marble is used for both calcitic and dolomitic marble (this relates to the matrix being either calcite or dolomite) (Schumann, 1993:324). Marble develops from limestone through contact or regional metamorphism {Schumann, 1993 #51@:324}. It is medium to coarse grain, which is a result of the metamorphism {Schumann, 1993 #51@:324}. Marble is monomineralic (Schumann, 1993:324) which means it is composed of a majority of one mineral. The remaining minerals are made of amphibole, chlorite, epidote, mica, garnets, graphite, hematite, limonite, plagioclase, pyrite, pyroxene, quartz, serpentine, vesuvianite, or wollastonite (Schumann, 1993:324). The rock texture is extremely compact and the pore volume is below 1% (Schumann, 1993:324).  Marbles can come in any shade of colour, and can appear wavy, flecked, grained, veined or striped (Schumann, 1993:324). Because it is so similar to limestone the following is used to help determine the differences.

| Marble | Limestone |
| --- | --- |
| Coarse grained - crystals visible with the naked eye | Fine grained – crystals only visible with microscope |
| Sparry fracture | Fine grained dull fracture |
| Translucent at edges | Not translucent at edges |
| No cavities | Occasional cavities |
| No fossils | Frequent fossils |

**Table 10 The difference between marble and limestone (from Schumann 1993:324)**

By using this set of characteristics it is determined that the quarry samples did not contain any signs of fossils or any cavities, and the grains were very easily seen. Therefore, it is evident that the quarry samples from Ban Rai were not made of limestone and are very likely marble.

Ban Rai quarry samples also included migmatite, black slate, and granulite. Migmatite is a metamorphic rock made up of two separate rock types (Schumann, 1993:310; Pellant, 2000:214). Rocks are typically coarse grain, often showing banding and small scale folds (Pellant, 2000:214). The composition of the rock is that of a "gneiss-like metamorphic rock" (or host rock) and a granitic igneous rock (or intruder rock) (Schumann, 1993:310; Pellant, 2000:214). Migmatites form in areas of regional metamorphism (mountain ranges) and are said to develop through one of two processes; through partial melting and crystallizing, or

through the metosomatic (change in chemical composition of a rock) exchange of minerals (Schumann, 1993:310).

Slate is a metamorphic rock which is sometimes classed as igneous (Schumann, 1993:314). However, true slate can be easily classed as metamorphic as it has both the presence of bedding and foliation (Schumann, 1993:314). The slate in the quarry samples is a black slate or clay slate; named as such because the rock is primarily made of clay, mud, shales, or fine-grained tuff (Schumann, 1993:314; Pellant, 2000:208). The organic matter in the composition of the rock gives it the dark (black) colour (Schumann, 1993:314; Pellant, 2000:208). This type of slate forms at mountain ranges when sediments such as mudstones or shales undergo regional metamorphism (Pellant, 2000:208).

Granulite, the last of the samples from Ban Rai quarry, is a form of regional metamorphic rock that develops in shield areas (Pellant, 2000:215). A shield area is tectonically stable area as the area sampled in Thailand is. These rocks are tough, coarse grained rocks which are often banded (Pellant, 2000:215; Schumann, 1993:310). These rocks are structured as pale distinct crystals that are set within a fine grained matrix (Pellant, 2000:215; Schumann, 1993:310).

Ban Tha Chang Dai quarry showed to have halleflinta. Halleflinta is a contact metamorphic rock associated with both gneiss and hornfels (Schumann, 1993:309-310; Pellant, 2000:221). It is metamorphosed from volcanic tuff (Pellant, 2000:221). It is a fine grained rock which is flinty in texture and shows when fractured (Schumann, 1993:309-310; Pellant, 2000:221). Porphyroblasts are sometimes found and the colour can vary (Pellant, 2000:221). Halleflinta can also be infused with secondary silica during metamorphism (Pellant, 2000:221).

This analysis shows that all of the rock samples from Ban Rai quarry were developed through the regional metamorphism of mountain ranges, while the samples from Ban Tha Chang Dai quarry were formed through contact metamorphism. A majority of the samples from Ban Rai quarry are marbles, which correlates with the chemical composition analysis between these quarry samples and bangles samples. That analysis concluded that it was a possibility for the stone bangles of Ban Non Wat to come from Ban Rai quarry. The evidence of slate at Ban Rai further solidifies the possibility of Ban Rai as the source, as slate was often used to make stone bangles as well.

## Summary

These results show that the bangle stone is either limestone or marble, which is helpful to narrowing down the source. Previous chemical composition analysis discovered that the bangle samples from series 1 excavation are from the one source, another tool used to narrow down the source. The chemical analysis also showed that there was a possibility that the Ban Non Wat bangle stone came from Ban Rai quarry which is further supported by the fact that most of the samples analysed from Ban Rai are marbles with some slate present as well. Because of the close correlation between samples and bangles, the majority of bangles are likely marble. Further analysis of the sources of the bangle stone is in the following chapter.

# Chapter 6: Understanding the Landscape

## Potential Manufacture & Trade Routes

The following combined palaeoenvironmental, geological, and archaeological map, specific to limestone and marble sources can be used to determine possible bangle stone trade routes throughout Southeast Asia and south China. The known trade routes are shown in yellow. These routes were used within the Bronze Age by seafarers for trade and may have been a source for inland communities to receive commodities from other regions.

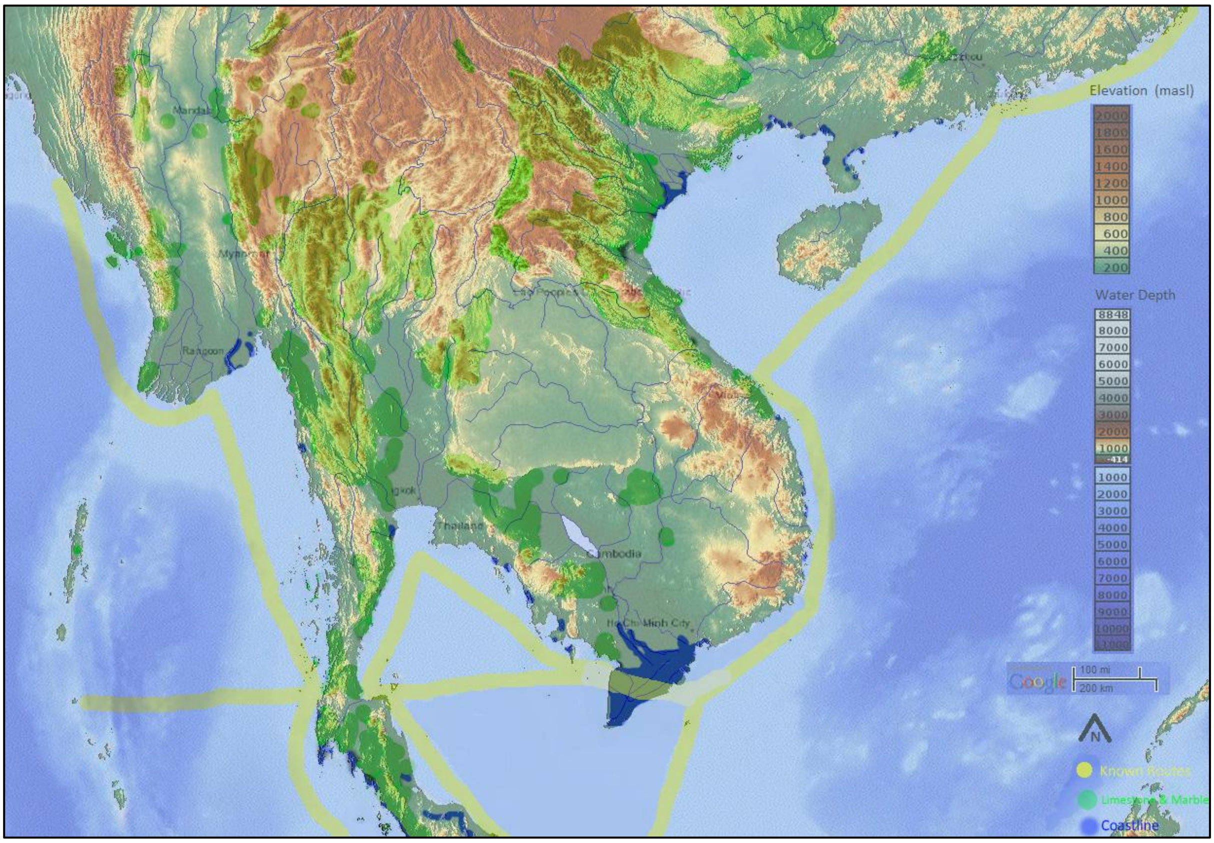


Figure 26 The palaeoenvironmental map of Southeast Asia with known trade routes and geological sources of limestone and marble

There is no possible geological source within the Khorat Plateau (as seen in the map), however, there are limestone and marble mountains on every side of the Khorat Plateau. There is the opportunity for the people to travel to the mountains in the southwest, south, northwest, and northeast corners of the Khorat Plateau. Any of these particular regions could have been the original source of the bangle stone. Three possible sources have been determined from studying this map (figure 26). These were established through studying

which sources would have been easily accessible and had the shortest travel time. The routes have been determined through following the natural pathways of the landscape.

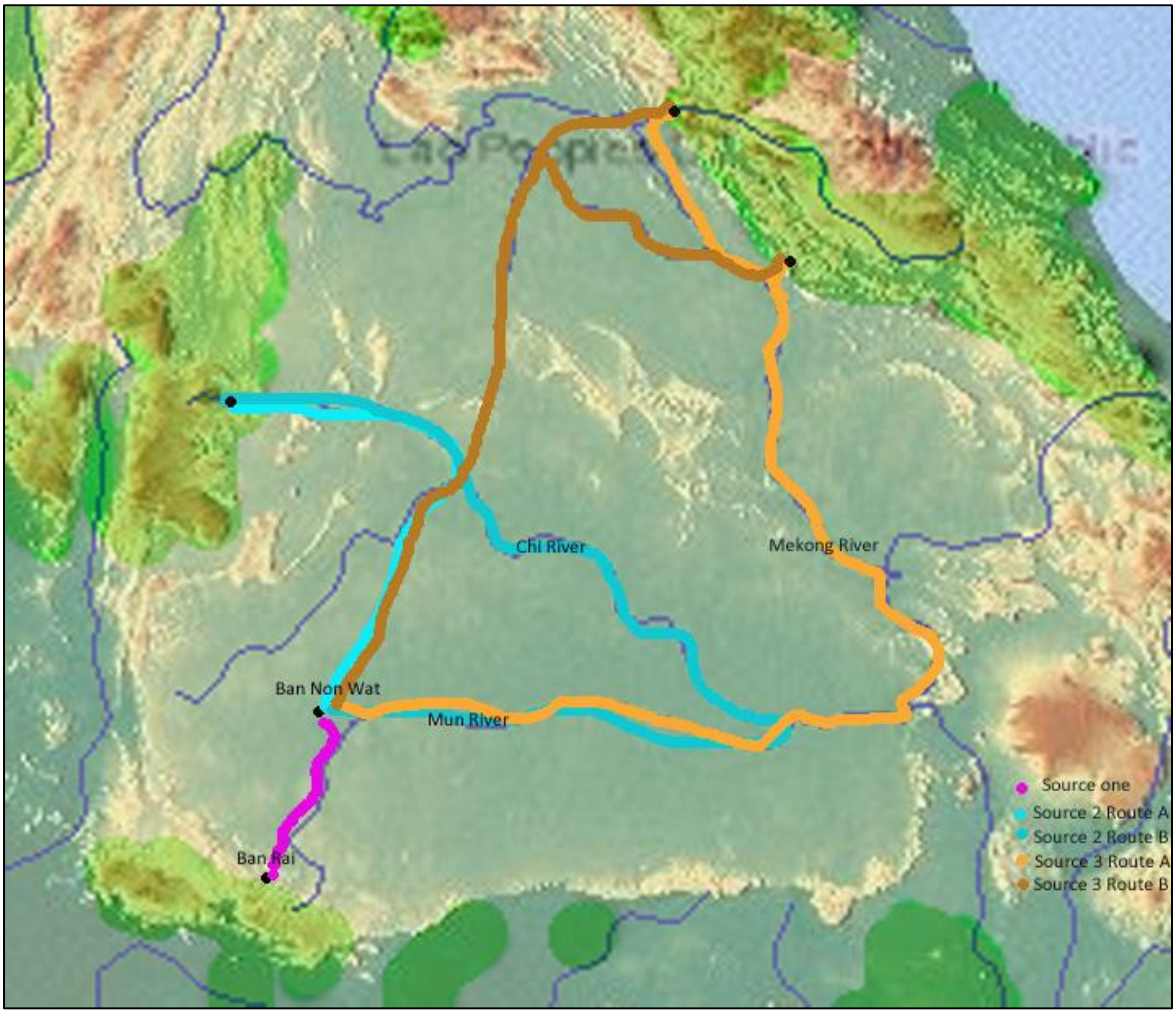


Figure 27 Three potential sources and routes for the bangle stone from Ban Non Wat

1. Ban Rai, is in the southwest corner of the Khorat Plateau, which identifies this quarry further as a potential source of bangle stone. People would have likely followed the Mun River all the way to the Ban Rai quarry. This journey is mostly an even journey along the river until the river ends and a crossing of a hill was necessary. The full elevation profile can be seen in figure 28. This is possibly the fastest and easiest potential route to the closest possible source of stone. This identifies as route one seen in pink in figure 27.

