TECHNOLOGY OF DVĀRAVATĪ POTTERY: A VIEW FROM PETROGRAPHIC ANALYSIS

Duangkamol Aussavamas

Rajabhat Suan Dusit University, Bangkok, Thailand; aussa@hotmail.com

ABSTRACT

This study focuses on the examination of aspects of the carinated pottery of the Dvāravatī period. This type of pottery is one of the most prominent types found in a large number of Dvāravatī sites in Thailand. Samples used for this study were collected from excavations at archaeological sites located in several regions of Thailand, including Northern, Northeastern and Central Thailand. The carinated potteries were analyzed using petrographic analysis. The objective of this work was to examine the pottery fabric. This method is used to establish sources of raw materials and whether production techniques, decorations, and firing temperature show patterns associated with the raw material source distributions. It is also possible to reconstruct the production technology of the vessels. Knowing the source of raw materials source of clay and temper and understanding the patterns of manufacturing and decorative processes help us better understand material distribution patterns of the Dvāravatī period. Analysis shows that Dvāravatī earthenware pottery raw materials include both primary and secondary clays, and that temper used was both organic matter (rice chaff) and grogs (fired clay mixed with iron oxide). Evidence for wheel-thrown production was associated with all decoration styles, and finishing techniques included plain, polishing, incising, cord marking, red slip and black burnishing. The firing temperatures were as low as 400-550° C. These samples indicate there was general homogeneity over a wide area, but also the presence of regional groups of pottery. This suggests the widespread circulation of pottery styles among various production centers during the Dvāravatī period.

INTRODUCTION

Literary and archaeological evidence has confirmed that Central Thailand was once the homeland of an early kingdom, or kingdoms, referred to in inscriptions as "Dvāravatī." Beal (1969) and Takakusu (1982) note that in the seventh century, Chinese historians and pilgrims to India spoke of the existence of a kingdom that they called To-lo-po -ti, situated to the west of Isanapura (Cambodia) and to the east of Sri Ksetra (Burma). The Chinese name for this civilization was interpreted as the Sanskrit word Dvāravatī, meaning "which has gates" (Boeles 1964). However it was not until 1964 that this interpretation was confirmed from two inscribed silver coins found at Nakhon Pathom (Indrawooth 2004:120).

Our knowledge of this civilization was expanded when Paul Pelliot (1904) suggested that the people of Dvāravatī were Mons. Coedès (1925) attributed the "Hindu non-Cambodian" images around the Gulf of Siam and described by Lajonquière to the Mons of Dvāravatī. In 1959, Pierre Dupont convinced most scholars that Dvāravatī was indeed a great Mon kingdom whose culture extended widely and came to encompass virtually the whole of modern Thailand. Not long after that, scholars supposed that Dvāravatī formed part of a Mon confederacy centered at Thaton in Lower Burma (Indrawooth 2004:120). However, scholars have long been troubled by the absence of early Buddhist remains in the Mon country of Lower Burma, particularly when compared with their abundance in Central Thailand. At present, excavations in Thailand indicate a concentration of Dvāravatī settlements in Central Thailand (110 sites, from Pisanupon 1999: 1-4), and diffusion to other regions of Thailand, including Northeastern (30 sites, from Saisign 2004:74), and Northern/ Southern (1-2 sites, from Saising 2004: 74). These archeological remains provide information on themes in Dvāravatī material culture, such as town plans, building construction, implements, domestic utensils, ornaments and ceramic wares, and suggest that to understand the formation of the Dvāravatī polity, one must study the chronological development of the cultural history of Central Thailand (Indrawooth 2004:120).

Figure 1. Examples of the carinated vessel forms sampled.

DVĀRAVATĪ POTTERY

Indrawooth (1985, 2005) classified Dvāravatī pottery from survey and excavation on various Dvāravatī sites of central Thailand for the period circa 600-1,000 C.E. (i.e. Chansen, Nakhon Sawan Province; Ban Ku Muang, Signburi Province; Ban Tha Kae, Lopburi Province; Ban Ku Bua, Rajburi Province; and ancient Nakhon Pathom, Nakhon Pakhorn Province). Indrawooth's basic functional subdivisions included, wares for daily life such as dish-on-stand and carinated vessels, and wares for special occasions or religious ceremonies such as spouted pots and sprinklers. The forms of Dvāravatī pottery can be traced back to prehistoric times, particularly the dish-on-stand and carinated pot, whose shape continued to be used as cooking vessels in Dvāravatī culture (Indrawooth 1985: 52). Spouted pots, or kendis, and spouted bowls used as lamps and sprinklers also show close similarity in both shape and design to Indian prototypes dating from the early Christian era up to the Gupta (400-600 C.E.) and the post Gupta period (700-800 C.E.). Decorative techniques include an incising technique with line and wave design, a wrapped paddle technique with cord and mat marking designs, and an impressing technique with finger design including snail and shell designs. The technique of decorating pots in relief by means of a mould (stamping technique) was introduced by Indian potters. Examples include human figures in different postures, animal figures, and flower motifs. The predilection for stamped decorated pottery seen during the Gupta period was the indirect result of local imitations of Roman stamped pottery (Arretine ware) during the period of Roman settlement in India. Motifs are derived from auspicious symbols found on Indian coins and early sculptures from the first century B.C.E to the third century C.E. such as *srivasa*, *swastika*, *vajra*, *purnaghata*, and animal figures (lion, elephants and swans).

We can conclude that the imitation of Indian pottery both in form and design indicates a close relationship between the Dvāravatī people and India, not only by way of trade but also possibly by way of population settlement. The continuity of some ancient types (dish-on-stand, carinated pot) and simple techniques and patterns of decoration (incising technique with line and wave design, wrapped paddle technique with cord, and mat marking design) since prehistoric times strongly suggests that Dvāravatī culture inherited many aspects of the prehistoric culture (Indrawooth 1985; 1999: 237-238).

