Petrographic Analysis of the 6th Millennium B.C. Dalma Ceramics from Northwestern and Central Zagros

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(Received: 05/ 05/ 2012 ; Received in Revised form: 10/ 07/ 2012; Accepted: 22/ 09/ 2012)

Sixth millennium BC Dalma ceramics from the northwestern and central Zagros have previously been described as being impossible to distinguish using decorative style analysis in spite of the great distance between the two regions. In this study, petrographic (thin section) analysis and a small-scale electron microprobe project was carried out on the ceramics of the two regions, as well as a small sample of the preceding and following Hajji Firuz and Pisdeli period ceramics.

The petrographic analysis of microstructure reveals minute differences in manufacturing techniques. The results suggest that the Dalma ceramics were a distinct ceramic group with a great degree of variability, suggesting that they were made locally at the household level by individual potters and their preferences for ceramic manufacturing techniques. However, there was enough communication between the different regions to keep the stylistic and to a certain degree ceramic manufacturing technique uniform over this wide area. The analyses suggest that Dalma ceramics were spread by small groups of nomadic pastoralists who maintained a relationship with the agricultural Dalma villages. In this way, petrographic analysis of ceramics and geospatial analysis allow for a better understanding of the distribution of Dalma ceramics, and suggest the role of nomadic populations in their spread.

Keywords: *Ceramic petrography; Electron microprobe analysis; Dalma ceramics; Interaction; Nomadic migration*

Introduction

This study aims to better understand the nature of interaction in the Zagros Mountains of western Iran during the sixth millennium BC through the material science analyses of Dalma ceramics. The setting of the Zagros Mountains is uniquely challenging to the study of interaction due to the combination of mountainous terrain, settlements, nomadic movements, and historically known trade routes.

The Zagros Mountains is a well-watered area, characterized by a folded mountain chain with numerous valleys, each with its own microenvironment. These valleys are separated by a system of northwest-southeast trending mountain ridges and *wadis*, seasonal rivers with steep embankments, and frequent narrow gorges that cut through the mountain ridges and flow towards the Tigris (Fisher 1968; Hole 1987a; 1987b; Oberlander 1965; Smith 1986; van Zeist and Bottema 1982; Young Jr 1967; Zohary 1969).

This extreme landscape makes communications north-south between valleys very difficult, resulting in each valley historically having distinctive cultures and traditions. However, some natural routes through the mountains have been utilized by transhumant pastoralists and traders throughout the years. These routes, which often coincide with modern highways, greatly affected the development of the cultures, enabling contacts among different regions (Burney and Lang 1971; Dyson Jr. and Young Jr. 1960; Hole 1987b; Voigt and Dyson 1992; Young Jr. 1967; 1974).

The period relevant to this study starts in the end of the Neolithic period around 8500 BP when ceramics were introduced in the region. By this time there is evidence of a large network of contact as seen in Central Anatolian obsidian, turquoise from Afghanistan, and shells from the Persian Gulf that have been found at various site (Hole 1987a; 1987c). It is in this context, during the sixth millennium BC, when we suddenly see

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a widespread distribution of Dalma ceramics, the subject of this study, characterized by a distinctive decorative style.

First identified in the Ushnu-Solduz valley of northwestern Zagros at the type site of Dalma Tepe, Dalma ceramics have been found in large quantities in the Mahidasht and Kangavar valleys of the central Zagros approximately 400 kilometers south of the Ushnu-Solduz Valleys. While few sites with Dalma pottery are known between these two areas, some elements of Dalma pottery reach even into the Caucasus Mountains (fig. 1). Especially notable is Dalma Painted ware with a single bold geometric pattern executed in a matte red paint, covering the complete vessel surface from top to bottom, over a light background. Also, often found together are the Dalma Impressed wares, Dalma Red Slipped, and Dalma Plain wares (Dyson 1962; Hamlin 1975; Henrickson and Vitali 1987; Hole 1987a; Levine and Young Jr. 1984; Oates 1983; Solecki and Solecki 1973; Vandiver 1985; Voigt and Dyson 1992; Young and Levine 1974).

The small soundings excavated at most Dalma sites provide little information about the people and their lives. The type site, Dalma Tepe, measures approximately 50 meters in diameter and rises 4 meters above the current plain surface. In 1958 and 1959, Charles Burney placed test trenches and T. Cuyler Young, Jr. carried out further excavations in 1961 (Vandiver 1985). At this site, two free-standing structures separated by a large open courtyard were found. Some of the floors and walls of these structures showed evidence of plaster and there was also a bin-like structure attached to one of the structures. Due to the lack of adult burials, adults seem to have been interred outside of the settlement, whereas infants were buried under the structures. These findings suggest a sedentary, agricultural occupation during the sixth millennium BC (Dyson 1962; Hamlin 1975; Henrickson and Vitali 1987; Hole 1987a; 1987c; Levine and Young Jr. 1984; Solecki and Solecki 1973; Vandiver 1985; Voigt and Dyson 1992; Young and Levine 1974).

Due to the lack of large scale excavations, the ceramics are the most well-known aspect of the Dalma culture. Hamlin (1975) describes the Dalma ceramics as follows. Dalma ceramics are "handmade, most frequently of heavily chaff-tempered clay with small grit inclusions. While generally fired to a pink- to orange-buff colour, cores or cores' centres are often grey. The pottery tends to fracture unevenly, and is relatively friable. A few sherds are marked by a greenish tinge, and in some cases the paint became slightly vitrified in firing" (Hamlin 1975: 117).

Dalma ceramics can be separated into four groups based on surface treatment: 1) Dalma Painted, 2) Dalma Impressed, 3) Dalma Red Slipped, and 4) Dalma Plain wares. The *Dalma Painted* wares have a very distinctive geometric decoration in a matte red paint ranging from purple to brown shades over a light, buff background covering the complete vessel surfaces (Burney and Lang 1971; Hamlin 1975). In most cases, only the outer surface of the vessel is painted, although in open-mouthed vessels the interiors are occasionally painted as well. The interior surfaces of most Dalma Painted ware vessels are left untreated or covered with a thick red slip. Although all of the Dalma Painted wares found at Dalma Tepe were monochrome, there are examples of bichromes at sites in the Central Zagros (fig. 2) (Burney and Lang 1971; Hamlin 1975).