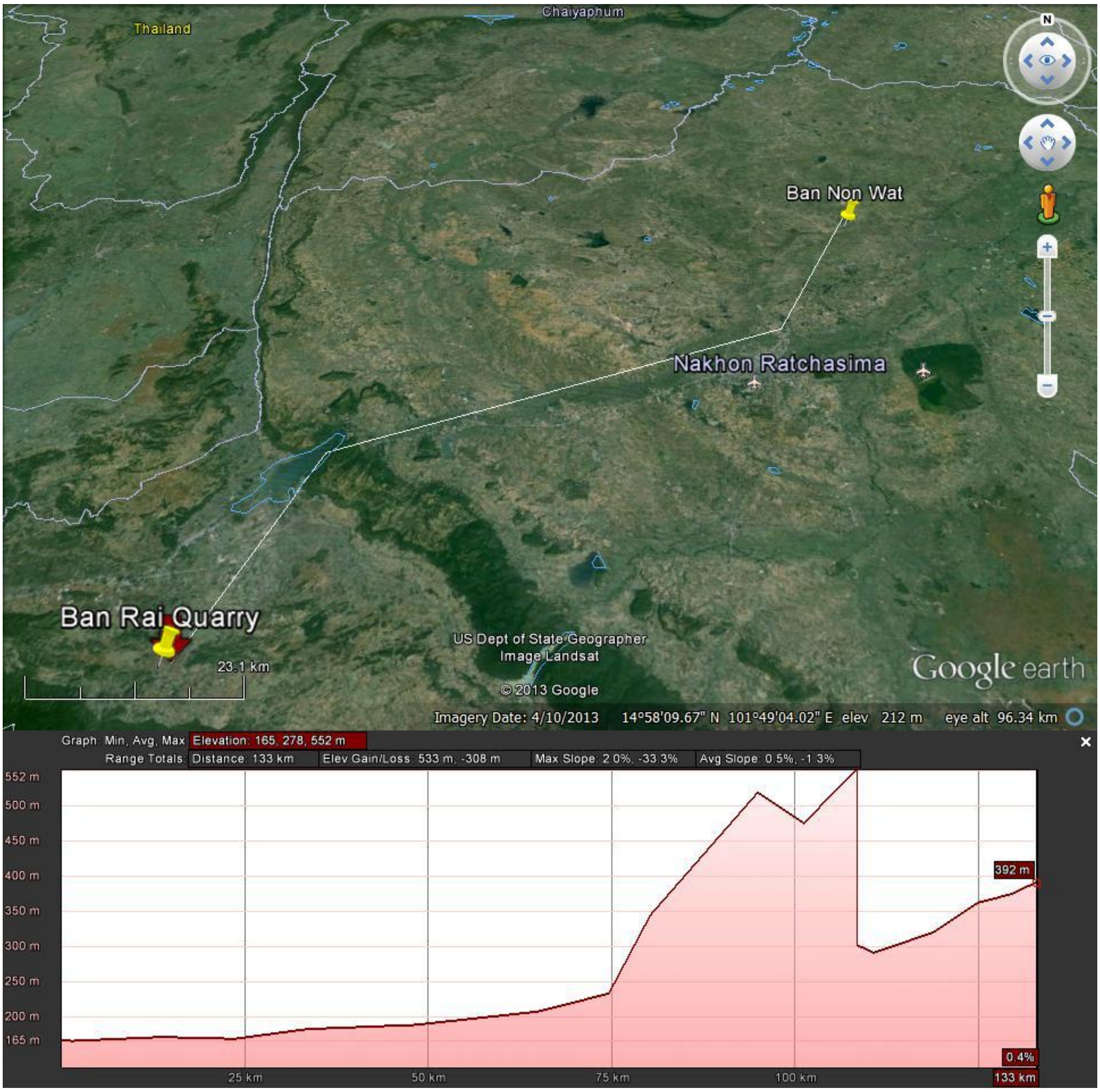


Figure 28 The elevation profile of Route 1

2. The second likely source for the bangle stone is the mountains to the northwest; the Petachabun Range which is an already established route for communication and trade. The first possible route for this (route 2A) would have involved an overland journey north to the Chi River which would have led straight to the mountains. This would have been a mostly level route until the entrance to the Petachabun Range source. The majority of this route is overland rather than via waterways. The elevation profile of this route is seen in figure 29.

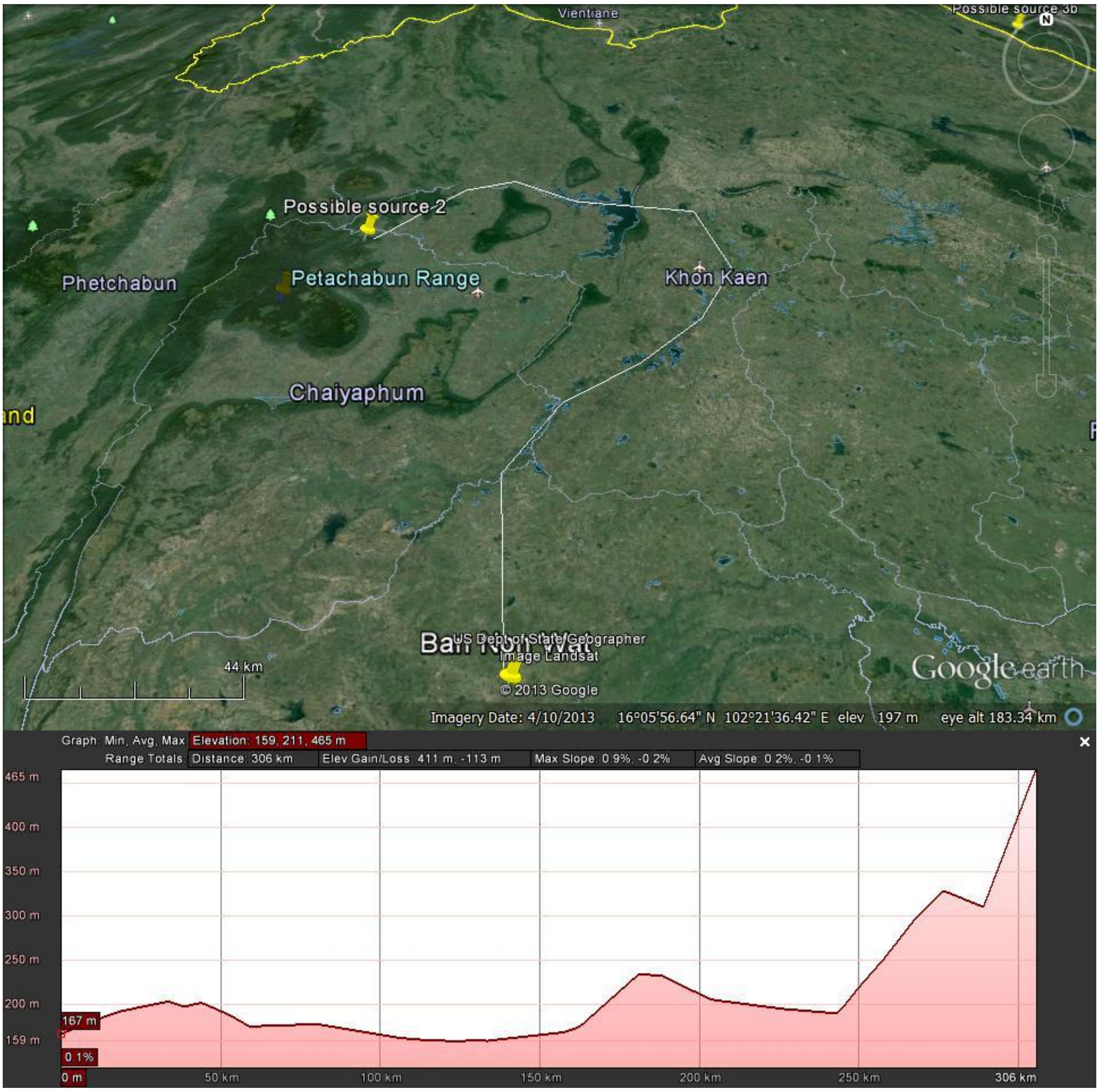


Figure 29 Elevation profile of Route 2A

Alternatively an east heading along the Mun River to the beginning of the Chi River is the second possible route (route 2B). From there would have been a northerly direction which follows the Chi River straight to the source. Aside from this route being much longer there is a similar elevation throughout the journey as 2A. The landscape is relatively even until the entrance to the Petachabun Range source. The full elevation profile is available in figure 30. Both of these options are seen comparatively in figure 27 in different shades of blue.