Researchers have often focused on the carinated pots, which are considered to be the most prominent type found at many Dvāravatī sites, and which can be traced back to prehistoric times in Thailand. Indrawooth (1999:237; 2005: 237) has established that Dvāravatī pottery is unglazed earthenware formed by wheel throwing and fired in an open hearth kiln. Analysis of Dvāravatī carinated pots has also revealed that the raw materials used by the native potters were local. Their upper bodies (Figure 1) are usually plain, having one, two or three ridges separated by wide smooth channels on their shoulders (a few carinations are notched). Their lower bodies are rarely plain, mostly decorated with mat or cord marks of criss-cross design and an incising technique with lines and wave design. In Thailand, pottery of this shape (carinated pots) came into existence during the Neolithic period, and continued to be used as cooking vessels during the Dvāravatī period, mostly disappearing after that time (Indrawooth1985:49-52).

THE PRESENT STUDY

This study examines aspects of technology and materials. Potsherds from all ceramic periods are one of the most prolific artifacts on archaeological sites. Stylistic and technical changes over time can reveal a great deal about the societies in which pottery was made, so that clay vessels serve as essential cultural and dating indicators as well as objects of individual skill and creativity. The type of pottery made is dependent on a large number of factors: the availability of particular clay raw materials, the fuel available for the kiln, the production and decoration techniques and the demands of the society within which it is produced (Fitzgerald 2002:8). Ceramics provide important evidence for daily life, development and culture of ancient populations.

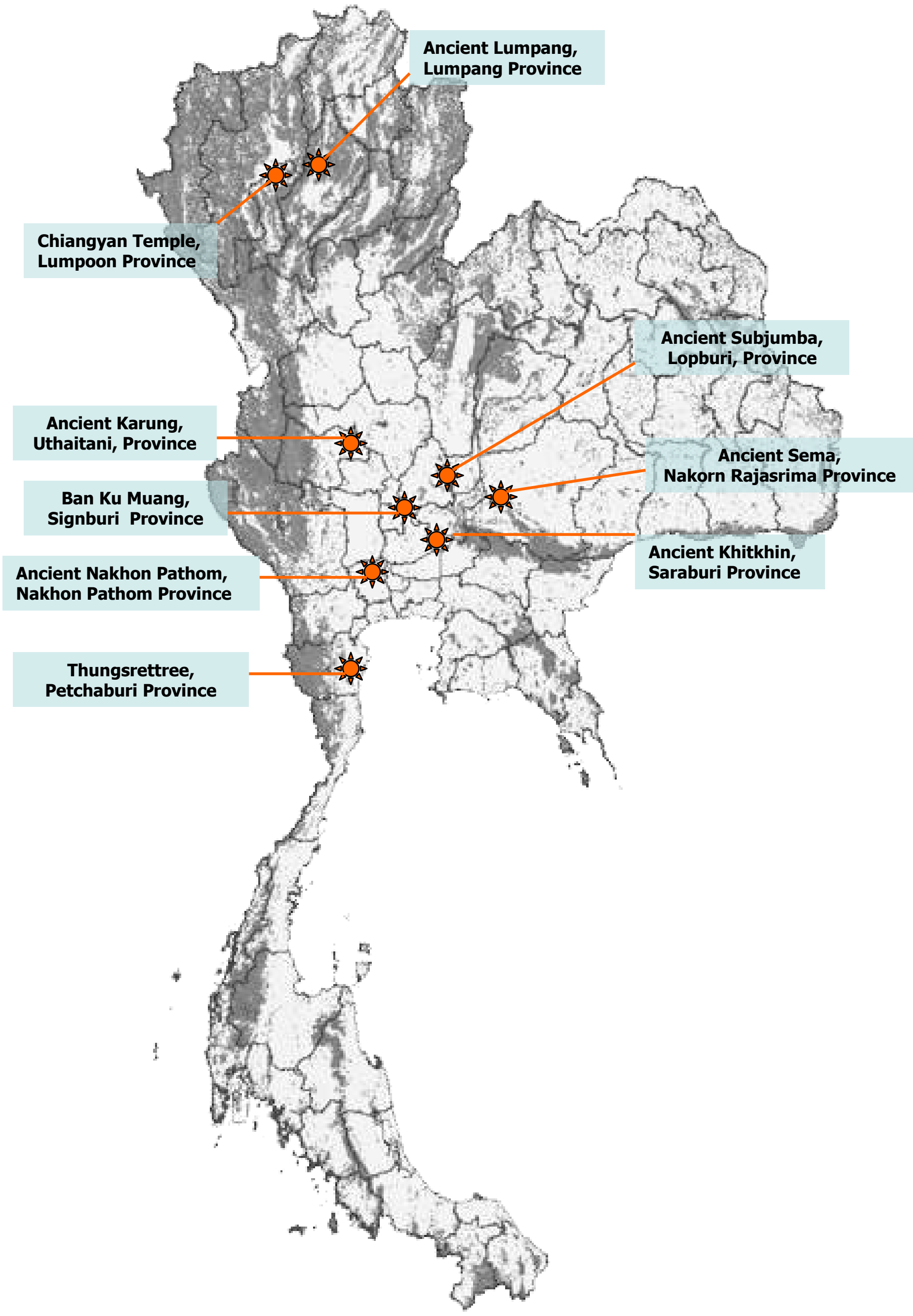

Figure 2. Location of samples.

This research has two goals. First, it is aimed at examining the components of the "soil fabric" of the ceramic. Fabric includes the total organization of the material, including the spatial arrangement, shape, size and frequency of the constituents (Courty et al. 1989:64). The second goal is to compare and confirm the relationship among Dvāravatī sites in Thailand using this ceramic data.