Dalma Impressed wares are restricted to a small variety of forms. Many of these vessels have a red slip or paint applied over the manipulated surface, while some have a blackened exterior, leading Hamlin (1975) to suggest a cooking function for these vessels. The technique of surface manipulation can vary from fingernail impressed designs to appliqué, suggesting there may be a need for change in the terminology from Dalma Impressed to Dalma Textured wares. However, for the sake of continuity with pre-existing literature, the term Dalma Impressed has been used in this paper. In most cases the surface manipulation covers most of the vessel surface. The interior of these impressed wares is left untreated or covered in a red slip/paint. There are no recorded instances where the interior of the vessel was similarly textured (fig. 3) (Hamlin 1975).

Dalma Red Slipped wares are covered completely on the exterior surface, and often also on the interior surface by a thick red slip, which can be almost plum colored. The slips tend to be quite thick

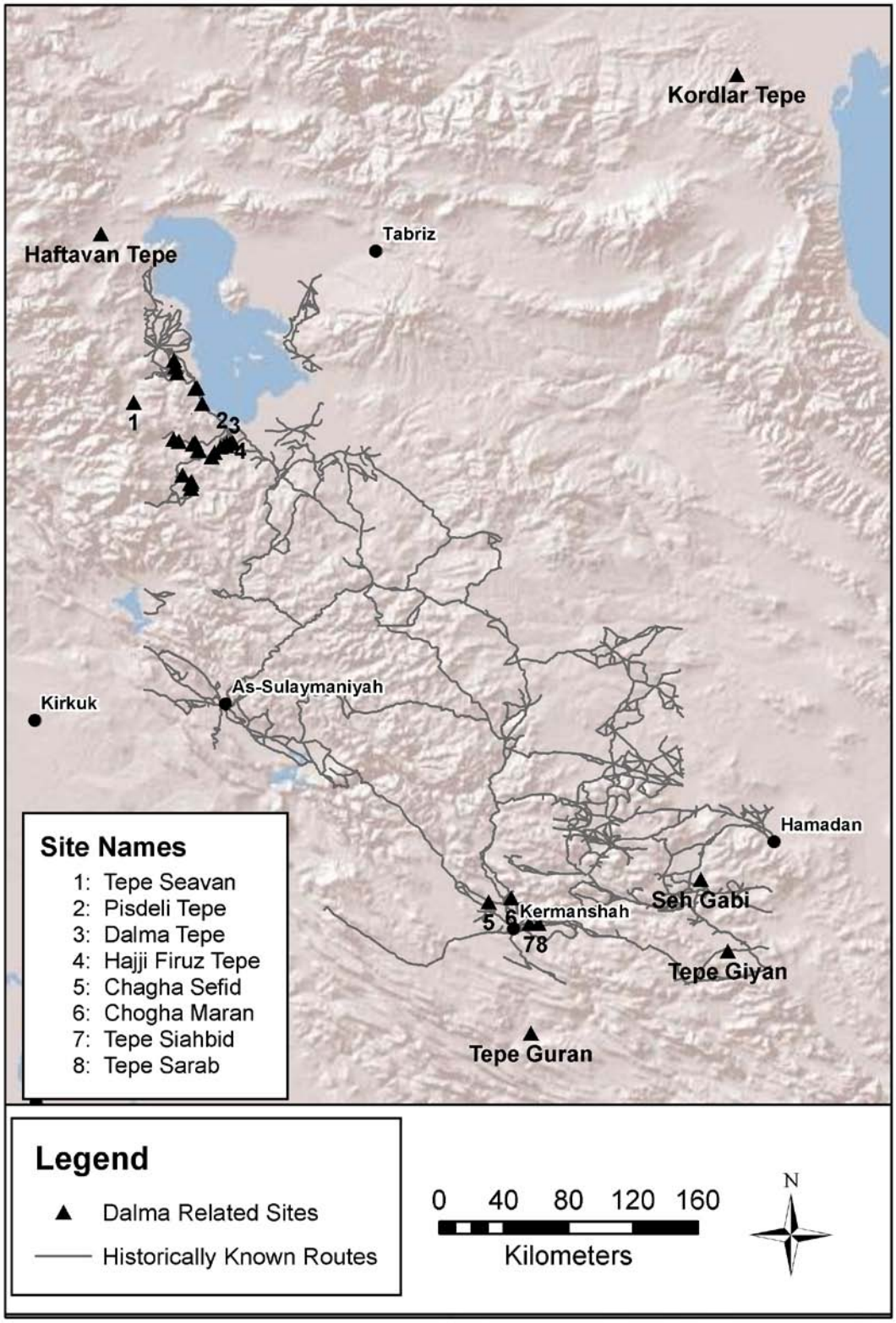


Fig.1: *Dalma Ceramic Distribution and Related Historically Known Routes.*

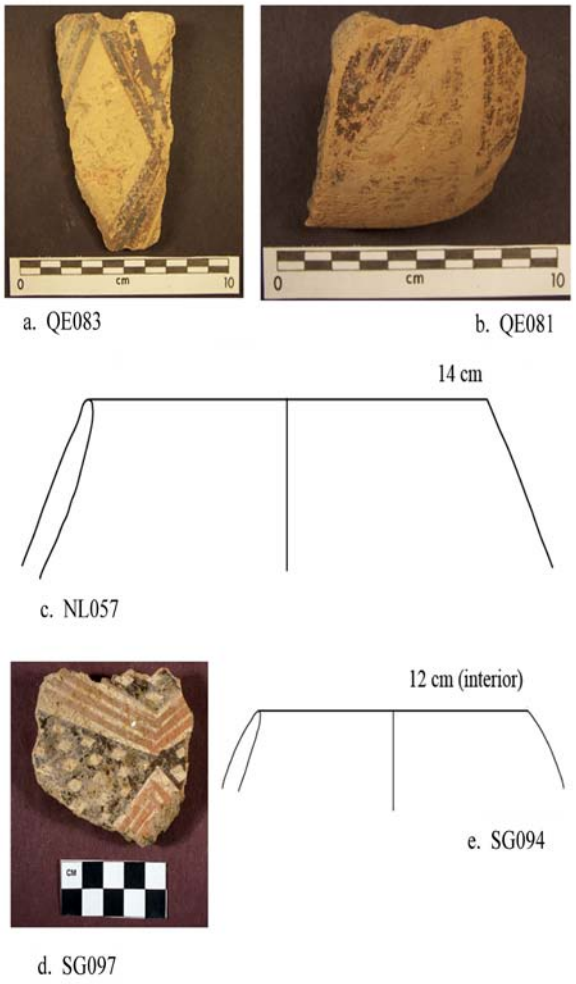


Fig. 2: *Dalma Painted Ceramics.* ***a-c****: Dalma Painted sherds;* ***d-e:*** *Dalma Bichrome Painted sherds.*