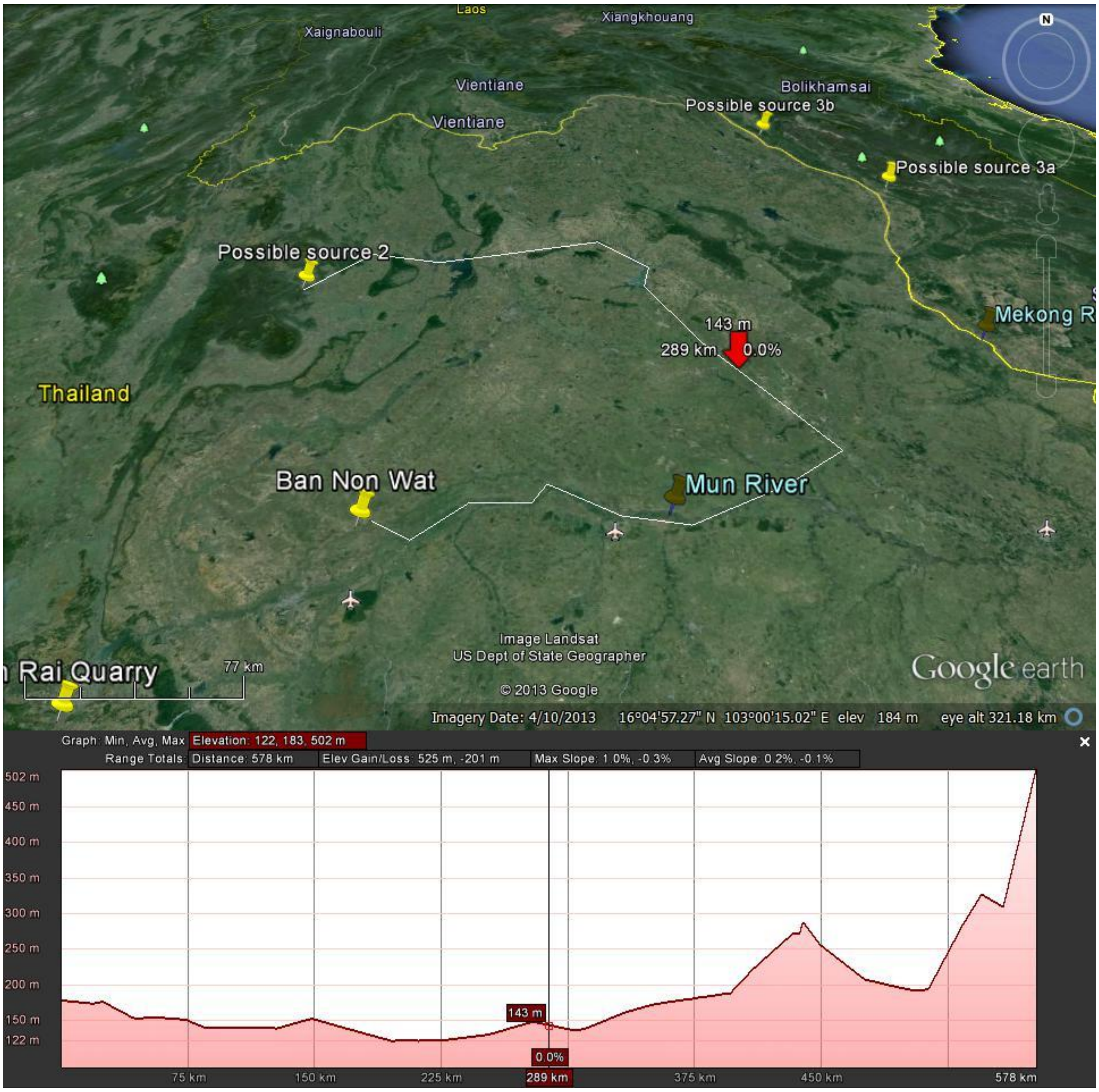


Figure 30 Elevation profile of Route 2B

3. The final possible source of bangle stone from Ban Non Wat is to the mountains to the northeast of the Khorat Plateau. This area is now in present day Laos. There are several possible sources in this area, however the two determined by this research were chosen by the close proximity to the end of the possible routes. The first route (route 3A) would go along the Mun River to the Mekong River. From here the Mekong River can be followed north to an outcrop close to the river. This route can be seen in figure 27 in orange. This entire journey would be tiresome as the landscape from Ban Non Wat to the source is completely uneven with some steep climbs. The elevation profile can be seen in figure 31.

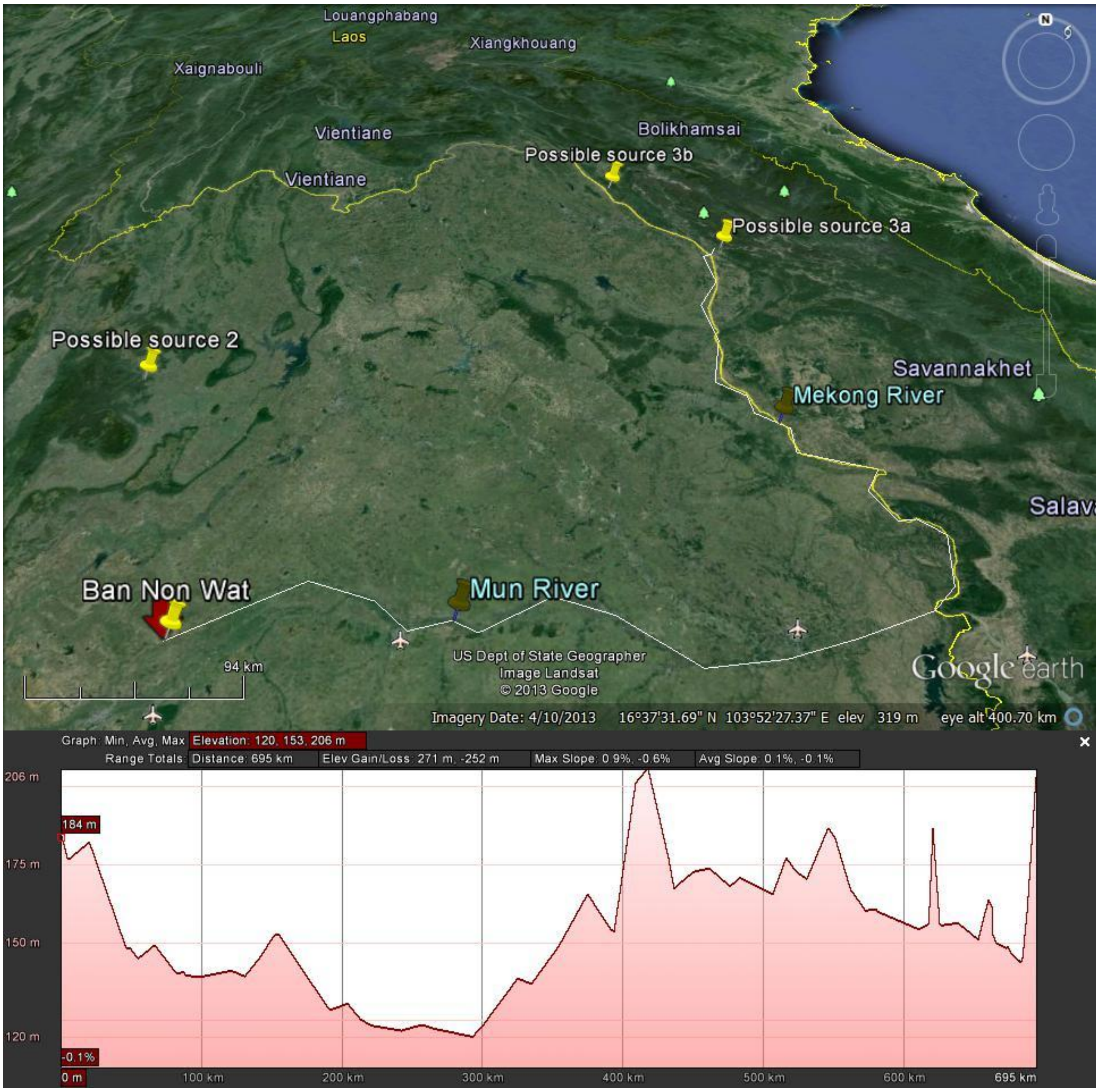


Figure 31 Elevation profile of Route 3A

Alternatively an overland journey in a north-easterly direction may have been possible as a direct route as seen in brown in figure 27. This route is predominantly overland with few times following waterways. It is also a much more even journey than the previous one, as well as shorter. The elevation profile for this route is seen in figure 32.

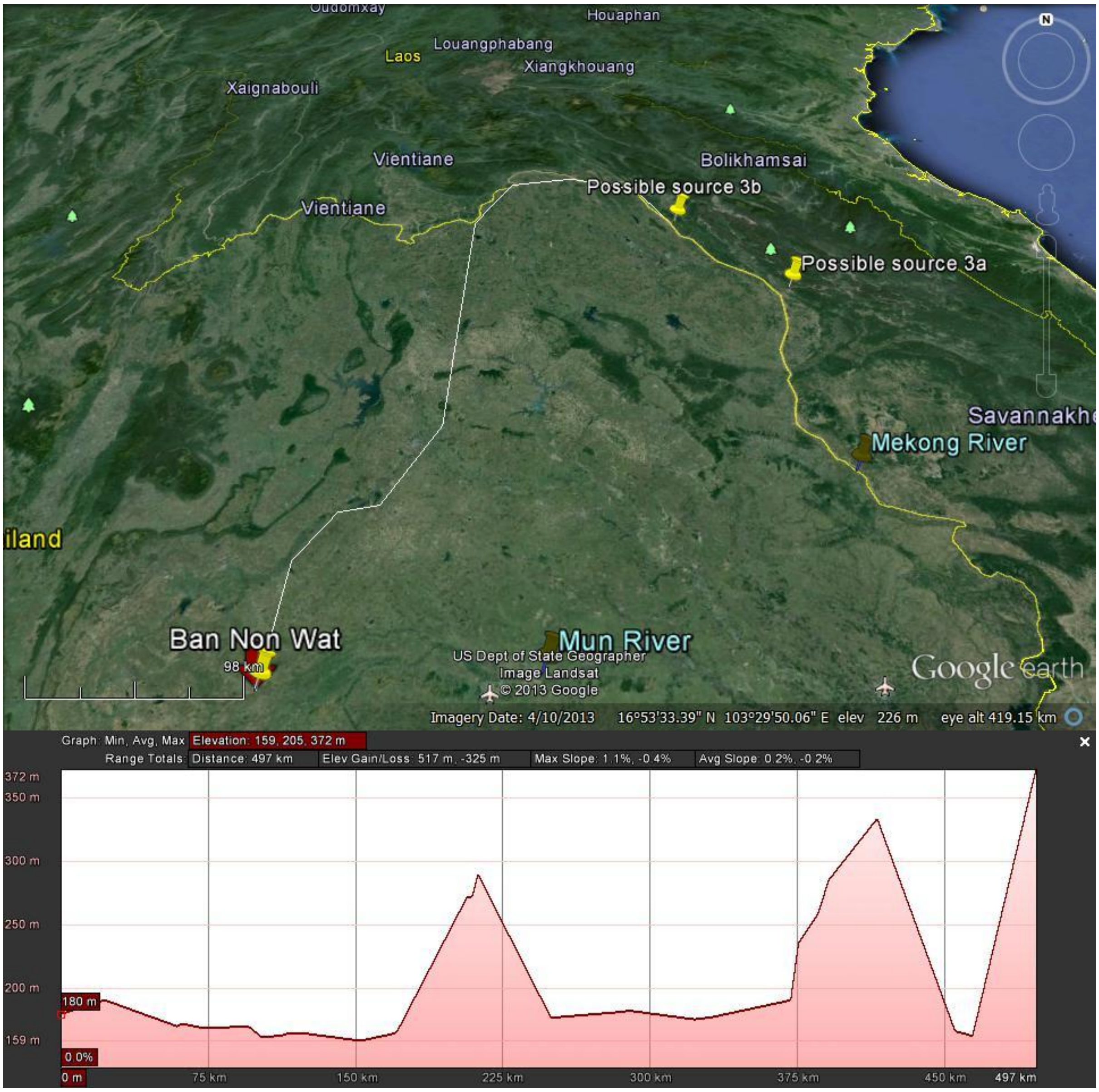


Figure 32 Elevation profile of Route 3B

Through examining the possible routes, the simplest and quickest route to a known source would have been to travel to Ban Rai Quarry from Ban Non Wat by way of water and land. This route is reasonably level along the waterways until the mountains are reached where an overland journey would continue.

## Summary

Using the combination of data from the palaeoenvironmental, geological, and archaeological research a map combining these things has been created. Three preliminary theories of bangle stone source and possible routes have been produced through studying this map. Further testing is needed to determine which sources match the bangle stone mineralogy.

Once this has been completed a more comprehensive theory the bangle stone sourcing is possible. Each route depends on the climate and landscape. Areas throughout the Khorat Plateau with extensive flooding may have caused routes to change. The change of landscape over time would inhibit some of these routes.

# Chapter 7: Discussion

The palaeoenvironment, archaeology, and potential trade routes for the bangle stone in Southeast Asia as well as analysis of the bangles and local quarry stone have now been described. This chapter now combines all of this knowledge in order to answer the original aim which was to construct a model of trade for the bangle stone from Ban Non Wat through understanding where the stone came from, and the manufacture and control of the bangles. By using the information from already known trade routes throughout Southeast Asia in conjunction with the geology of limestone and marble and the landscape, three potential trade routes have been mentioned. The first section of this chapter will discuss these routes and how and why these sources are the three most likely. Following on from this will be an in depth discussion on the likely manufacture of the bangles at each possible source. Finally the final section will consider how controllable this trade may have been depending on by who and where the bangles were manufactured.