The comparative archaeological samples were selected from nine sites located in various regions of Thailand, including the Central Plain (6 sites), the North (2 sites) and the Northeast (1 site). These Dvāravatī site samples date circa 600-1000 C.E., a rather broad temporal range that places some limitations on our ability to observe changes through time. Hence most observation of differences made by the present study involves regional comparisons rather than temporal comparisons.

Fifty-eight samples from these nine archaeological contexts were used for analysis. The samples were chosen following two criteria. First, the samples were selected from excavated Dvāravatī site contexts (among those available pre -2008). Second, the samples were taken on carinated pots (Figure 1).

Carinated potsherds from central Thailand were used from the following sites:

-Ancient Nakhon Pathom, Nakhon Pathom Province, 2 samples.

-Ancient Karung, Uthaitani, Province, 3 samples.

-Ancient Subjumba, Lopburi, Province11 samples.

-Ancient Khitkhin, Saraburi Province, 13 samples.

-Ban Ku Muang, Signburi Province, 6 samples.

-Thungsrettree, Petchaburi Province, 5 samples.

From the Northern region, the following were sampled:

-Chiangyan Temple Lumpoon, Province, 10 samples.

-Ancient Lumpang, Lumpang Province, 1 sample.

And from the Northeastern region, these were sampled:

-Ancient Sema, Nakorn Rajasrima Province, 7 samples.

METHODS

This study utilizes a range of petrographic analysis on thin-sectioned samples. The scheme of thin-section observation and description used is a compromise between those used in geology and those used in pedology and has been modified to include archeological material (Courty et al. 1989:63)

Petrographic analysis has been borrowed and adapted from standard geological techniques used for many years in the study of rocks, minerals and soils. Petrographic analysis allows for the examination and identification of the mineral and rock fragments which may be present in a sherd of pottery. The technique of thin sectioning provides an objective method for classifying fabrics or pottery pastes. Classification is based on a wide variety of minerals, rock fragments, and other non-plastic inclusions that normally occur in pottery. A microscopic examination of a thin slice of pottery will reveal the size, shape, and arrangement of the mineral grains, which can be used to assist in the identification of their rock constituents. Thin sectioning is also used to evaluate the textures of the samples as a function of temper, the ratio of coarse (mineral) to fine (clay or organic) fraction, and other components (Willams 1983:303).

The most striking results achieved by the thin-sectioning of ancient pottery have usually been shown in studies concerned with fairly coarse wares containing exotic minerals or rock fragments, which can be shown to have a particular geological distribution (Willams 1983:303).

All samples analyzed were examined in petrographic thin-section 0.03 mm. thick. The microscopic characteristics of each sample were recorded in detail on the basis of this examination with a petrographic stereo microscope. The results of these techniques provided a picture of the structure and composition of these samples.

Thin sections can be kept indefinitely for future comparative studies (Willams 1983:316). Sample preparation and thin sectioning were conducted at the laboratory of the Office of Science for Land Development, Land Development Department, Thailand.

TERMS

Terms used here are the geological classifications, and are more accurate for archaeological purposes than potter's terminology (Gibson 1997:122)

Clays. Natural silicate-based soils with a strongly plastic quality are of two main types, based on geologic formation processes: primary (also called residual) and secondary (also called sedimentary). Primary clays have formed at the original location of their parent material and are a minority of the world's clay sources. Such clays occur when other soluble elements of the parent soil or igneous rock have been dissolved. These residual clays have fewer organic and mineral impurities, but also have larger, less plastic particle sizes that require higher firing temperatures. Secondary clays are transported from their place of origin and deposited elsewhere. Clay can be transported from decomposed parent rock by water, wind, or ice. While being transported, the clay is subjected to impact and the already tiny particles become smaller still, and more plastic (Frank and Janet 1977:4-5). Most clay sources are secondary. Ceramics produced from secondary clays are typically earthenware and terracotta.

Tempers. Tempers are materials which have been added to clay to improve its drying and firing qualities (Gibson and Woods 1997:32). The proportion of temper to clay must be controlled (Labbé 1985:5). Common tempers are plant materials (rice husk), sand, and grog (crushed low-fired clay). Temper serves to control the rate of shrinking or expansion during the firing process. It helps to prevent cracking and adds strength and durability to the finished product (Labbé 1985:5). Rice husks are also mixed with clay for high plasticity. Plasticity and strength are important to potters using traditional forming methods (Frank and Janet 1977:6).

Forming technique. Wheel-thrown vessels, as opposed to forms built by hand, can be identified in thin section provided the section is cut horizontally from the sample vessel. This is parallel to the plane of the wheel head, and the parallel flow pattern can be recognized in polarized light by the parallel orientation of constituent particles (Figure 19) (Willams

1983:305). The free hand or hand building method can be identified in thin section provided that the section is cut horizontally from the sample vessel, and the microscopic structure shows a "stipple speckled," disoriented pattern of constituent particles.

Firing temperature and color. For any pottery fabric the color range is partlydependent on firing conditions and temperature. Using a standard chart, such as that produced by Munsell, ceramic colors and be systematically and accurately described (Orthan et. al. 1993: 68-69). Colors of brown, tan, grey, black, and orange typically seen on prehistoric and early historic pottery, combined with dull porous texture, are indicative of open hearth firing techniques with secondary clays.

RESULTS

The basic constituents (texture features) of each sample are clay material and sand. The results of all the samples showed that the vessels are earthenware pottery. Every piece of pottery was formed by hand (i.e. hand built or thrown, not molded). Earthenware is the earliest type of pottery made by humans. It was usually unglazed and the color varies widely from shades of grey to buff to reddish-orange. The texture is coarse and porous so it is easily broken, which is why so much earthenware is present in archaeological contexts. It is relatively simple to make, requiring only ordinary clay and a simple open pit for firing (Rooney 1987:4).