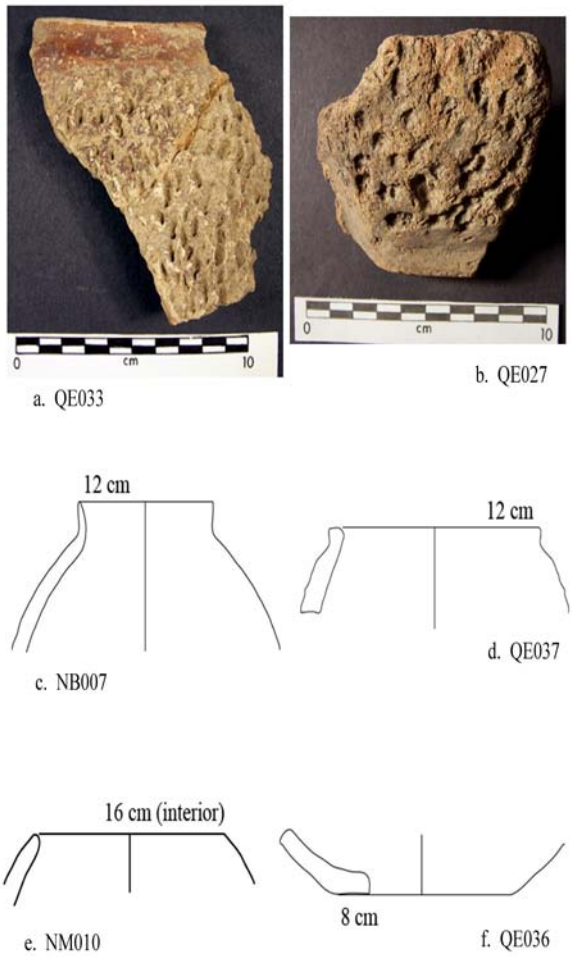


Fig. 3: *Dalma Surface Manipulated Ceramics.*

and often are "crackled and partially flaked away" (Hamlin 1975: 119). In a few cases, there are traces of burnishing, and in some instances, it seems that these vessels were double slipped; first with a white layer of slip followed by the red layer (fig. 4). A large variety of vessel forms were treated with this surface treatment. The paste has been described by Hamlin (1975) as being less friable than the Dalma Impressed wares.

Although there have been no excavations at Dalma sites in Iran since 1979, the term Dalma has continued to be used casually in recent years, even appearing in reports from the Caucasus region. By taking advantage of the pre-existing Dalma ceramic collections, we can gain a better understanding of the Dalma culture and help guide the direction of future research.

The research questions addressed here are: 1) what is meant by the term 'Dalma ceramics,' 2) what is the intra-valley and inter-valley variability of Dalma ceramics, 3) how can the existence or lack of such variability be explained, and 4) which of the various proposed hypotheses relating to the spread of Dalma ceramics is supported by the data?

Ceramic Analysis and Methodology

Most literature on the Dalma ceramics has focused on stylistic analysis of its distinctive surface decoration. Although the analysis of

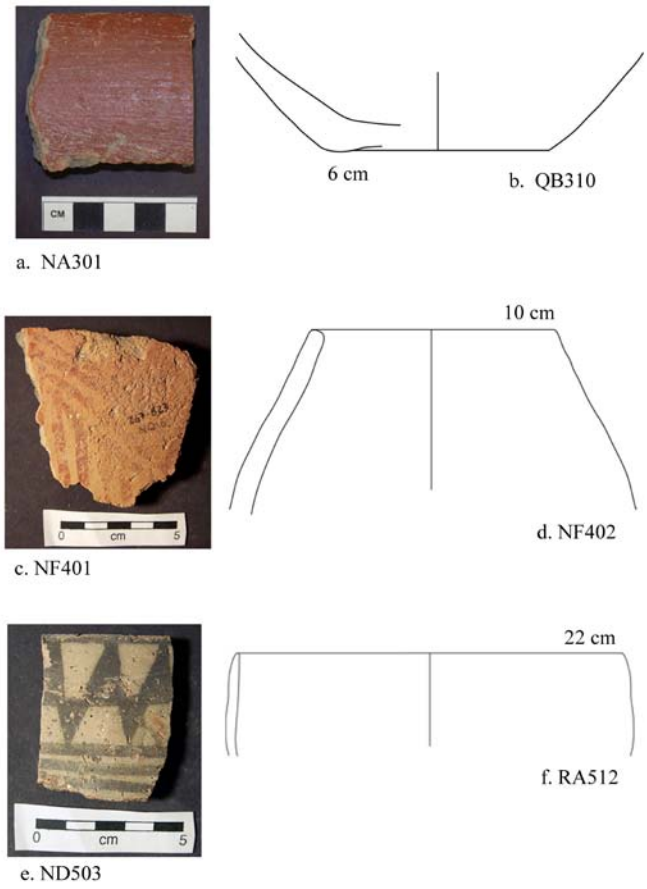


Fig. 4: *: Dalma Red-Slipped, Hajji Firuz Painted, and Pisdeli Painted Ceramics;* ***a-b****: Dalma Red Slipped sherds;* ***c-d:*** *Hajji Firuz Painted sherds;* ***e-f:*** *Pisdeli Painted sherds.*

decorative style has been used and long proven as a useful way to identify cultural groups and their interactions in numerous studies such as the classic study by Longacre (1970), it deals only with the visual aspects of the pottery.