## Other Geological Trade Networks

The obsidian trade networks within Island Southeast Asia can help understand the trade of geological material on Mainland Southeast Asia. The use and trade of obsidian artefacts in East Timor have been sourced to Papua New Guinea (Reepmeyer et al., 2011), while Papua New Guinea artefacts from the Sepik Coast have been sourced to Fergusson Island (Golitko et al., 2012). West Javan obsidian artefacts have been sourced to Nagreg and Garut in West Java, Indonesia (Chia et al., 2010), which is unlike the previous artefacts. This shows that geological artefact trade can be either long distance or localised.

## Where does the stone come from?

The three potential sources and routes for the bangle stone include:

1. Ban Rai, in the southwest corner of the Khorat Plateau. Further identifying this quarry as a potential source of bangle stone. The route for this source would be the fastest and easiest by heading southwest on the Mun River straight to the source.
2. The second likely source is the Petachabun Range to the northwest. Two routes have been described for this source. Either an overland heading to the Chi River which would have then led straight to the mountains and been the most direct route, or an

east heading along the Mun River to the Chi River and from there a northern direction to the mountains.

3. The final source for the bangle stone from Ban Non Wat is the mountains in the northeast of the Khorat Plateau. This source has two potential routes as well. People could have departed along the Mun River to the Mekong River and headed north from this point. Alternatively, they could have trekked overland in a north-easterly direction. This is just as likely as it is a more direct route.

As mentioned in the discussion of trade in south China and Southeast China, mountain ranges served as natural barriers throughout the region. This suggests that people did not only rely on the waterways for trade and exchange as it was and still is necessary to cross these mountain ranges in order to cross regions. Therefore overland journeys would have been essential. With the second and third source routes this information has been taken in to account and therefore two routes for each source have been established; using overland routes combined with waterways, and using a waterway only route.

If the stone for the bangles was sourced from the Ban Rai quarry, this would mean the source of stone used in bangles was close to the Mun Valley region and all of its inhabitants. If the source of bangle stone was from the mountains in the northeast or northwest, the source would have been closer to the highland people. These details are important for the understanding of the manufacture and control of the bangle stone.

## Where were the bangles manufactured and how controllable was the trade?

There has been no evidence to suggest that stone bangles were being manufactured at Ban Non Wat. Bangle manufacture will depend on the type of trade occurring. There are three possibilities for the manufacture of the stone bangles. They could have been sourced and manufactured by Ban Non Wat and other villages independently, the people of Ban Non Wat could be manufacturing and trading the bangles themselves, or the manufacture and trade could have been controlled entirely by another party. The trade routes would be different depending on where the manufacture and trade occurred, and control of the bangle stone trade depends on the distance between the source of the stone and the village. The three versions of the manufacture and trade control are further described in the following.

1. Were the people of Ban Non Wat manufacturing bangles for themselves at the source? If this was the case, the source of the stone would have been close to the village. This would make the Ban Rai quarry the source of the stone. There would have been craft specialisations at Ban Non Wat, and there would have been no control over the bangle stone, therefore no changes to the common socio-economic models for Ban Non Wat and the Khorat Plateau.
2. Were the people of Ban Non Wat manufacturing and trading the stone bangles? If Ban Non Wat was in control of the manufacture and trade of the bangle stone, the source would be required to be close to the village in order to keep the trade under their control. Ban Rai quarry would be, again, the most obvious source of the stone if this was the case. The effort and organisation needed to control this type of trade would mean that the socio-economic hierarchy would be more advanced both within the village and with surrounding villages than the common models from the Khorat Plateau would suggest.
3. Was the manufacture and trade being controlled by another party? If the bangle stones were manufactured from the sources in the highlands it is most likely that the highland communities would be in control of this trade. Both the source in the northeast and the source in the northwest have the potential to be controlled by the highland communities. It is possible that the products from this area may have been a valuable commodity for the villages in the Khorat Plateau or in particular, the Mun Valley. If this was the case it could be argued again that there was a more advanced hierarchy between the villages from the bangle trade and within Ban Non Wat itself. The position of Ban Non Wat amongst the neighbouring villages would have been lower than if they were in control of the bangle trade.

### How does this differ from the current Naga culture of Southeast Asia?

The Naga tribes differ dramatically from the stone bangle trade from Ban Non Wat. The bangles from the Naga were originally brought in from Southeast Asia when the Naga migrated. There is a likely chance that this was from the same trade that was occurring in the Khorat Plateau. However, once the bangles were integrated in to the society, the bangles were then being made in individual tribes by specialised craftsmen and traded between tribes along with other commodities. This shows that the Naga had a more

sophisticated socio-economic hierarchy in comparison to Ban Non Wat. The people of Ban Non Wat did not manufacture the bangles at the village. Within the Naga tribes, bangles were worn as both everyday ornaments or for special occasions and were predominantly worn by women. At Ban Non Wat the bangles were worn by men, women, and children. This analysis means that when the Naga migrated to the mountains in northern Burma and India, the people adapted and changed to create their own manufacture and use of the bangles, while the trade of bangles continued throughout the rest of Southeast Asia.

## Summary

Through looking at an overview of the relevant landscape, geology, and archaeological evidence of Southeast Asia and south China, three possible sources were marked. From these sources, various routes had been replicated from both overland and waterway use. Using these differing sources, theories about manufacture and trade control could be established, remembering these are preliminary theories and more research is necessary to create an accurate conclusion.

# Chapter 8: Conclusion

## The Original Challenge: construct a model for the origin of trade of the bangle stone from Ban Non Wat, Thailand

There are three preliminary models outlined in the discussion for the origin of trade of the bangle stone from Ban Non Wat, Thailand. This includes the Ban Rai quarry from which two types of trade could have occurred; independent manufacture and use, or manufacture and trade control of the bangle stone. It also includes two potential sources in the mountains of the northeast and northwest. These sources may have been controlled by highland communities. Given the above, at this stage and while understanding the socio-economic hierarchy at Ban Non Wat and within the Khorat Plateau, the most likely scenario is that the stone was sourced from a nearby location (i.e. Ban Rai quarry) and manufactured independently among different villages for personal use. With the evidence uncovered so far, the bangles would have had to have been manufactured outside of the village as there is no evidence to suggest Ban Non Wat was manufacturing bangles.

## Recommendations for Further Testing and Research

### Testing

In order to test this theory a more in depth study of the socio- economic hierarchy in Ban Non Wat and the Khorat Plateau is needed, as well as in to whether craft specialisation for bangles was present at Ban Non Wat. Preliminary results from the analysis of the landscape show three potential areas that the bangle stone could have come from. Further minero-petrographic and isotopic testing is needed to compare with the bangles of Ban Non Wat and other local sites. Isotope analysis has been proven to be the most effective when it comes to sourcing stone, therefore making it the best option for further chemical composition testing. I would recommend that the Ban Rai samples are further tested, as well as samples from an appropriate source in both the northwest (Petachabun Range) and northeast mountain regions (in Laos) off the border of the Khorat Plateau. Once this testing is completed it is then possible to further the research using a GIS program.

### Potential Petrographic and GIS Project

A well thought out GIS database and data management system should be developed. The location should be within Mainland Southeast Asia and Southern China. Specific layers in the

GIS database should include minerals, rock types, elevation, and palaeoenvironment. Known archaeological sites that include bangles as well as data on trade routes and any known quarries should also be included.

The petrographic analysis that was originally planned for this research is essential in the GIS analysis. Understanding the mineralogy of the bangle stones will help to determine regions within Southeast Asia and south China for further testing when compared to the bangles using chemical composition and minero-petrographic analysis. These comparisons will determine accurate potential sites throughout Southeast Asia and south China. In addition a layer of all of the sites within the area which have similar stone bangles found should be added. Using this information a 'least cost path' analysis on the GIS program can help to create potential routes from the site to the source of the stone by creating the most direct and easiest path. Once potential sources and paths from Ban Non Wat are determined, the manufacture and trade control of the bangle stone can be determined. Each potential source site should be looked at for the possibility of manufacturing the stone on site. Control will then depend on the number of alternate sources and manufacture. This research can lead to further research questions.

## Research Questions

There are a variety of further questions that are in need of investigation. The first question is: are we able to value the stone bangles based on how hard they were to make or obtain? This question could be answered by doing experimental archaeology combined with the sourcing research. The next question is: does the quantity of bangles present at Ban Non Wat change over time? Why or why not? This can be answered by determining the quantity of bangles in each different age range and graphing the results. The final question is: does the sourcing, manufacture and trade differ fundamentally from latter iron-age agate and carnelian bead trade (Theunissen, 2013)? This can be answered once the sourcing research has been completed by way of a comparative analysis.

## Summary

This particular study is important to understanding the interregional communication within Southeast Asia and south China. The GIS database that results could further be used for the provenance of other stone artefacts from Ban Non Wat, and to answer further research

questions. The biggest significance is related to contributing to the trade and exchange knowledge of Bronze Age society in Southeast Asia. It is important to know where the material was sourced in order to understand the sort of social contacts and complexity in the area; whether it was a widespread emulation of an ornamental style by local craftsman with the use of raw materials, or whether it was long distance prestige goods trade {Theunissen, 2012 #54}. On completion of this study, preliminary manufacture and quarry sources are determined and recommended for further sampling. It is most likely that the stone from Ban Non Wat bangles are from the Ban Rai quarry, however further analysis is needed to accurately establish this.

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# Appendices

## A: Permian of Southeast Asia – Lopingian Period

| Country | Location | Lopingian Period |
|---|---|---|
| Thailand | Peninsular | |
| | West | |
| | NW of Chang Mai | Limestone predominant from the base to the top of the Permian |
| | North of Chang Mai | Probably continuous deposition, of siliceous rocks with radiolarians |
| | North | Area north of Lampang |
| | Central | |
| | Nam Duk Basin | Shale |
| | Northeast | Shale, sandstone with plants |
| | Si Racha, Klaeng | Limestone/Shale |
| | South of Sa Kaeo | Chert with Middle-Upper Permian radiolarians, some Limestones |
| | Near Cambodia | Limestone |
| Vietnam | North, East Bac Bo | Dong Dang Fm. |
| | West Bac Bo | Yen Duyet Fm./Cam Thuy Fm. |
| | North Trung Bo | Cum Lo |
| | South Trung Bo | Volcanic Rocks |
| | Nam Bo | Ta Thiet Limestone overlying clastic beds |
| Cambodia | East Cambodia | Kampot/Kompong Trach |
| | West Cambodia | |
| Malaysia | Perlis, Kedah | |
| | Kintah Valley | |
| | Semangol, Bentong Raub | Lower to Middle Permian radiolarians |

| | | |
|---|---|---|
| | North Pahang | Merapoh, Sungai Kenong, Kuala Lipis Sungai Atok |
| | South Pahang | Shale with plants |
| | Kelantan | Sakmarian to Changhsingian marine sequences |
| | Terengganu | |
| | Johor | Lingiu Flora |
| | Sarawak | |
| Sumatra | South Sumatra | |
| | Central Sumatra | |
| | North Sumatra | |
| | Belitung | |