The coarse/fine fraction ratios show the varying dominance of one or the other end of the textural spectrum (Table 1). The predominant mineral present in each sample is quartz. The differences observed among the samples are from mineral components in the coarse fraction and the organic component. Table 1 presents the comparative fabric constituents, production technology, and decorative motifs for the analyzed samples in the three regions of Thailand.

The Central Region (Figures 3-9).

Raw material of this group was clays or soils taken from both primary and secondary sources. Coarse fraction (mineral grains -- minor and major) representing igneous rocks, characteristics of grain size, shape and roundness (e.g. Figure 3), and the ratio of each sample generally presented homogeneity in this group. The ratio of Ancient Khitkhin Sample 6, however, was 5:95, and Sample 11, 2:98, presenting limited instances of heterogeneity or probable non -local pots in this group.

Four tempers included husk as a 5%-10% proportion in samples 1, 2, 4 and 6 of Ban Ku Muang, Ancient Khitkhin proportion of 10-15% in samples 6, 8, 10, 11 and 12, and Ancient Subjumba 5-10% in samples 4, 7, 8 and 11 (Figure 4). Grog material could be observed as a 2-5% proportion in the samples 1 and 5 of Thungsrettree (Figure 5). It can be observed that the grog particles are separated from fabric, often surrounded by voids. Husk and grog mixed was observed in Ancient Subjumba, Sample 9 (husk 5% and grog material 2% -- Figure 6). Sand mixed with clay bodies in the samples (Figure 7) was present in 10-20% proportion in Ancient Subjumba samples 1 and 2, Ancient Khitkhin samples 1-5 and 9; 20% in Ancient Karung Sample 2; as a 15-20% proportion in Thungsrettree samples 2 and 4, and Ancient Nakhon Pathom samples 1 and 2; and 20-25% in Ban Ku Muang Sample 3.

Natural inclusions in the original clay were observed in samples 1 and 3, Ancient Karung, samples 3 and 5, Ban Ku Muang, and samples 2 and 4, Thungsrettree.

Forming technique. Both wheel-thrown and free-hand methods were observed in the Central group. Parallel orientation of clay, all minerals, temper, and voids in the fabric (Figure 8) indicates wheel-thrown production.

Decoration and color (Figure 9). Surface treatment techniques include plain, polished, cord marked and red slipped outer pottery surfaces. Fabric colors include red, brown, gray, and yellow; exterior and interior colors are sometimes different.

Temperature and firing technique. The low firing temperatures indicated by the fabric characteristics (ranging 400-550°C) are consistent with firing in an open hearth.

The Northern Region (Figures 10-15).

Raw material of this group was clays from primary formation sources (Figures 10, 11) similar to the Central region primary sources, but soil resources located stratigraphically close to parent material (mountain or primary clays).

Temper. Sand could be observed as 5-15% in Chiangyan Temple site samples 1 and 7 (Figure 11), and natural clay inclusions were present in Sample 1, Ancient Lumpang (Figure 12), and samples 2, 5, 8 and 10, Chiangyan Temple (Figure13).

Forming technique. Wheel-thrown technique was observed (Figure 14).

Decoration and color. Techniques of plain, polished, cord marked (Figure 15) and red slipped outer surfaces could be observed in thin-section. Color in this group was mostly yellowish brown and brown; colors of the outer and inner surfaces could vary.

Temperature and firing technique. The inferred firing temperatures of the Northern samples were the same as the Central region, open firing and low temperature ranging 400-550°C.

The Northeastern Region (Figures 16-19)

Raw material. The clays of this group were from both primary and secondary sources. The relation between grain size, shape and roundness, major and minor mineral grains and the coarse/fine ratio of five samples presented some

Table 1. Comparison of technology of carinated pots in each region by petrographic analysis.

	Raw material				Temper***			
Regions	C/F* Ratio	Mineral grain		Size grain	1	2	3	4
		major	Minor**					
Central	20:80	Quartz	quartz, plagioclase feldspar, k-feldspar, biotite, mica, muscovite, tourmaline, horn-blende and basalt rock fragments	very fine - very coarse sand (subrounded – angular)	X	X	X	X
North	30:70	Quartz	mica, feldspar, iron oxide nodules, metamorphic quartz and chert rock fragments	fine - coarse sand (angular - subrounded)				X
Northeast	5:95	Quartz	muscovite, feldspar, polycrystalline quartz, broken quartz, chert rock fragments	silt – medium sand (subrounded)	X			X

	N ****	Forming Technique*****			Decoration styles******				color		Temperature (C°)	Firing
Regions		1	2	3	1	2	3	4	1 layer	2 layers		
Central	X	X	X	X	X	X	X	X	red, brown, gray, and yellow	X	400-550	Open firing
North	X	X			X	X	X	X	yellowish brown and Brown	X	400-550	Open firing
Northeast	X	X			X	X		X	Brown	X	400-550	Open firing

Notes
* C/F = coarse fraction (rock or mineral) and fine fraction (clay)
** Minor = the minor mineral grains (<5% in coarse fraction)
*** Temper = 1 organic component (chaff rice or husk)
= 2 grog material (clay mixed iron oxide)
= 3 husk and grog material
= 4 sand
**** N = natural inclusions in untempered clay