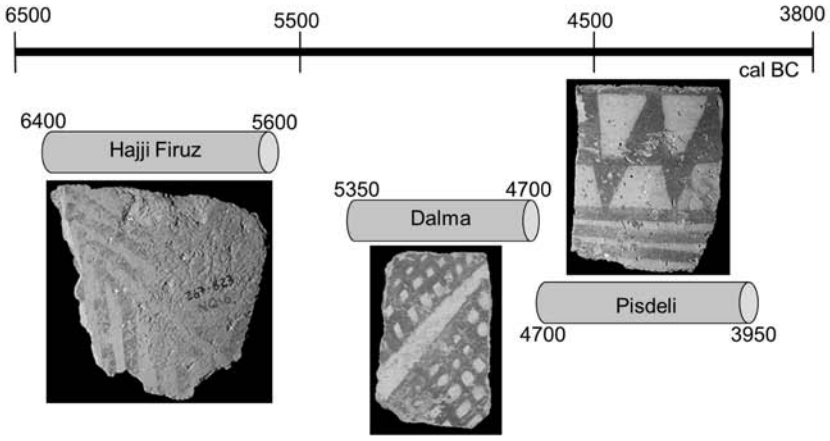
With the recent developments in archaeological theory and scientific techniques, ceramic assemblages that were once believed to have been studied thoroughly are now potential treasure troves of information for reanalysis. Instead of focusing exclusively on decorative style analysis, we are able to investigate a range of other aspects of ceramics, specifically technological style, through the use of material science approaches. By doing so, we can better address issues such as intra-regional and inter-regional interaction patterns and the nature of such interactions.

A few earlier studies were carried out using different archaeometric methods on Dalma ceramics, such as Hancock *et al*. (1989); Henrickson and Vitali (1987) and Vandiver (1985; 1987; 1988). However, these did not focus solely on Dalma ceramics and did not specifically address the issues of clarifying what Dalma ceramics are and understanding its spread.

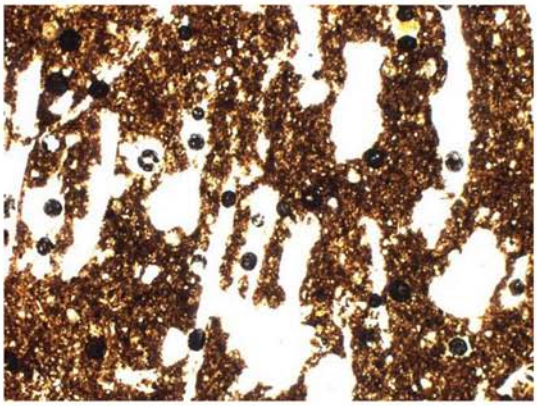
With this background (see Tonoike 2010 for a synthesis of pre-existing literature), a labor-intensive but low-cost method, ceramic petrographic (thin section) analysis, was selected to study Dalma ceramics in further detail. 149 sherds were selected from collections at two North American institutions: 1) a collection at Yale University (New Haven, Connecticut) from the Solduz basin, including the small valleys of Naqadeh, Qaleh Paswah, and Rezaiyeh valleys, in the northwestern Zagros that was collected by Frank Hole in 1961 and 2) a collection at the Royal Ontario Museum (Toronto, Canada) from central Zagros, from excavations at Seh Gabi, Tepe Siahbid, and Godin Tepe, collected by T. Cuyler Young, Jr. through excavations. Most samples (n=131) are Dalma period sherds, but a few Hajji Firuz (n=4) and Pisdeli (n=14) period sherds from the previous and following phases in northwestern Zagros were also analyzed for comparative purposes (fig. 4 and fig. 5a).

Ceramic petrography is a method of determining the mineral components and the microstructure of a sample. Ceramics are cut into 30 micron sections, placed on a glass slide and examined under a polarizing microscope. Put simply, this microscope passes a beam of light through the ceramic thin section and the minerals included in the ceramic are identified using their unique optical properties (see fig. 5b-e for examples). An Olympus BX-60 microscope set up with transmitted light available at Yale University Archaeology Laboratories was used for this analysis.

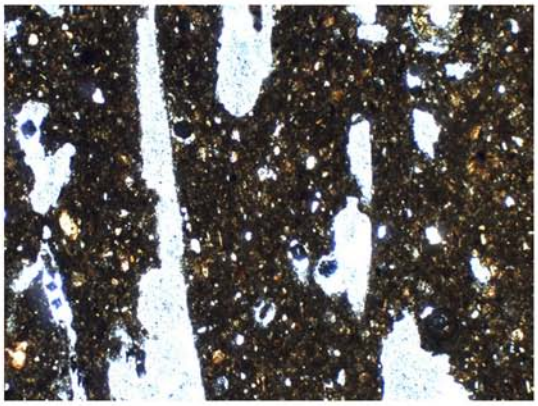
Petrographic analyses' usefulness in the analysis of archaeological materials has long been established (e.g. Peacock 1967; Shepard 1936; 1985; Thuesen *et al.* 1989). However, as Whitbread (1989) points out, much work has focused on the analysis of aplastic inclusions, often for provenance studies (e.g. Ferring and Perttula 1987; Katsarou *et al.* 2002; Lombard



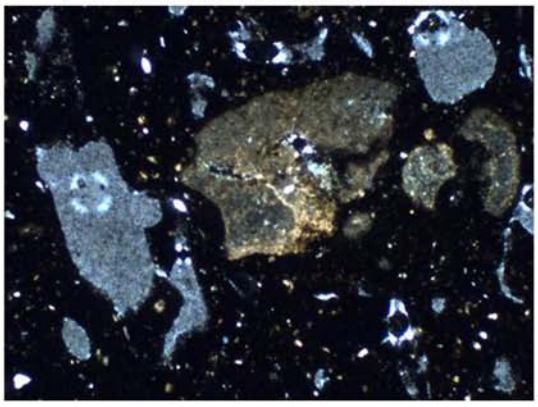
a. Cultural Timeline of Northwestern Zagros
(Recalibrated based on original C14 dates from Voigt and Dyson 1992: 128-138)



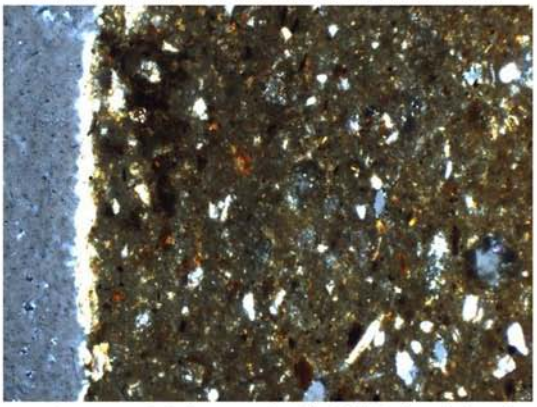
b. Petrographic image of a Dalma Painted sherd
Note aligned channel voids.
(NB055, Plane polarized, x04 magnification)



c. Petrographic image of a Dalma Impressed sherd
Note evidence of chaff temper, moderate voids, and few inclusions. (NM010, Cross polarized, x04 mag.)



d. Petrographic image of a Hajji Firuz Painted sherd
Note evidence of large inclusions and voids.
(NF401, Cross polarized, x04 mag.)



e. Petrographic image of a Pisdeli Painted sherd
Note evidence of few inclusions and voids.
(RA512, Cross polarized, x10 mag.)