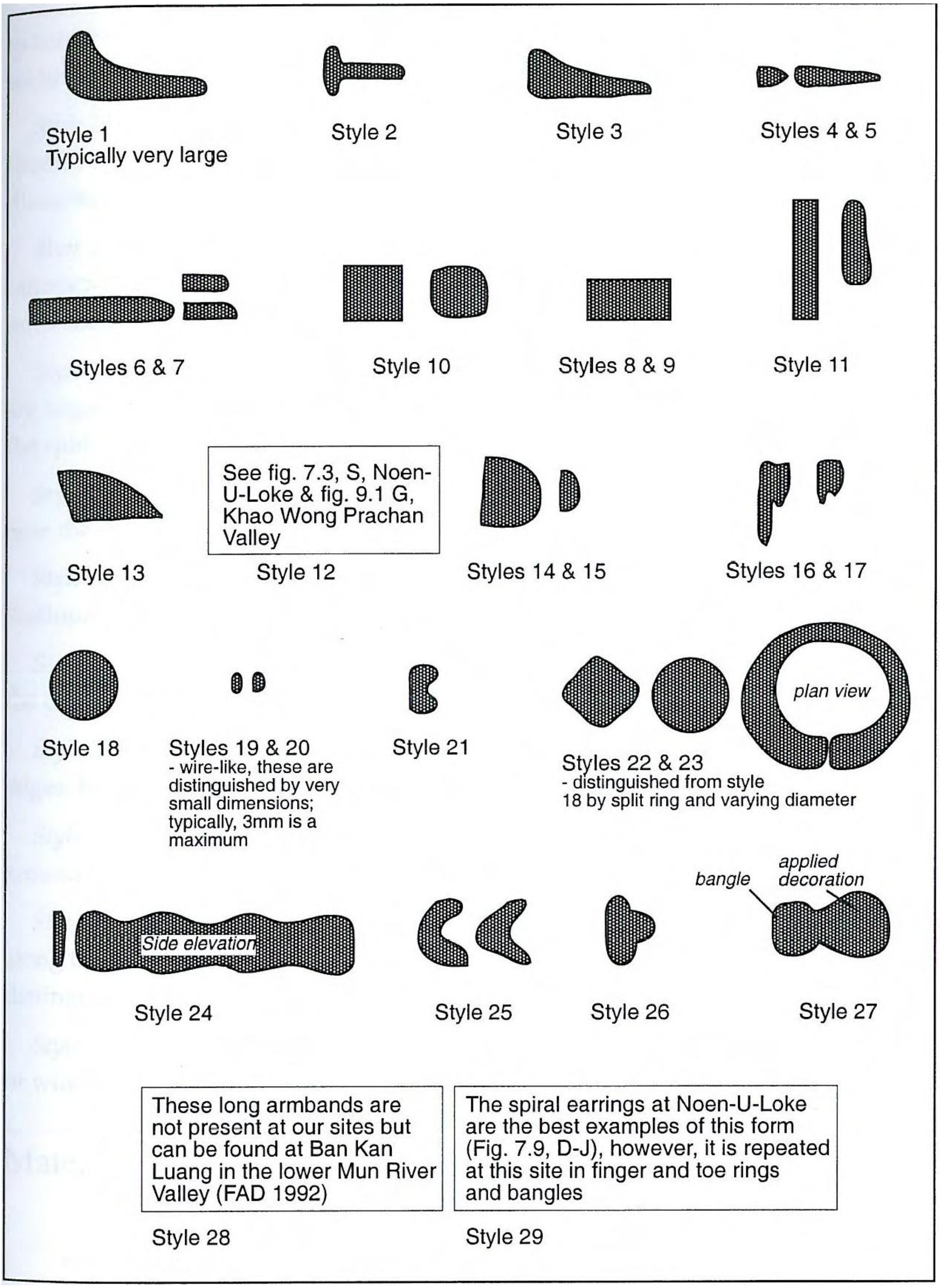
This table describes the uppermost layer of the Permian rock that is spread throughout Southeast Asia (Fontaine 2012).

## B: Major Palaeoenvironmental Trends in the Upper Mun Valley

| Calendar C BC/AD | Palaeo-geographic phases | Vegetation phases and thresholds | Hydrological phases and thresholds | Social changes | Regional social influences | Regional environmental influences |
|---|---|---|---|---|---|---|
| 9 AD | | | | | Angkor | |
| 8 AD | | ?modern conditions | ?modern conditions | Centralised state landscape | | |
| 7 AD | Phase 6 | | | | Zhenla | |
| 6 AD | | | | | | Dry, seasonal rainfall, floodplain sedimentation |
| 5 AD | | Rapid change | Rapid change | Rapid change | | |
| 4 AD | | | Construction engineering | | Funan | |
| 3 AD | | | | | | |
| 2 AD | Phase 5C | Phased landscape management | | | | |
| 1 AD | | | Adaptive Engineering | Change in focus on identity, claim on place, and social intensification | Social dislocations in the region | |
| 1 BC | | | | | | |
| 2 BC | | | | | | |
| 3 BC | | | | | Indianisation? | |
| 4 BC | Phase 5B | | | | | |
| 5 BC | | | | | | |
| 6 BC | | | | | | |
| 7 BC | | | | | | |
| 8 BC | | | | | | Gradual drying, run-off reduction |
| 9 BC | | | Settlement beside rivers, gradual hydrological change | | | |
| 10 BC | | | | Internal focus on identity and landscape; mixed economy | | |
| 11 BC | Phase 5A | | | | | |
| 12 BC | | Early gradual vegetation change | | | | |
| 13 BC | | | | | | |
| 14 BC | | | | | | |
| 15 BC | | | | | | |
| 16 BC | | | | | | |
| 17 BC | | | | | | |
| 18 BC | Phase 4 | | | Arrival from outside region: establishing a place in the landscape | | Warm, humid, lakes and swamps on floodplain |
| 19 BC | | | | | | |
| 20 BC | | | | | | |

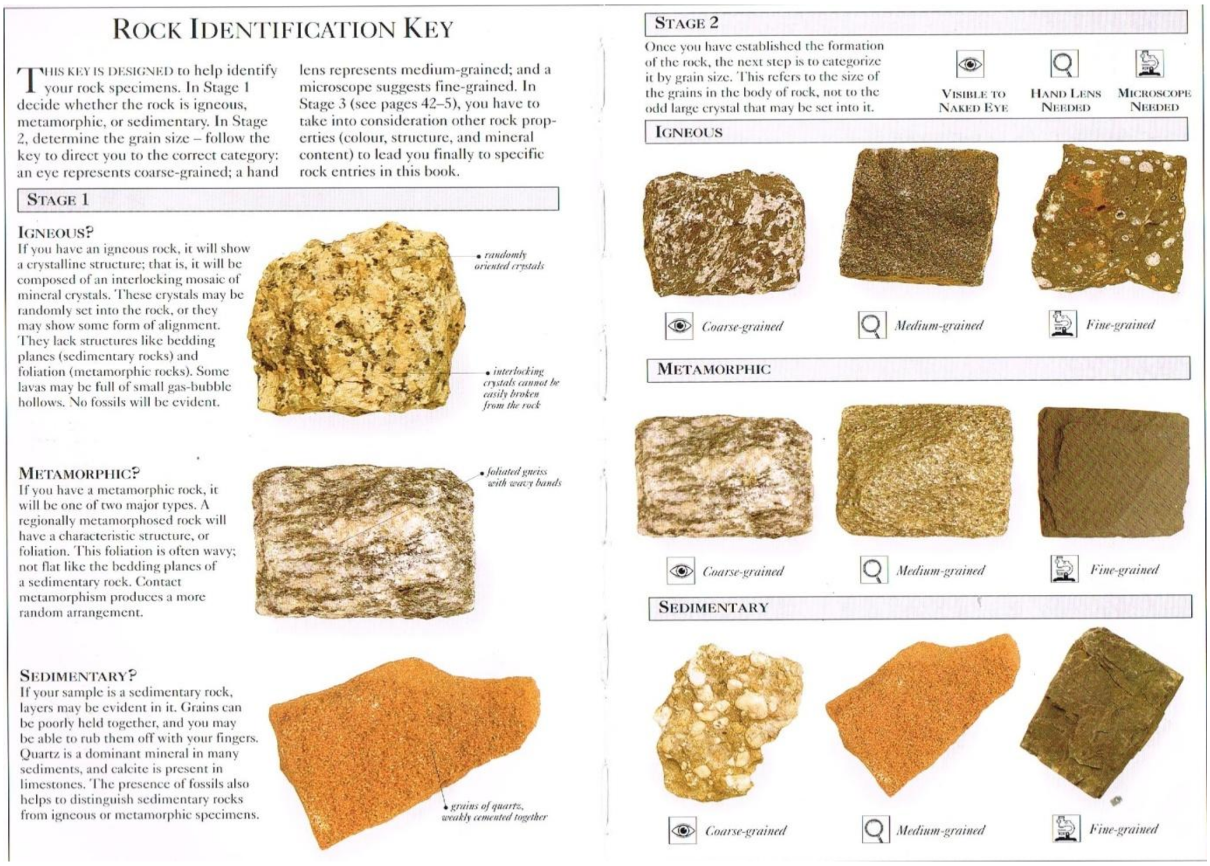
Significant changes between phases are determined by the boldness of the horizontal lines (Boyd and Chang, 2010:277).

## C: Stone Bangle Typology




The above image shows cross-section diagrams of each individual style of bangle (Chang, 2001:34).

## D: Rock Identification Key



# Rock Identification Key

This key is designed to help identify your rock specimens. In Stage 1 decide whether the rock is igneous, metamorphic, or sedimentary. In Stage 2, determine the grain size – follow the key to direct you to the correct category: an eye represents coarse-grained; a hand lens represents medium-grained; and a microscope suggests fine-grained. In Stage 3 (see pages 42–5), you have to take into consideration other rock properties (colour, structure, and mineral content) to lead you finally to specific rock entries in this book.

### Stage 1

**Igneous?**
If you have an igneous rock, it will show a crystalline structure; that is, it will be composed of an interlocking mosaic of mineral crystals. These crystals may be randomly set into the rock, or they may show some form of alignment. They lack structures like bedding planes (sedimentary rocks) and foliation (metamorphic rocks). Some lavas may be full of small gas-bubble hollows. No fossils will be evident.

*randomly oriented crystals*

*interlocking crystals cannot be easily broken from the rock*

**Metamorphic?**
If you have a metamorphic rock, it will be one of two major types. A regionally metamorphosed rock will have a characteristic structure, or foliation. This foliation is often wavy; not flat like the bedding planes of a sedimentary rock. Contact metamorphism produces a more random arrangement.

*foliated gneiss with wavy bands*

**Sedimentary?**
If your sample is a sedimentary rock, layers may be evident in it. Grains can be poorly held together, and you may be able to rub them off with your fingers. Quartz is a dominant mineral in many sediments, and calcite is present in limestones. The presence of fossils also helps to distinguish sedimentary rocks from igneous or metamorphic specimens.

*grains of quartz, weakly cemented together*

### Stage 2

Once you have established the formation of the rock, the next step is to categorize it by grain size. This refers to the size of the grains in the body of rock, not to the odd large crystal that may be set into it.