***** Forming Technique = 1 wheel-thrown
= 2 free hand
= 3 unidentified

****** Decoration styles = 1 plain
= 2 polished
= 3 cord marked
= 4 red slip

Figure 3. Ancient Khitkhin, Sample 7, Central Region. XPL magnification 7.5x

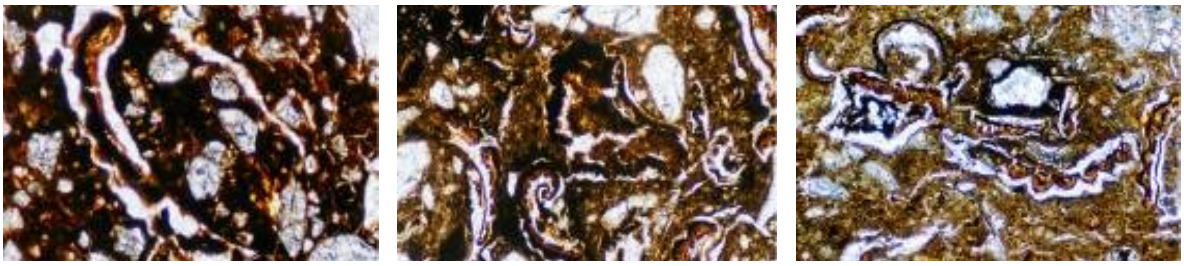

Figure 4: Organic component or husk 5-10%, PPL magnification 10x. Left photo: Ban Ku Muang, Sample 2. Middle: Ancient Khitkhin, Sample 10. Right: Ancient Khitkhin, Sample 6.

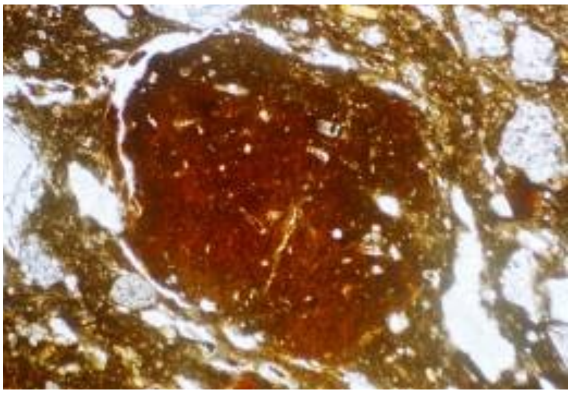

Figure 5 Grog material (clay mixed with iron oxide), 2-5%, Thungsrttree, Sample 1, Central Region, PPL magnification 10x

Figure 6: Husk and grog material, Ancient Subjumba, Sample 5, Central Region, PPL magnification 10x

Figure 7. Sand grains 10-20%, Ancient Khitkhin Sample 2, PPL magnification 10x.

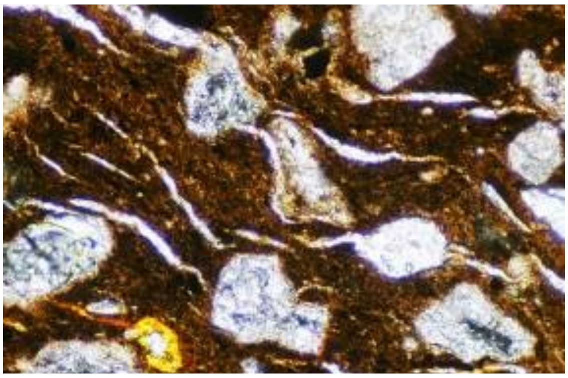

Figure 8. Ancient Karung Sample 2, Central Region, XPL magnification 10x.