Fig. 5: *Cultural Timeline and Selected Petrographic Images.* ***a****: Cultural Timeline of Northwestern Zagros.* ***b:*** *Petrographic image of a Dalma Painted sherd. Note aligned channel voids (NB055, Plane polarized, x04 magnification).* ***c:*** *Petrographic image of a Dalma Impressed sherd. Note evidence of chaff temper, moderate voids, and few inclusions (NM010, Cross polarized, x04 mag).* ***d:****Petrographic image of a Hajji Firuz Painted sherd. Note evidence of large inclusions and voids (NF401, Cross polarized, x04 mag).* ***e:*** *Petrographic image of a Pisdeli Painted sherd. Note evidence of few inclusions and voids. (RA512, Cross polarized, x10 mag).*

1987). As a result, many researchers in the Near East have dismissed all archaeometric methods as being unsuitable for studying Near Eastern ceramics due to the similarity in the geology over a wide area and difficulty of identifying provenience, as discussed by Delougaz (1952: 31). However, as Vandiver (1985) implies, if used carefully with a understanding of what to focus on, archaeometric techniques can be useful for better understanding the pottery of the Near East. For example, in the case of petrographic analysis, structural and microstructural analyses are the key in areas with homogeneous geology. Through the systematic use of terminology from sedimentary petrography and soil micromorphology, emphasized for ceramic petrographic analysis by Whitbread (1989; 1995), it has become possible to comprehensively describe the features of the various ceramic fabrics and consider how the clay and inclusions were manipulated. This in turn, allows us "to interpret technological aspects of ancient pottery" (Tsolakidou *et al*. 2002: 19), such as the manufacturing process (e.g. Whitbread *et al.* 2002). This ability to analyze the structure and microstructure of the fabric is a clear advantage over chemical characterization techniques (e.g. Druc 1998; Schubert 1986; Stoltman 1989; 1991; Stoltman *et al.* 2005; Whitbread 1995; Williams 1983), as the microstructures reflect each step taken when manipulating the raw materials. For example, the technique used to form the vessel or how well the clay was kneaded can be inferred from the alignment and size of voids. Therefore, the focus on microstructure allows archaeologists to understand technological style and avoid potential problems such as the effect of temper (e.g. Arnold *et al.* 1978; Bishop and Neff 1989; Neff *et al.* 1988; 1989; Olin and Sayre 1979; Rands and Bishop 1980; Rice 1987), secondary calcites and other contaminants that have often affected chemical characterization studies (e.g. Buxeda i Garrigos 1999; Buxeda i Garrigos *et al.* 2001; Cau Ontiveros *et al.* 2002; Olin *et al.* 1978; Olin and Sayre 1979).

However, when used in combination with petrographic analysis, chemical characterization studies are useful in providing further insight, such as the identification of minerals difficult to identify under the petrographic microscope. Due to its ability to provide high magnification images from secondary and back-scattered electrons and the resulting ability to pinpoint the area of analysis, the JEOL JXA-8600 'Superprobe' Electron Microprobe with four wavelength-dispersive spectrometers and an EDAX light-element capable energy-dispersive spectrometer was used under the guidance of Dr. James Eckert, Jr. (Department of Geology and Geophysics, Yale University) on a total of 6 samples. Samples were polished, coated with carbon, and placed in the electron microprobe, whose scanning probe deflects an electromagnetic beam across the surface of a sample. The electron beams hit the sample and produce x-rays that can be measured. The wavelengths and energies of the x-rays are characteristic to each chemical element, therefore enabling us to analyze what element is present in the targeted area. In addition, by measuring the intensity of the x-rays and comparing them to that of a pure standard, it is possible to measure the amount of each chemical element as well (Stewart 1973).

Results

The detailed results of this study are available in Tonoike (2010). Here, rather than going into details about the data itself, the focus will be on what the data informs us about the question of Dalma ceramics.

Based on the results of the petrographic and electron microprobe analyses, the following can be said of the three ceramic traditions: Hajji Firuz, Dalma, and Pisdeli. The alignment of voids and elongated inclusions parallel to the vessel walls in the ceramics from all three time periods, support Vandiver's observations that they were made by the sequential slab construction method, most likely using montmorillonite clays (Vandiver 1985, 1987, 1988). The potters of all three traditions intentionally added temper to their paste, as suggested by the distribution pattern of the inclusion sizes (Whitbread 1989). Different amounts of channel voids found in most samples also indicate that chaff was used as a common temper. The chaff was added directly and not in the form of animal dung, as indicated by the ends that are cut and not frayed. This common use of chaff as temper contradicts an earlier study by Vandiver (1985), who noted that chaff temper was not used during the Dalma period at Seh Gabi

Mound B and at Dalma Tepe. The use of chaff as temper was important, since it would have made it possible to construct vessels quickly using the sequential slab construction by counteracting the problems of excessive dry shrinkage and lack of wet strength, typical for the calcareous fine-particled montmorillonite clays, suggested as having been used by Vandiver (Rice 1987; Skibo *et al.* 1989; Vandiver 1985; 1987; 1988).