Visible to Naked Eye — Hand Lens Needed — Microscope Needed

**Igneous**

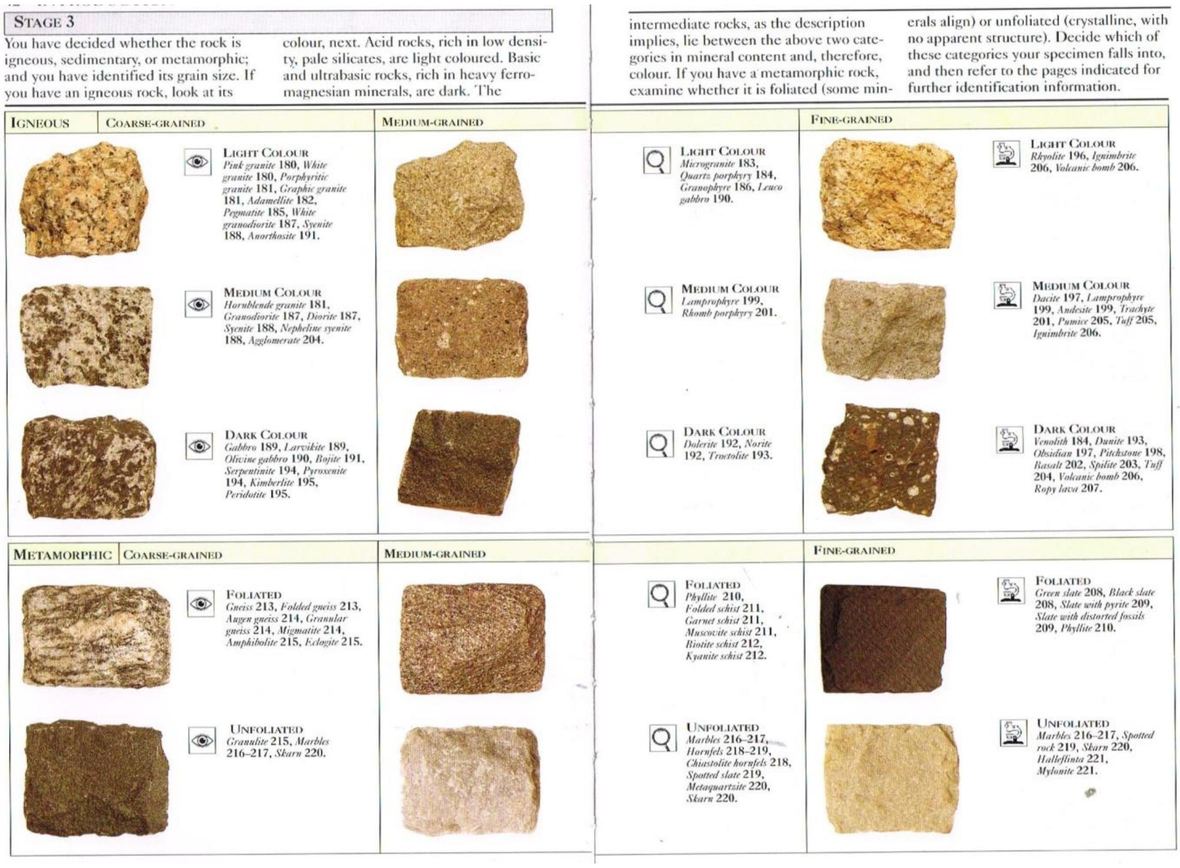
*Coarse-grained* — *Medium-grained* — *Fine-grained*

**Metamorphic**

*Coarse-grained* — *Medium-grained* — *Fine-grained*

**Sedimentary**

*Coarse-grained* — *Medium-grained* — *Fine-grained*

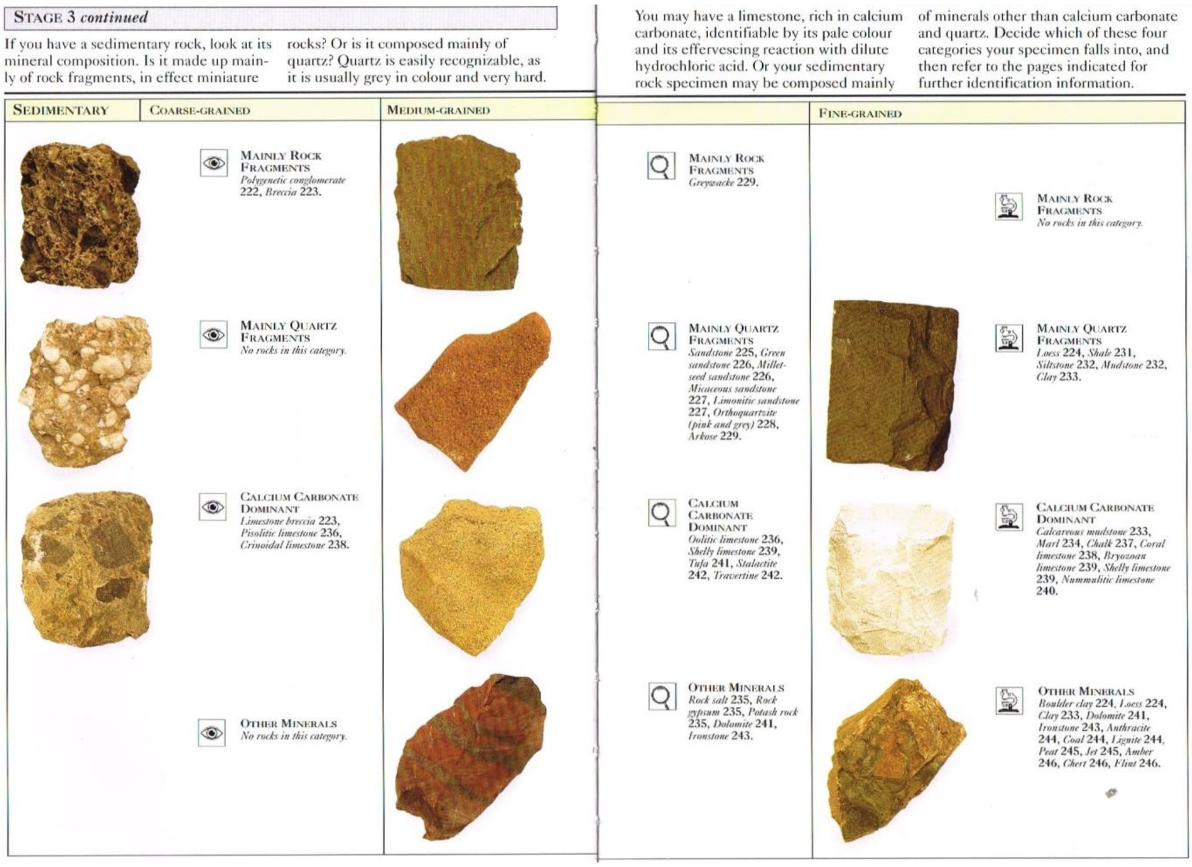


### Stage 3

You have decided whether the rock is igneous, sedimentary, or metamorphic; and you have identified its grain size. If you have an igneous rock, look at its colour, next. Acid rocks, rich in low density, pale silicates, are light coloured. Basic and ultrabasic rocks, rich in heavy ferro-magnesian minerals, are dark. The intermediate rocks, as the description implies, lie between the above two categories in mineral content and, therefore, colour. If you have a metamorphic rock, examine whether it is foliated (some minerals align) or unfoliated (crystalline, with no apparent structure). Decide which of these categories your specimen falls into, and then refer to the pages indicated for further identification information.

| Igneous | Coarse-grained | Medium-grained | Fine-grained |
| --- | --- | --- | --- |
| Light Colour | *Pink granite* 180, *White granite* 180, *Porphyritic granite* 181, *Graphic granite* 181, *Adamellite* 182, *Pegmatite* 185, *White granodiorite* 187, *Syenite* 188, *Anorthosite* 191. | *Microgranite* 183, *Quartz porphyry* 184, *Granophyre* 186, *Leuco gabbro* 190. | *Rhyolite* 196, *Ignimbrite* 206, *Volcanic bomb* 206. |
| Medium Colour | *Hornblende granite* 181, *Granodiorite* 187, *Diorite* 187, *Syenite* 188, *Nepheline syenite* 188, *Agglomerate* 204. | *Lamprophyre* 199, *Rhomb porphyry* 201. | *Dacite* 197, *Lamprophyre* 199, *Andesite* 199, *Trachyte* 201, *Pumice* 205, *Tuff* 205, *Ignimbrite* 206. |
| Dark Colour | *Gabbro* 189, *Larvikite* 189, *Olivine gabbro* 190, *Bojite* 191, *Serpentinite* 194, *Pyroxenite* 194, *Kimberlite* 195, *Peridotite* 195. | *Dolerite* 192, *Norite* 192, *Troctolite* 193. | *Venolith* 184, *Dunite* 193, *Obsidian* 197, *Pitchstone* 198, *Basalt* 202, *Spilite* 203, *Tuff* 204, *Volcanic bomb* 206, *Ropy lava* 207. |

| Metamorphic | Coarse-grained | Medium-grained | Fine-grained |
| --- | --- | --- | --- |
| Foliated | *Gneiss* 213, *Folded gneiss* 213, *Augen gneiss* 214, *Granular gneiss* 214, *Migmatite* 214, *Amphibolite* 215, *Eclogite* 215. | *Phyllite* 210, *Folded schist* 211, *Garnet schist* 211, *Muscovite schist* 211, *Biotite schist* 212, *Kyanite schist* 212. | *Green slate* 208, *Black slate* 208, *Slate with pyrite* 209, *Slate with distorted fossils* 209, *Phyllite* 210. |
| Unfoliated | *Granulite* 215, *Marbles* 216–217, *Skarn* 220. | *Marbles* 216–217, *Hornfels* 218–219, *Chiastolite hornfels* 218, *Spotted slate* 219, *Metaquartzite* 220, *Skarn* 220. | *Marbles* 216–217, *Spotted rock* 219, *Skarn* 220, *Halleflinta* 221, *Mylonite* 221. |



STAGE 3 *continued*

If you have a sedimentary rock, look at its mineral composition. Is it made up mainly of rock fragments, in effect miniature rocks? Or is it composed mainly of quartz? Quartz is easily recognizable, as it is usually grey in colour and very hard. You may have a limestone, rich in calcium carbonate, identifiable by its pale colour and its effervescing reaction with dilute hydrochloric acid. Or your sedimentary rock specimen may be composed mainly of minerals other than calcium carbonate and quartz. Decide which of these four categories your specimen falls into, and then refer to the pages indicated for further identification information.

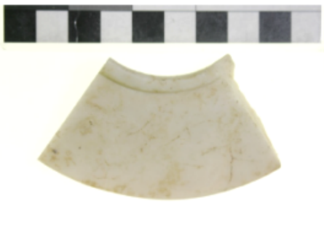
| SEDIMENTARY | COARSE-GRAINED | MEDIUM-GRAINED | FINE-GRAINED |
| --- | --- | --- | --- |
| MAINLY ROCK FRAGMENTS | *Polygenetic conglomerate* 222, *Breccia* 223. | *Greywacke* 229. | No rocks in this category. |
| MAINLY QUARTZ FRAGMENTS | *No rocks in this category.* | *Sandstone* 225, *Green sandstone* 226, *Millet-seed sandstone* 226, *Micaceous sandstone* 227, *Limonitic sandstone* 227, *Orthoquartzite (pink and grey)* 228, *Arkose* 229. | *Loess* 224, *Shale* 231, *Siltstone* 232, *Mudstone* 232, *Clay* 233. |
| CALCIUM CARBONATE DOMINANT | *Limestone breccia* 223, *Pisolitic limestone* 236, *Crinoidal limestone* 238. | *Oolitic limestone* 236, *Shelly limestone* 239, *Tufa* 241, *Stalactite* 242, *Travertine* 242. | *Calcareous mudstone* 233, *Marl* 234, *Chalk* 237, *Coral limestone* 238, *Bryozoan limestone* 239, *Shelly limestone* 239, *Nummulitic limestone* 240. |
| OTHER MINERALS | *No rocks in this category.* | *Rock salt* 235, *Rock gypsum* 235, *Potash rock* 235, *Dolomite* 241, *Ironstone* 243. | *Boulder clay* 224, *Loess* 224, *Clay* 233, *Dolomite* 241, *Ironstone* 243, *Anthracite* 244, *Coal* 244, *Lignite* 244, *Peat* 245, *Jet* 245, *Amber* 246, *Chert* 246, *Flint* 246. |

The previous is the Rock Identification Key used in the identification process of the quarry samples (Pellant, 2000:40-45).