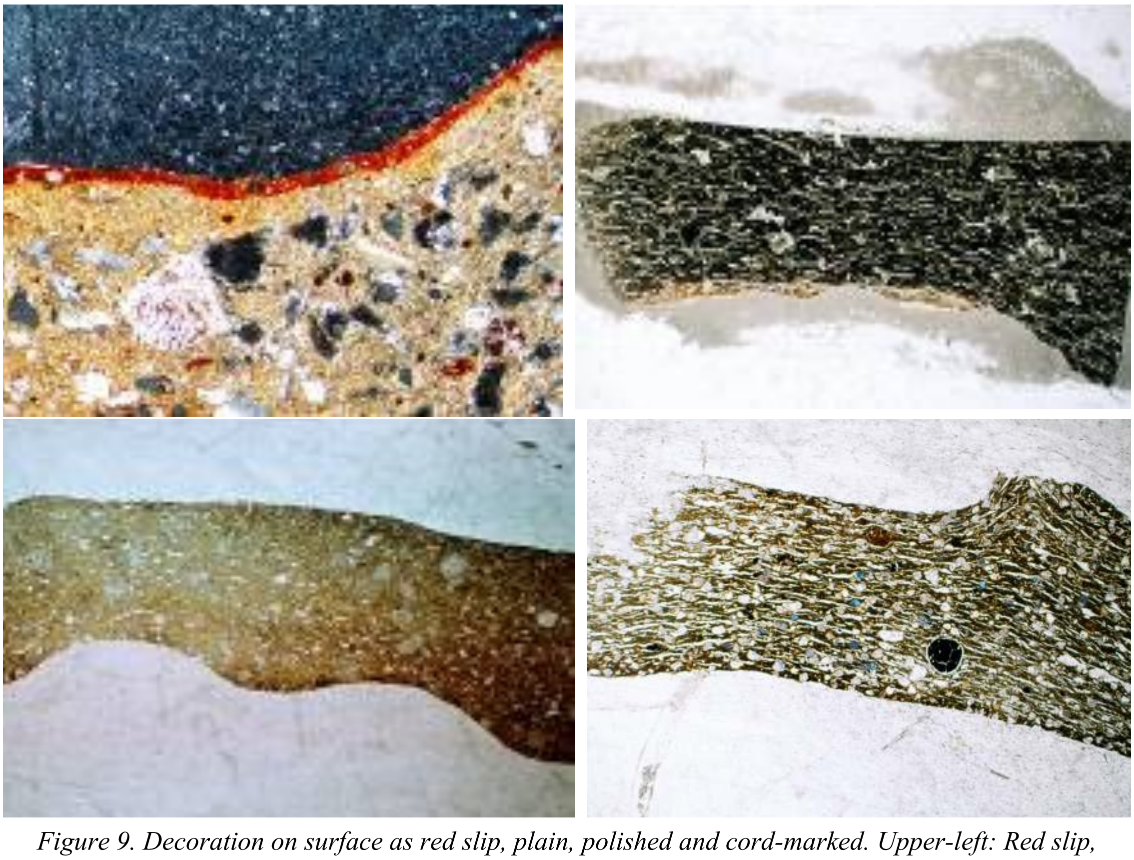

Figure 9. Decoration on surface as red slip, plain, polished and cord-marked. Upper-left: Red slip, Ancient Khitkhin Sample 3, XPL magnification 4x. Upper-right: Polish, Ancient Khitkhin Sample 11, PPL magnification 0.75x. Lower-left: Cord mark, Ban Ku Muang, Sample 5, PPL magnification 0.75x. Lower-right: Plain, Ancient Khitkhin, Sample 5, PPL magnification 0.75x.

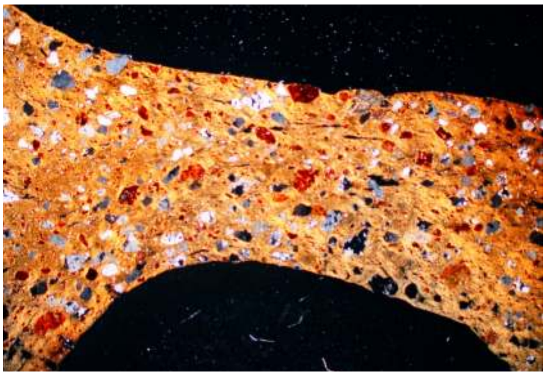

Figure 10. Ancient Lumpang Sample 1, Northern Region, XPL magnification 1x.

Figure 11. Sand grains 15%, Northern Region, Chiangyan Temple Sample 1, PPL magnification 10x.

Figure 12. Natural inclusions, Ancient Lumpang Sample 1, PPL magnification 0.75x.

Figure 12. Natural inclusions, Chiangyan Temple Sample 5, PPL magnification 0.75x.

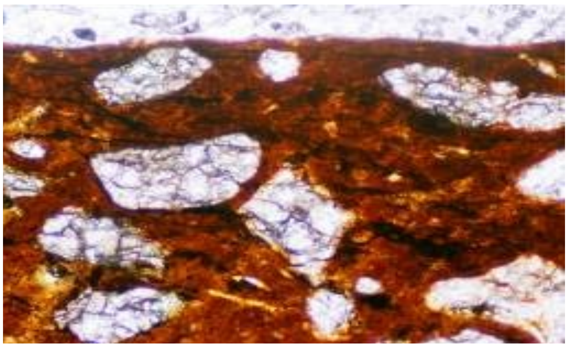

Figure 14. Chiangyan Temple Sample 1, PPL magnification 10x.

Figure 15. Chiangyan Temple Sample 3, cord marked, PPL magnification 0.75x.

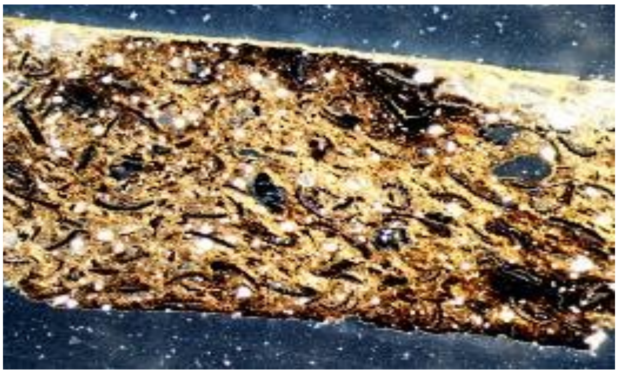

Figure 16. Ancient Sema Sample 5, Northeast Region, XPL magnification 2.5x.

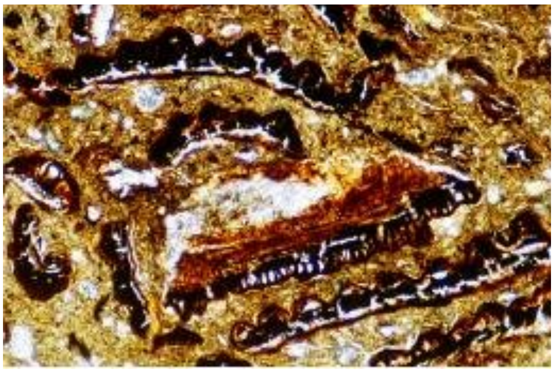

Figure 17. Husk 10-20%. Ancient Sema Sample 6, PPL magnification 10x.

Figure 18. Sand grains 20-25%, Ancient Sema Sample 3, PPL magnification 0.75x.

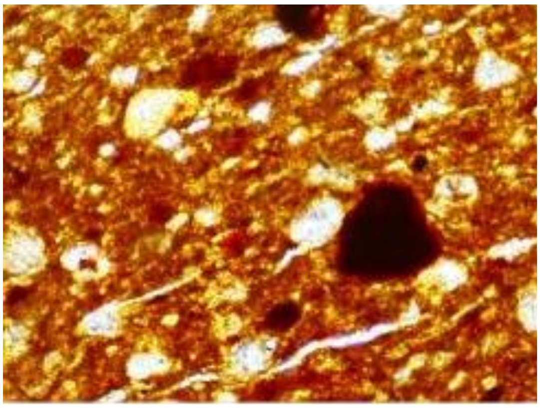

Figure 19. Wheel-thrown technique, Ancient Sema Sample 7, PPL magnification 10x.

homogeneity in this group. Samples 3 and 7, however, presented heterogeneity within this group with ratios of 30:70 and 10:90 (Table 1).