Although the potters of the three traditions shared these ceramic manufacturing techniques, they also showed differences in other ways. For example, Hajji Firuz potters from northwestern Zagros in the seventh millennium BC were not very careful in their treatment of the clay, as indicated by the many large inclusions of rock fragments and feldspars in the paste. There are a moderate amount of voids, which together with the numerous large inclusions, seem to suggest that the paste was not worked thoroughly (Rye 1981; Vandiver 1988). As Vandiver (1988) also observed, Hajji Firuz ceramics seem to have been fired for relatively a short time in low temperatures, as evidenced by the black core with diffuse margins, caused by the incomplete oxidation of carbonaceous (organic) matter found in the clay. These observations are consistent with non-kiln (open) firing, which has a very short duration of maximum temperature (Rice 1987). The resulting pots were most likely removed from the open firing area and cooled in the air, as there is no evidence of any surface blackening, which would have resulted if pots had cooled in the firing area (Rye 1981).

Pisdeli potters, also of northwestern Zagros, dating to the latter part of the fifth millennium BC, seem to have had a much more uniform, deliberate manufacturing technique. They have few inclusions in their clay paste, suggesting that they took care in cleaning their clay before manufacture. Most of the Pisdeli ceramics are even-colored throughout the cross section and do not show any black cores, suggesting longer, complete firing until all of the carbonaceous matter in the clay had a chance to oxidize, or the use of clay with no organic matter. However, as there is abundant evidence of chaff temper in the observed Pisdeli ceramics, very likely they were fired in some type of kiln, since open fired ceramics tend to show a relatively high frequency of blackening of the core. The samples that do show a slight gray core have a diffused margin, suggesting a slow cooling process, which would be consistent with kiln firing. As the earliest evidence of kilns in the Near East has been found dating to the seventh millennium BC at Hassuna and Samarra sites such as Yarim Tepe I and Tell es-Sawwan, it is feasible to consider the use of kilns for the Pisdeli period (Merpert and Munchaev 1993; Oates and Oates 1976; Streily 2000; Vandiver 1988).

Although Vandiver (1987) mentions a switch to grit-tempered ceramics eventually, which resulted in the utilization of a different manufacturing technique involving the aging of montmorillonite clays, this change must have happened after the Pisdeli period, since the amount of chaff inclusions, as evidenced by the percentage of channel voids, do not differ from that of Hajji Firuz ceramics.

Dalma period ceramics from the late sixth millennium BC are much more variable. There are slight patterns that can be seen as differences between Dalma ceramics from different regions, sites, and different wares. In general, they seem to be made quickly, as they have abundant voids, numerous channel voids, and seem to have been fairly low fired for short periods of time. However, in other aspects they are very variable making them difficult to describe as a coherent group, which is interesting considering how similar they look based on the external decorative design. Although different patterns emerge, the analysis of quantitative attributes of the Dalma ceramics suggest that function was the most important factor that differentiated the Dalma ceramics. This was followed by inter-site difference. Although Vandiver (1985; 1988) found clear regional difference in the use of different types of joins, regional difference was not clear from the manufacturing techniques or inclusions visible in the petrographic analysis. This great variability suggests that although the Dalma potters had a mental template for how a Dalma ceramics should look on the outside, the actual manufacturing techniques were probably up to the individual potters. These individual potters used whatever temper that was most suitable to the clay source they had access to, and they formed the Dalma ceramics according to local customs.

Distribution Mechanism of Dalma Ceramics

Although this analysis was informative regarding the characteristics of the Hajji Firuz, Dalma, and Pisdeli pottery, the larger issue is the means by which Dalma ceramics spread over such a wide area. Traditional explanations have considered trade and exchange, the movement of material goods and information, emulation of status or technology, and the movement of people (colonization, migration, nomadic movement, etc.). Let us consider each of these possibilities in light of the information provided by the above analyses.

First thing to consider is whether the ceramics themselves were moving between the various regions as trade items or as containers for the trade of its contents, as was suggested for Halaf pottery by Galbraith and Roaf (2001). This is a very unlikely possibility, especially for the Dalma Painted wares. If the ceramics themselves were moving between the various Dalma-related areas, having been manufactured in a few select regions and traded to the other areas, the petrographic analysis should show homogeneity in the whole Dalma assemblage or at least coherent groupings based on the trade relationships. However, the results of the petrographic analysis show that although all of the Dalma ceramics show a certain degree of homogeneity when compared to the ceramics of the previous and following time periods, Hajji Firuz and Pisdeli, making them a cohesive group, there is still a great degree of variation. This variation is not only a result of wares, regions, and sites, but also continues to persist even when a single ware within a single site is examined. This also eliminates the scenario suggested for the 'Ubaid period where potters may have traveled between the various sites using local materials to manufacture stylistically similar pottery (Berman 1994). This conclusion is reinforced by the observations that there is variation in the way the materials were manipulated had less to do with the need to make pottery using different local materials, and more as the result of unconscious learned behavior of how to manufacture pottery.

How about the idea of emulation? Could the people in one region (for example, the central Zagros) start making Dalma ceramics as copies of pots from another region (for example, northwestern Zagros)? Emulation might be for the perceived status of Dalma vessels or simply for the technology. Since as discussed above, the Dalma ceramics were not all made in the same way, the technology of making these ceramics was not communicated from one region to another. What distinguishes Dalma ceramics as a distinct group is its decorative style, the idea of how a ceramic should be decorated. It also seems unlikely that the decorative style was adopted for status, considering the lack of clear evidence for status differentiation at Dalma sites. A more likely explanation for the spread of Dalma pottery is through the actual movement of people, whether through colonization, migration, or nomadism. Considering the strong similarity of the decorative style over a long period of time without drifting apart from each other, a one-time migration would not provide the enduring connection that would have been necessary between the two regions to sustain the idea of how a ceramic should be decorated.

Nomadism, on the other hand, has been a historically important aspect of life in the Dalma region. For example, Stein (1940) describes semi-nomadic families of the Turkic Shahsavand tribe using the area around Naqadeh near the ancient mounds as their winter camp grounds, while they summered "in the hills east of the lake" (Stein 1940: 386). de Planhol (1966) also mentions the importance of pastoral nomadism in the high valleys of Azerbaijan (de Planhol 1966: 303). Henrickson (1985: 16-24) has a useful summary of ethnographies of nomads in the Zagros Mountains.