## E. Stone Bangle Datasheets

### Series 1

**Category #:** 6648 **Context:** 2333
**Sq:** C3 **Layer:** 4 **Spit:** 4



**Style:** 2
**Material:** stone
**Colour:** ivory
**Grainsize:** fine
**Weight:** 39.98g
**Effervescence:** no reaction
**Percentage Complete:** 19%
**Flange:** two-sided right angle
**Radial Height:** 10mm **Radial Width:** 39mm
**Inner Diameter:** 30mm **Outer Diameter:** 68mm

**Other notes:** marbled surface

**Category #:** Y839 **Context:** 72
**Sq:** Y1 **Layer:** 7 **Spit:** 2

**Style:** 2
**Material:** stone
**Colour:** dark grey/
**Grainsize:** fine
**Weight:** 13.9g
**Effervescence:** no reaction
**Percentage Complete:** 12.5%
**Flange:** straight two sided right angle
**Radial Height:** 10mm **Radial Width:** 27.5mm
**Inner Diameter:** 53mm **Outer Diameter:** NA

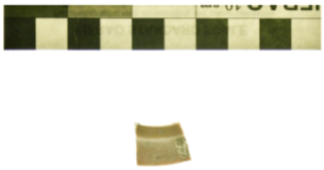
**Other notes:** square outer edge, marbled surface

**Category #:** 8639 **Context:** 3974
**Sq:** B6 **Layer:** 4 **Spit:** 3
**Feature:** 4

**Style:** 4
**Material:** stone
**Colour:** grey
**Grainsize:** coarse
**Weight:** 47.41g
**Effervescence:** mild reaction
**Percentage Complete:** 13%
**Flange:** one-sided convex
**Radial Height:** 21mm **Radial Width:** 31mm
**Inner Diameter:** 39mm **Outer Diameter:** 70mm

**Other notes:** surface sparkles, surface areas of talc/calcite, in 2 pieces

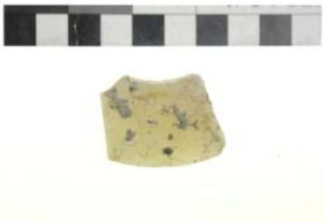
**Category #:** 6607 **Context:** 2307
**Sq:** - **Layer:** 3 **Spit:** 4



**Style:** 2
**Material:** stone
**Colour:** pink
**Grainsize:** medium
**Weight:** 1.84g
**Effervescence:** reaction
**Percentage Complete:** 6%
**Flange:** two-sided right angle
**Radial Height:** 5.5mm **Radial Width:** 13mm
**Inner Diameter:** 27mm **Outer Diameter:** 50mm

**Other notes:** surface accretions, marbled surface, recategorised as stone

**Category #:** 6059 **Context:** 2608
**Sq:** C2 **Layer:** 3 **Spit:** 4



**Style:** 2
**Material:** stone
**Colour:** beige
**Grainsize:** fine
**Weight:** 15.67g
**Effervescence:** mild reaction
**Percentage Complete:** 12.5%
**Flange:** two-sided right angle
**Radial Height:** 11.5mm **Radial Width:** 27mm
**Inner Diameter:** 30mm **Outer Diameter:** 55mm

**Other notes:** surface accretions, marbled surface

**Category #:** 6626 **Context:** 3305
**Sq:** C2 **Layer:** 4 **Spit:** 9

**Style:** 2
**Material:** stone
**Colour:** grey
**Grainsize:** fine
**Weight:** 5.2g
**Effervescence:** no reaction
**Percentage Complete:** 10%
**Flange:** two-sided right angle
**Radial Height:** 8.1mm **Radial Width:** 22mm
**Inner Diameter:** 32mm **Outer Diameter:** 50mm

**Other notes:** marbled surface, in 2 pieces

This is the context and physical characteristics of the bangle fragments from series 1 using artefact datasheets.

## Series 2

Category #: 31613 Context: 13879
Sq: G104 Layer: 6 Spit: 2
Feature: 17 Burial: 676

Style: 2
Material: stone
Colour: light grey
Grainsize: fine
Weight: 36.2g
Effervescence: no reaction
Percentage Complete: 80
Flange: two-sided right angle
Radial Height: 13mm Radial Width: 19.5mm
Inner Diameter: 50mm Outer Diameter: 36mm

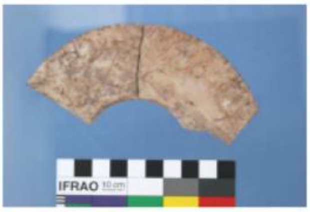
Other notes: fine grain cross section, mix of high polished and pitted surface

Category #: 31324 Context: 13606
Sq: G104 Layer: 3 Spit: 3


Style: NA
Material: Stone
Colour: ivory
Grainsize: fine
Weight: 72.9g
Effervescence: no reaction
Percentage Complete: 30%
Flange: one-sided straight
Radial Height: 14.5mm Radial Width: 28mm
Inner Diameter: 58.5mm Outer Diameter: 108.5mm

Other notes: outer edge may have originally been hexagonal, octagonal, or star shaped (style 12)

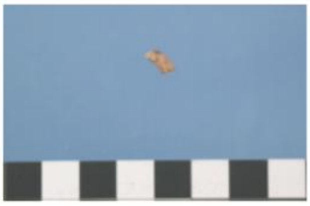
Category #: 31210 Context: 13576
Sq: G104 Layer: 3 Spit: 1
Burial: 652




Style: 2
Material: stone
Colour: ivory
Grainsize: fine
Weight: 83.6g
Effervescence: no reaction
Percentage Complete: 30%
Flange: two-sided right angle
Radial Height: 8.5mm Radial Width: 40mm
Inner Diameter: 30mm Outer Diameter: 60mm

Other notes: flange is subtle

Category #: 31630 Context: 13507
Sq: G104 Layer: 1 Spit: 5



Style: 10
Material: stone
Colour: beige
Grainsize: fine
Weight: 0.1g
Effervescence: no reaction
Percentage Complete: 5%
Flange: two-sided right angle
Radial Height: 4.5mm Radial Width: 3.5mm
Inner Diameter: 40mm Outer Diameter: 50mm

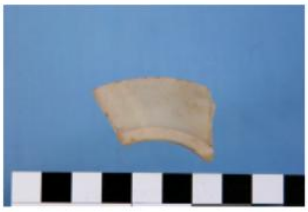
Other notes: NA

Category #: 31235 Context: 13606
Sq: G104 Layer: 3 Spit: 4

Style: 2
Material: stone
Colour: light grey
Grainsize: fine
Weight: 21.5g
Effervescence: no reaction
Percentage Complete: 20%
Flange: two-sided right angle
Radial Height: 9.5mm Radial Width: 29.5mm
Inner Diameter: 58mm Outer Diameter: 115mm

Other notes: white veins present, polished surface

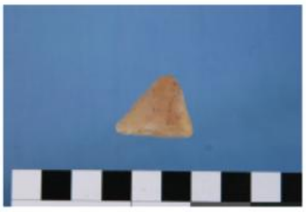
Category #: 27814 Context: 12588
Sq: N100 Layer: 7 Spit: 3



Style: 2
Material: stone
Colour: ivory
Grainsize: fine
Weight: 8.9g
Effervescence: no reaction
Percentage Complete: 15%
Flange: two-sided right angle
Radial Height: 7mm Radial Width: 21.5mm
Inner Diameter: 56mm Outer Diameter: 100mm

Other notes:

Category #: 27629 Context: 12005
Sq: N100 Layer: 1 Spit: 3
Feature: 1



Style: -
Material: stone
Colour: ivory
Grainsize: fine
Weight: 6.4g
Effervescence: no reaction
Percentage Complete: -
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: -

Other notes: could be something other than a bangle fragment

Category #: 27337 Context: 12331
Sq: N100 Layer: - Spit: -
Burial: 654

Style: 2
Material: stone
Colour: beige
Grainsize: fine
Weight: 5.8g
Effervescence: no reaction
Percentage Complete: 15%
Flange: two-sided right angle
Radial Height: 7mm Radial Width: 21mm
Inner Diameter: 60mm Outer Diameter: -

Other notes: outer edge appears broken/fragmented

Category #: 27304 Context: 12303
Sq: N100 Layer: 5 Spit: 1
Burial: 648


Style: -
Material: stone
Colour: ivory
Grainsize: fine
Weight: 7.1g
Effervescence: no reaction
Percentage Complete: -
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: 180mm

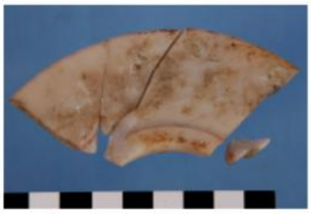
Other notes: maximum thickness of fragment is 7.5mm

Category #: 27306 Context: 12305
Sq: N100 Layer: 5 Spit: 1

Style: 14
Material: stone
Colour: black
Grainsize: very vine
Weight: 2.2g
Effervescence: mild reaction
Percentage Complete: 10%
Flange: no flange
Radial Height: 7mm Radial Width: 8mm
Inner Diameter: 56mm Outer Diameter: 75mm

Other notes: -

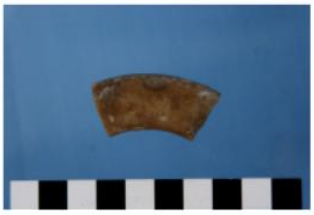
Category #: 27370 Context: 12401
Sq: N100 Layer: 6 Spit: 1



Style: 2
Material: stone
Colour: ivory
Grainsize: fine
Weight: 39.8g
Effervescence: no reaction
Percentage Complete: 20%
Flange: two-sided right angle
Radial Height: 11mm Radial Width: 41mm
Inner Diameter: 60mm Outer Diameter: 140mm

Other notes: style 2 is subtle, 4 pieces

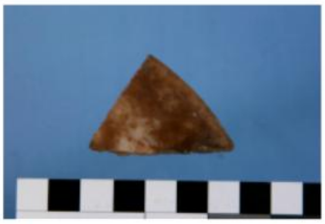
Category #: 27378 Context: 12448
Sq: N100 Layer: 6 Spit: 2



Style: 10
Material: stone
Colour: brown
Grainsize: fine
Weight: 25.8g
Effervescence: no reaction
Percentage Complete: 15%
Flange: no flange
Radial Height: 15mm Radial Width: 19mm
Inner Diameter: 56mm Outer Diameter: 78mm

Other notes: -

Category #: 27401 Context: 12490
Sq: N100 Layer: 6 Spit: 3



Style: -
Material: stone
Colour: brown & ivory
Grainsize: fine
Weight: 13.8g
Effervescence: no reaction
Percentage Complete: 5%
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: 180mm

Other notes: marbled surface, maximum thickness of fragment 6mm

Category #: 27554 Context: 12543
Sq: N100 Layer: 7 Spit: 1

Style: 4
Material: stone
Colour: beige
Grainsize: medium
Weight: 57g
Effervescence: no reaction
Percentage Complete: 15%
Flange: two-sided convex
Radial Height: 21.5mm Radial Width: 24mm
Inner Diameter: 70mm Outer Diameter: 120mm

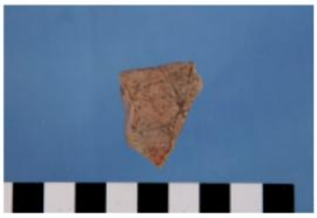
Other notes: -

Category #: 27766 Context: 12157
Sq: N100 Layer: 3 Spit: 5
Feature: 12

Style: -
Material: stone
Colour: beige
Grainsize: coarse
Weight: 7.6mm
Effervescence: no reaction
Percentage Complete: -
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: -

Other notes: maximum thickness of fragment 10mm, presence of veins

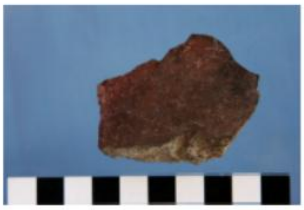
Category #: 27770 Context: 12030
Sq: N100 Layer: 2 Spit: 4



Style: -
Material: stone
Colour: grey
Grainsize: coarse
Weight: 10.1g
Effervescence: no reaction
Percentage Complete: -
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: 180mm

Other notes: maximum thickness of fragment 8mm, broken inner edge, veins present

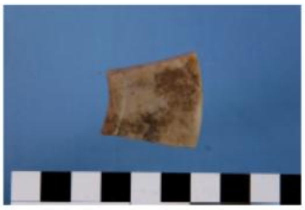
Category #: 27879 Context: 12514
Sq: N100 Layer: 6 Spit: 4



Style: -
Material: stone
Colour: red
Grainsize: coarse
Weight: -
Effervescence: no reaction
Percentage Complete: -
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: -

Other notes: polished surface, possibly not a bangle fragment

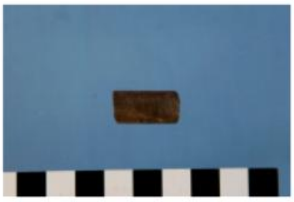
Category #: 39511 Context: 18141
Sq: N96 Layer: 5 Spit: 2