Temper. Two tempers were observed for this group. Rice husk (Figure 17) could be observed as a 10%-20% component in samples 1, 2, 4, 5 and 6; sand as a 20-25% component in Sample 3 (Figure 18). Sample 7 was tempered by natural inclusions.

Forming technique. Wheel-thrown technique was observed (Figure 19).

Decoration and color. Techniques of plain, polished and red slipped outer surfaces could be observed in thin-section. The predominant color of this group is brown, though the color separated into inner and outer layers.

Temperature and firing technique. The firing temperatures of the Northeast samples were similar to the Central and North regions, ranging 400-550°C in an open hearth environment.

COMPARATIVE DISCUSSION AND CONCLUSIONS

The studies of carinated pottery of the Dvāravatī period based on petrographic analysis on thin section indicate that these vessels have homogeneity of basic ceramic type in all regions of Thailand. All of the carinated potteries are earthenware fired at low temperature. Thin sectioning reveals the process of making Dvāravatī carinated pottery: the clay body with temper is formed into a vessel shape by hand building or throwing on a wheel, decorating (plain, polished, red slipped or cord marked) and fired in an open hearth to circa 400-550 °C. No mould production is indicated.

The petrographic characteristic of the samples from *the Central Region group* are generally a coarse fabric due to the substantial presence of various igneous minerals (quartz, feldspar, biotite, mica, muscovite, tourmaline, hornblende, and basalt). Clays of this group were always taken from secondary sources transported far from parent material. Clay body texture of each sample in this region shows many minerals mixed in the fabric acquired during transit from the parent source.

The thin-sections indicate four tempers: rice chaff or husk, grog (fired clay mixed with iron oxide), husk and grog material, and sand grains; some samples also exhibit natural inclusions in original clay, providing a natural tempering constituent. The five temper types of this group represent a much higher variety in this category than for other regions.

Surface treatments show a variety of techniques such as plain, polished, cord marked and red slipped. Firing is in an open hearth at low temperatures ranging 400-550°C.

The petrographic characteristics of the samples from *the Northern Region group* are similar to Central in having a coarse fabric with various mineral fragments. Single quartz grains are dominant and secondary minerals include mica, feldspar, iron oxide nodules, metamorphic quartz, and chert rock fragments. Raw materials or clays of this group are residual (primary) clays from eroded locations such as mountain sources.

Temper observed in the Northern Region samples is markedly different -- sand grains in only 2 samples and the others are original clay with no temper. Texture of these sand grains is similar to the sand temper of the Central Region.

Vessel formation of the Northern samples is wheel-thrown technique only, and decoration techniques on surface are plain, polished, cord marked and red slipped. Low firing temperature of 400-550°C in an open hearth is again indicated.

The results of analysis of fabric from *the Northeastern Region group* are different from those of the Central and Northern areas. The ratio of coarse fractions (the mineral fragments) is much lower, when it is present at all. Two samples present a few mineral fragments (larger grain size) such as muscovite, feldspar, polycrystalline quartz.

Raw material of this group was clay taken from secondary sources (sedimentary sources) redeposited far from their place of origin. The predominant temper was rice chaff or husks in 10-20% proportion; only one sample presented sand grains in a 20-25% proportion similar to the Central region.

Wheel-thrown production technique was present and surface decoration included plain, polished and red slipped. Low temperature (400-550°C) and open firing were also indicated.

Comparative prehistoric data – Northeast Thailand

The comparative evidence of pottery characteristics in prehistoric Northeast Thailand includes petrographic analysis of 9 samples from Ban Chiang (Velde 1985), 23 pottery samples from Prasat Phanom Wan (Aussavamas1999) and Ban Bung Noi (Aussavamas and Niyomkar 2000), 40 samples from Ancient Sema site (Ausssavamas and Niyomkar 2001), 11 samples from Ancient Muang Burirum (Ausssavamas 2008), 2 samples from Noan Ta Tone (Ausssavamas 2008), 23 samples from Noan Ba Cha Kao (Ausssavamas 2008; 2009) and 2 samples from Ban Kabuang site (Ausssavamas 2009).

Various materials were used as temper in prehistoric Northeast Thailand. In the earliest periods of pottery production, the most common temper was sand. Later, both grog and rice chaff were used. Crushed potsherds can serve as grog, although, in northeast Thailand separately prepared grog seems to have been used (Labbé 1985:5).

Thin sections by Velde (1985:37) prepared for 9 samples from Ban Chiang, northeastern Thailand for petrographic investigation are all made of clay-rich material that is black in its natural state, then upon firing, oxidizes to an orange or buff color. Grits, or sand grains (0.25 micrometers or less in diameter) are found in all samples in varying quantities, from high abundance (about 80% of the paste) to low abundance (about 10%). The mineral present is almost exclusively quartz. Several green hornblende or amphibole grains were found in two samples, minerals also noted by McGovern (1986). By contrast, no sponge spicules, chert, plagioclase of other feldspars were found, nor any shell material, as reported by Vincent (1988) for soil or clay samples taken from the Sakon Nakorn basin of Northeast Thailand.