It has been often assumed "that nomads are light travelers and therefore leave little archaeological imprint in the way of recoverable material or modifications to their environment … (ever) since Childe (1936) pointed out the futility of searching for archaeological traces of nomads" (Cribb 1991: 65; Childe 1936: 70). It is true that clear archaeological traces have very rarely found, except for a few possible nomadic camping sites such as Tepe Tula'i and Tepe Sarab (see Hole 1974 for more on Tepe Tula'i and McDonald 1979 on Tepe Sarab). However, based on ethnography, it seems that this lack of nomad sites is a matter of knowing where and what to look for. Ethnography has shown that

"while there may be a bias towards lighter, more portable materials, the range of objects that may be observed in a nomad camp is comparable to that observable in Near Eastern villages" (Cribb 1991: 69; See Cribb 1991: 70-73 for more details. See also de Schauensee 1968; Hole 1978; 1980; Watson 1966; 1979). In addition, under some forms of pastoralism, the nomadic people had seasonal villages with typical village artifacts. Furthermore, the close relationship between nomadic peoples and settled communities is clearly seen in several examples in the ethnographic record (cf. Barth 1961; 1962; Cole 1975; Coon 1976 (1951), Khazanov 1984; Kramer 1977; Lees and Bates 1974; Levy 1983) and also documented as far back as 3,000 B.C. Such relationships are often based on kinship ties and/or tribal membership. (Henrickson 1985).

Therefore, this paper proposes that it was the movement of nomadic peoples, in the form of pastoralism that acted as the transfer agent for the Dalma ceramic style. It is hypothesized that groups of nomads were related to the settled people living at the village sites in both the North and Central Zagros. The transmission of the Dalma ceramic style may have occurred during the annual migrations between the winter pastures of the lowlands and the summer pastures of the highlands, as they used a lowland route at the base of the mountains, connected to the highlands at the few natural routes into the mountains. Such routes exist between the Ushnu-Solduz valley and the lowlands, and between the Mahidahst-Kangavar valleys. In such a scenario, the villagers would have made the pottery using their own local manufacturing techniques, and the related nomadic groups continued the flow of ideas to keep the decorative style almost identical throughout the years as they moved back and forth. In ethnography, for example, Cribb (1991) describes the following situation.

The traveller in the more isolated parts of the Near East should not be surprised to see groups of migrating nomads passing through villages whose inhabitants dress in the same manner as the nomads, speak the same dialect, employ the same range of household utensils, possess the same species of domestic animals, and, in some cases, claim the same tribal affiliation. Differences there certainly are, but these are often ideological, organizational and economic rather than 'cultural' (Cribb 1991: 65).

However, there are a few other factors to consider that are still not explained by this scenario. First, if seasonal migration was for survival of the people and their flocks, it does not seem to have been necessary to travel such long distances between northwestern and central Zagros (Voigt 1977; see also Stein 1940 on the Sahsavan tribe). It is true that some tribes such as the Qashqai, the Basseri, and the Bakhtiari, travel as much as approximately 970 kilometers between their winter and summer pastures (Barth 1961, Cooper 1925, Henrickson 1985, Ullens de Schooten 1956). These long migrations, between highlands and lowlands are facilitated by pack animals. In the Urmia region, a much shorter highland to lowland migration from the Urmia region, with a maximum distance of approximately 150km, would be suitable (see Tonoike 2010 for details). However, if the complete distribution area of the Dalma ceramics is considered, there is a much larger distance between northwestern and central Zagros, which is not a lowland-highland trek; rather it is all highland with few natural routes. Therefore, although the proposed scenario explains the core areas, it does not explain the complete distribution areas of the Dalma ceramics.

Another issue is why in the northwestern Zagros, there are no other ceramic traditions associated with the Dalma ceramics, but in some sites in the central Zagros, there are co-existing ceramic traditions in different combinations. Even if the answer is that the northwestern Zagros was the heartland of the Dalma ceramics, it doesn't explain the various co-existing traditions in the central Zagros, or the existence of different 'Dalma' types in the central Zagros, such as the Dalma 'Ubaid ware and the Dalma Bichrome ware.

Even more puzzling, the various Dalma wares have a different pattern of distribution. The Dalma Painted wares are much more restricted in distribution compared to the Dalma Impressed wares that have reportedly been found from Central Zagros all the way into the Caucasus Mountains. For the Dalma Impressed ware, nomadic migration is not a sufficient answer for such a widespread

distribution. Perhaps the Dalma Impressed wares, most of which are quite coarse, were used to carry a particular product suitable for trade, as suggested earlier for the Halaf ceramics by Galbraith and Roaf (2001). There are ethnographic observations of nomads carrying out trade with others as discussed above. Another possibility is that these Dalma Impressed wares had a very specific function, which was emulated by other unrelated peoples and some of the Dalma Impressed and Dalma-related Impressed wares mentioned in the literature have little to do with the rest of what has loosely been defined as the Dalma "culture". However, without studying the Dalma Impressed wares in more detail together with other archaeological evidence from each of the sites, this is all simply speculation.

If nomadic movement was the mechanism for the distribution of the ceramics, Dalma-related sites should follow migration routes. The routes of nomadic movement are greatly confined by the topography of the area, as well as being affected by other factors such as suitability of the animals, tribal affiliations, relationships with agriculturalists, and climate (Barth 1961; 1962; Cooper 1925; Gibson 1981a; 1981b; Henrickson 1983; 1985; Johnson 1969; Khazanov 1984; Salzman 1972; Spooner 1973; Stein 1940).

Originally, GIS modeling was considered for comparing the actual Dalma site distributions and probable nomadic routes projected by considering the various factors that would affect an ideal migration route. However, as more research was carried out on ethnographic records regarding migration and factors affecting it and more discussions were carried out with GIS specialists about the possible methods of weighing these various factors, it was quickly realized that it was basically impossible to consider all of the various factors and to weigh them in a realistic manner. Various methods were considered, but in the end it was decided that it was better to follow the known routes marked in the British Army Quarter Inch Series Maps from the early 1940s. Since these maps were produced in the early periods of industrialization, only a few of the roads had been paved or modified, and most of the roads are marked as paths and tracks. Most likely, these have been in use for a long time, especially considering that there have been no major changes in topography. Therefore, the paths and tracks in the relevant regions were digitized from the British Army maps and compared with the known Dalma sites and sites with Dalma related ceramics using the ArcGIS program. A general picture of the results is shown in fig 1. As a result, it is clear that most of the Dalma sites are situated right by the probable routes and the few exceptions are located in areas where multiple routes are accessible within a short distance (see fig. 6 for an example).