Style: 2
Material: stone
Colour: beige
Grainsize: fine
Weight: 9.4g
Effervescence: no reaction
Percentage Complete: 10%
Flange: two-sided right angle
Radial Height: 8mm Radial Width: 32mm
Inner Diameter: 70mm Outer Diameter: 135mm

Other notes: -

Category #: 39193 Context: 18113
Sq: N96 Layer: 4 Spit: 9
Feature: 10



Style: 14
Material: stone
Colour: brown
Grainsize: fine
Weight: 2.3g
Effervescence: no reaction
Percentage Complete: 15%
Flange: no flange
Radial Height: 12.5mm Radial Width: 5.5mm
Inner Diameter: 50mm Outer Diameter: 60mm

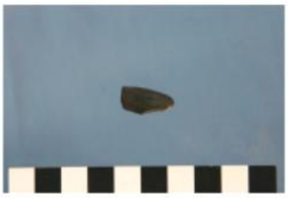
Other notes: polished surface, multi-colour

Category #: 34522 Context: 15256
Sq: S400 Layer: 4 Spit: 2

Style: -
Material: stone
Colour: light grey
Grainsize: fine
Weight: 2.4g
Effervescence: no reaction
Percentage Complete: -
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: 140mm

Other notes: -

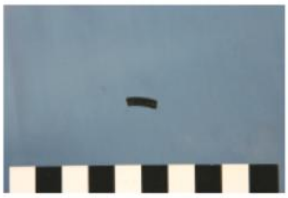
Category #: 34521 Context: 15267
Sq: S400 Layer: 4 Spit: 3



Style: 14
Material: stone
Colour: black
Grainsize: fine
Weight: 1.8g
Effervescence: no reaction
Percentage Complete: 10%
Flange: no flange
Radial Height: 11mm Radial Width: 6mm
Inner Diameter: 45mm Outer Diameter: 55mm

Other notes: -

Category #: 34528 Context: 15065
Sq: S400 Layer: 2 Spit: 9



Style: 11
Material: stone
Colour: black
Grainsize: fine
Weight: 0.5g
Effervescence: no reaction
Percentage Complete: 10%
Flange: no flange
Radial Height: 6mm Radial Width: 3.5mm
Inner Diameter: 40mm Outer Diameter: 47mm

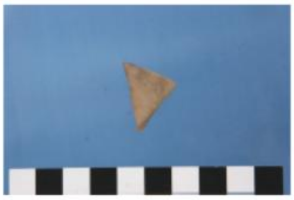
Other notes: polished surface

Category #: 28192 Context: 12676
Sq: 200 Layer: 5 Spit: 4

Style: 2
Material: stone
Colour: black
Grainsize: fine
Weight: 3g
Effervescence: no reaction
Percentage Complete: 7%
Flange: two-sided right angle
Radial Height: 8mm Radial Width: 20mm
Inner Diameter: 56mm Outer Diameter: 10mm

Other notes: polished surface

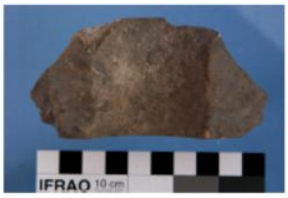
Category #: 32194 Context: 14350
Sq: TU199-200 Layer: 8 Spit: 1



Style: -
Material: stone
Colour: grey
Grainsize: fine
Weight: 2.8g
Effervescence: no reaction
Percentage Complete: -
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: -

Other notes: maximum thickness of fragment 4.5mm

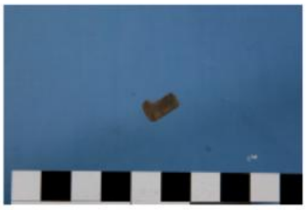
Category #: 36338 Context: 16318
Sq: V200 Layer: 7 Spit: 1




Style: 3
Material: stone
Colour: grey
Grainsize: medium
Weight: 170.5g
Effervescence: no reaction
Percentage Complete: 25%
Flange: one-sided convex
Radial Height: 49mm Radial Width: 26mm
Inner Diameter: 80mm Outer Diameter: -

Other notes: appears fragmented on outer edge

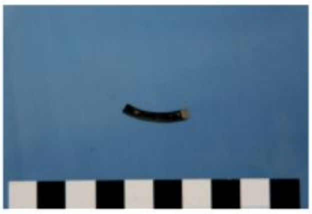
Category #: 36140 Context: 16096
Sq: V200 Layer: 4 Spit: 5



Style: -
Material: stone
Colour: grey
Grainsize: fine
Weight: 0.7g
Effervescence: no reaction
Percentage Complete: -
Flange: -
Radial Height: - Radial Width: -
Inner Diameter: - Outer Diameter: -

Other notes: possible not a bangle fragment

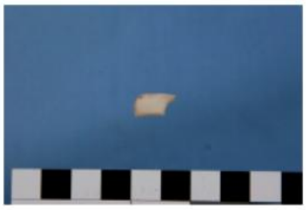
Category #: 33149 Context: 16095
Sq: V200 Layer: 4 Spit: 4
Feature: 2



Style: 11
Material: stone
Colour: black
Grainsize: fine
Weight: 1.3g
Effervescence: no reaction
Percentage Complete: 15%
Flange: no flange
Radial Height: 8mm Radial Width: 3.2mm
Inner Diameter: 50mm Outer Diameter: 58mm

Other notes: -

Category #: 29090 Context: 13094
Sq: Z201 Layer: 4 Spit: 3
Feature: 11



Style: 14
Material: stone
Colour: white
Grainsize: fine
Weight: 1.1mm
Effervescence: no reaction
Percentage Complete: 5%
Flange: no flange
Radial Height: 5mm Radial Width: 7mm
Inner Diameter: 56mm Outer Diameter: 70mm

Other notes: -

This is the context and physical characteristics of the bangle fragments from series 2 using artefact datasheets.

## Rock Samples

Quarry Name: Ban Rai Sample #: 1
GPS Point: 33


Structure: unfoliated
Grain Size: coarse
Banding: no
Minerals Visible: quartz, talc, calcite
Effervescence: reaction
Rock Formation: metamorphic
Rock Identification: granulite, marble, or skarn
Conclusion: Grey marble
Pressure & Temperature: low pressure/high temperature

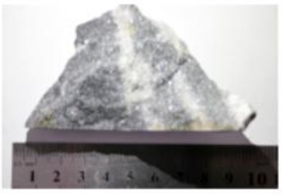
Other notes: -

Quarry Name: Ban Rai Sample #: 2
GPS Point: 33

Structure: unfoliated
Grain Size: coarse
Banding: yes
Minerals Visible: quartz, talc, calcite
Effervescence: reaction
Rock Formation: metamorphic
Rock Identification: granulite, marble, or skarn
Conclusion: Grey marble
Pressure & Temperature: low pressure/high temperature

Other notes: -

Quarry Name: Ban Rai Sample #: 3
GPS Point: 34



Structure: foliated
Grain Size: coarse
Banding: yes
Minerals Visible: quartz, biotite
Effervescence: no reaction
Rock Formation: metamorphic
Rock Identification: Gneiss, migmatite, amphibolite, eclogite
Conclusion: Migmatite
Pressure & Temperature: High pressure/high temperature

Other notes: -

Quarry Name: Ban Rai Sample #: 4
GPS Point: 35

Structure: unfoliated
Grain Size: coarse
Banding: no
Minerals Visible: talc, quartz, muscovite, calcite
Effervescence: no reaction
Rock Formation: metamorphic
Rock Identification: granulite, marble, or skarn
Conclusion: Grey marble
Pressure & Temperature: low pressure/high temperature

Other notes: very compact

Quarry Name: Ban Rai Sample #: 5
GPS Point: 36

Structure: unfoliated
Grain Size: coarse
Banding: no
Minerals Visible: quartz, muscovite, talc, amphibole, olivine
Effervescence: mild reaction
Rock Formation: metamorphic
Rock Identification: granulite, marble, or skarn
Conclusion: Grey marble
Pressure & Temperature: low pressure/high temperature

Other notes: pink and white veins

Quarry Name: Ban Rai Sample #: 6
GPS Point: 37

Structure: unfoliated
Grain Size: medium
Banding: yes
Minerals Visible: talc, muscovite, olivine, quartz, calcite
Effervescence: mild reaction
Rock Formation: metamorphic
Rock Identification: marble, hornfels, slate, metaquartzite, or skarn
Conclusion: Grey marble
Pressure & Temperature: low pressure/high temperature

Other notes: very compact

Quarry Name: Ban Rai Sample #: 7
GPS Point: 37

Structure: unfoliated
Grain Size: medium
Banding: no
Minerals Visible: talc, quartz, muscovite, calcite
Effervescence: no reaction
Rock Formation: metamorphic
Rock Identification: marble, hornfels, slate, metaquartzite, or skarn
Conclusion: Grey marble
Pressure & Temperature: low pressure/high temperature

Other notes: quartz veins

Quarry Name: Ban Rai Sample #: 8
GPS Point: 38


Structure: foliated
Grain Size: fine
Banding: no
Minerals Visible: NA
Effervescence: no reaction
Rock Formation: metamorphic
Rock Identification: slate/phyllite
Conclusion: Black slate
Pressure & Temperature: low pressure/low temperature

Other notes: very compact

Quarry Name: Ban Rai Sample #: 9
GPS Point: 39

Structure: unfoliated
Grain Size: coarse
Banding: no
Minerals Visible: quartz, muscovite, amphibole, calcite
Effervescence: no reaction
Rock Formation: metamorphic
Rock Identification: granulite, marble, skarn
Conclusion: Grey marble
Pressure & Temperature: low pressure/high temperature

Other notes: veins

Quarry Name: Ban Rai Sample #: 10
GPS Point: 40

Structure: unfoliated
Grain Size: medium
Banding: no
Minerals Visible: talc, quartz, muscovite, calcite
Effervescence: no reaction
Rock Formation: metamorphic
Rock Identification: marble, hornfels, slate, metaquartzite, or skarn
Conclusion: Grey marble
Pressure & Temperature: low pressure/high temperature

Other notes: -


Quarry Name: Ban Rai Sample #: 11
GPS Point: 41

Structure: unfoliated
Grain Size: medium
Banding: no
Minerals Visible: talc, quartz, muscovite, calcite
Effervescence: no reaction
Rock Formation: metamorphic
Rock Identification: marble, hornfels, slate, metaquartzite, or skarn
Conclusion: Pink marble
Pressure & Temperature: low pressure/high temperature

Other notes: veins

Quarry Name: Ban Rai Sample #: 12
GPS Point: 41

Structure: unfoliated
Grain Size: coarse
Banding: yes
Minerals Visible: quartz, talc
Effervescence: mild reaction
Rock Formation: metamorphic
Rock Identification: Granulite, marble, or skarn
Conclusion: Granulite
Pressure & Temperature: high pressure/high temperature

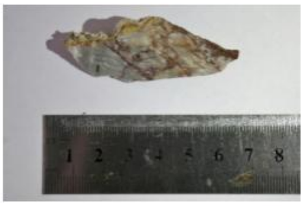
Other notes: mix of coarse and medium size grains


Quarry Name: Ban Tha Chang Dai

Sample #: 13
GPS Point: 42

Structure: unfoliated
Grain Size: fine
Banding: yes
Minerals Visible: NA
Effervescence: mild reaction
Rock Formation: metamorphic
Rock Identification: marble, spotted rock, halleflinta, mylonite
Conclusion: Halleflinta
Pressure & Temperature: low pressure/high temperature

Other notes: -



Quarry Name: Ban Tha Chang Dai
Sample #: 14
GPS Point: 42

Structure: unfoliated
Grain Size: fine
Banding: yes
Minerals Visible: NA
Effervescence: no reaction
Rock Formation: metamorphic
Rock Identification: marble, spotted rock, halleflinta, mylonite
Conclusion: Halleflinta
Pressure & Temperature: low pressure/high temperature

Other notes: -

This is the context and physical characteristics of the quarry samples used for analysis in this study.