Lumps of clay-rich material are found in a large portion of the samples from Ban Chiang. This material, noted by McGovern (1986), is generally not oxidized (fired) but is, at times, of lighter color than the enclosing paste matrix. These clay lumps could be either grog (previous fired clay materials) or lumps of unworked clay. Vincent (1988) suggests, on a comparison with present pottery practices in the region, that clay lumps were fired at low temperatures to produce a grog material. There are signs of the presence of organic material; cavities are present that suggest rice plant remains which have now disappeared during the firing process. Irregular dark areas that could indicate the presence of highly reduced and, perhaps, organic-rich zones are present in all of the samples investigated. At times, the dark areas are formed by the clay lumps. At other times, they are disseminated throughout the clay matrix (Velde 1985:37).

The major characteristic of these Northeastern samples is their heterogeneity. For the most part, the clay paste was little worked and shows strong segregations of the different components of clay-rich material, sand grits and clay lumps (Velde 1985:37).

Analysis of 23 domestic or mortuary pottery samples from Prasat Phanom Wan, Muang District, Nakhorn Ratchasima Province by Aussavamas (1999) derive from two prehistoric periods. The first cultural period of Prasat Phanom Wan was dated prior to 370 B.C.-230 C.E.., while the second cultural period is dated between 370 B.C.-230 C.E. Petrographic analysis and chemical analytical techniques, including ICP-Atomic Emission Spectrometry, were used to compare the samples of the different periods.

The results showed changes through time in pottery production at this site: the earlier period was characterized by grog tempered and hand formed vessels, with decoration consisting of plain, coiling, incised and impression or mat; the second period was characterized by organic matter or rice chaff tempering, wheel-formed vessels., and decorative techniques that included polishing and black burnishing. Firing temperature of both periods was the same: open firing at low temperature (ranging up to 550 °C).

This evidence of cultural change at Phanom Wan contrasts with other sites in the Upper Mun Valley, where pottery shared the same types and temper through these periods. (Aussavamas 1999)

The pottery thin section data for prehistoric Northeastern Thailand includes Ausssavamas and Niyomkar (2000) at Ban Bung Noi site, Nakhon Ratchasima Province, Ancient Sema (Ausssavamas and Niyomkar 2001), Nakhon Ratchasima Province, Ancient Muang Burirum site (Ausssavamas 2008), Buriram Province and Noan Ba Cha Kao (Ausssavamas 2008; 2009), Nakhon Ratchasima Province. All of these prehistoric pottery samples exhibited secondary clay sources and rice chaff temper in 10-50% proportions. The major characteristic of these materials is their homogeneity in the Upper Mun Valley.

Grog temper (composed of rice husks and clay) was found at the Muang Burirum site, Buriram Province (Ausssavamas 2008) and the Noan Ba Cha Kao, Noan Ta Tone and Ban Kabuang site, Nakhon Ratchasima Province (Ausssavamas 2008 and 2009). Tempering with rice chaff, however, seems to be a marker for pottery originating in Northeast Thailand. Both techniques—hand building with clay anvil and wheel throwing–were indicated at these Northeastern sites. Open firing at low temperature (400-550° C) was also standard.

Comparative prehistoric data – Central Thailand

The evidence of pottery characteristics in prehistoric central Thailand includes petrographic analysis of 26 samples from the Nong Ratchawatra site, Supanburi Province (Aussavamas 2009). All the pottery produced was earthenware fired at low temperature (400-550°C). Most of the samples exhibited a clay body from primary clay sources with a coarse fraction and many minerals and used grog for temper. Other pottery utilized clay from secondary sources, organic matter (rice husks) for temper, and is assumed to be imported from northeastern Thailand Neolithic sites such as Muang Burirum site, Buriram Province (Ausssavamas 2008) and Noan Ba Cha Kao, Noan Ta Tone and Ban Kabuang site, Nakhon Ratchasima Province (Ausssavamas 2008 and 2009). Vessels were formed both via hand building with clay anvil and wheel-throwing.

Petrographic analysis of prehistoric pottery from Ban Mai Chaimongkol, Amphoe Takhli, Changwat Nakornsawan, by Somprasonk (1997) shows that pottery was produced using different raw materials in different periods. During the Bronze Age, materials for tempering pottery consisted of igneous and metamorphic rock fragments; firing was not higher than 550°C. In the late Bronze Age, tempers consist of quartz and plant tissue, and firing was not higher than 440°C. The firing duration was short.

CONCLUSIONS

Comparisons of thin section data between the Dvāravatī and prehistoric periods in Central and Northeastern regions of Thailand permits some temporal observations. Raw clay materials were from local sources and the potter prepared the clay for forming and firing by putting various tempering materials (organic matter, grog etc.) into the clay. These tempers were used from prehistoric times until the Dvāravatī period when only grog lumps (organic matter with clay) or rice husks were used in the Northeastern Region (the Sakon Nakorn and Korat basins).

Sand tempering with grains of similar sizes, and present in 10-25% proportions, was found in the carinated potteries of the Central Region. These Central occurrences may be the first time that sand temper was used during the Dvāravatī period. Sand tempered ceramics were also found in the Northern and Northeastern regions of Thailand.

Vessels were formed by hand with clay anvil or by wheel-throwing. Both techniques were used since prehistoric times, but wheel forming was the predominant method during the Dvāravatī period.

Decoration on carinated pots included plain, cord marking, polishing and red slipping. Petrographic analysis indicates that the firing of Dvāravatī pottery was similar to prehistoric methods -- open firing at low temperatures ranging from 400-550°C.

This study provides new data important to our understanding of products (carinated pots) and technology among widely distributed communities in Central, North and Northeast regions of Thailand, ranging from the Neolithic period to the Dvāravatī culture era.

Overall, the petrographic analysis data is interpreted to confirm observable regions of homogeneity based on patterns of raw material (clay body and tempers), production techniques, decoration, and firing temperature. These regional production traditions, however, exist within the broader presence of carinated earthenware pottery associated with the Dvāravatī culture.

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