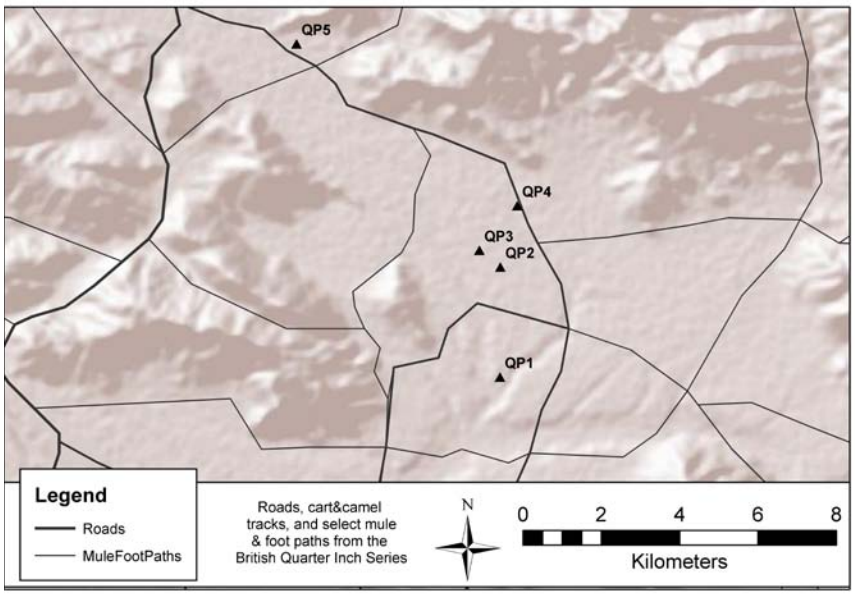


Fig. 6: *Example of Dalma Sites Located in Proximity to Multiple Routes.*

This site distribution pattern in relationship to the probable migration routes support the suggested interpretation that a village-based form of seasonal migration accounted for the distribution of the Dalma ceramics, especially for the northwestern and central Zagros sites with Dalma Painted wares.

Conclusion

The petrographic and electron microprobe analyses of Dalma ceramics have allowed us to better understand this sixth millennium ceramic tradition, especially in comparison with the preceding and following ceramic traditions, Hajji Firuz and Pisdeli, in the northwestern Zagros region. The basic manufacturing technique was similar for all three ceramic traditions, built using the sequential slab construction with montmorillonite clays tempered with cut chaff and small minerals. However, when both the qualitative and quantitative data are studied, the three ceramic traditions show a clear difference in the microstructure, signaling that these ceramics were manufactured in different ways. Aspects such as firing temperatures and duration, quantities of preferred inclusions, and the degree to which the clay was prepared and manipulated all differed and were significantly more consistent within each ceramic tradition than between ceramic traditions. Even when the central Zagros Dalma wares were included in the analysis, they shared more similarities with the northwestern Zagros wares, than the three northwestern Zagros ceramic traditions shared with each other. This suggests that each of these ceramic traditions, identified on stylistic grounds, were truly ceramic traditions that shared a manufacturing technique, not just a stylistic technique.

However, when the Dalma wares were observed more closely it was clear that they were very variable. This variability was not completely random. The most important attribute that distinguished the Dalma wares from each other was the character of the ware itself. For example, the Dalma Painted wares were clearly different from the Dalma Impressed wares in the various attributes of the petrographic analysis, indicating that different choices had been made during their manufacturing process. This difference was more significant than the difference between regions or sites, even when focused on a single ware. This is understood to be a result of function. The various Dalma wares had clearly very different functions such as cooking, storage, and serving, as could be understood from even the macroscopic observations, and ceramic manufacture, especially concerning the inclusions and voids varied accordingly. However, when this variability was taken out of the equation by focusing on a single ware (for example the Dalma Painted ware), other factors that affected differences and similarities became clear: Dalma Painted wares from different sites showed clear differences. There were also suggestions of possible regional differences. However, overall, even when focused on a single ware at a single site, Dalma ceramics were characterized by variability. This may have been a result of individual potters using their own ceramic manufacturing technique within their household production. The Dalma potters had an idea of what a pot should look like, but used the material that was available to them and manipulated their clay in the manner that they were accustomed to.

The main goal of this project was an attempt to better understand the pattern and mechanism of the distribution of Dalma ceramics. Found spread over hundreds of kilometers through difficult terrain at such an early time period, the distribution of Dalma ceramics is an interesting question. Comparing the location of known Dalma sites in ArcGIS, it became clear that they were all located along paths or in convenient areas to access paths. These routes were located using old British Army maps from the 1940s, including even foot paths in most regions. Through a consideration of geography, ethnography, and location of sites, as well as the consideration of archaeological markers for each of the possible scenarios for the spread of Dalma ceramics, it is suggested that a village-based form of seasonal migration was the most likely scenario, where small groups of nomads moved between villages where they maintained relationships.

Although this study has improved our understanding of Dalma ceramics, there is a need for future studies. The different distribution patterns of the various Dalma wares are an interesting issue

that could not be answered within the scope of this study. The relationship of the various Dalma Painted subwares to non-Dalma traditions at a few central Zagros sites are also another issue. In addition, the so-called Dalma-related wares from the Caucasus Mountains need to be further investigated, as well as the question of the direction of the spread of the Dalma Red Slipped wares. All of these issues can be studied through the use of archaeometric techniques of ceramic analysis employed in this study, with a careful selection of samples geared specifically towards each of these questions.

Acknowledgments

I would like to thank Dr. Frank Hole for his unfailing support in carrying out this research and writing this article. In addition, I would like to thank Drs. William Honeychurch, Elizabeth (deceased) and Robert Henrickson, Peter Day, Mary Voigt and her trusty team at the University of Pennsylvania Museum, Michael Gregg, Bill Pratt and all of the others at the Royal Ontario Museum, Laurent Bonneau, Maria Masucci, Fereydoun Biglari, Adam Smith, Giulio Palumbi, Thomas Tartaron, James Eckert and Mr. Abraham Parrish, for their generous assistance and advice on various aspects of this research. Finally, I would like to thank Yale University Department of Anthropology for their support and access to resources. Any inaccuracies are the sole responsibility of the author.

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