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# PETROGRAPHIC AND STABLE ISOTOPE ANALYSES OF LATE CLASSIC ULÚA MARBLE VASES AND POTENTIAL SOURCES*

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*Ulúa marble vases from the Ulúa Valley of northwestern Honduras are a hallmark luxury good from Late Classic (AD 600–900) Mesoamerica. Archaeological and stylistic data point to centralized production at one site, Travesía. This paper analyses stable isotope and petrographic data from the vases and three potential procurement areas. The results indicate that the vases were produced from one primary source with one, potentially two, secondary sources. Procurement patterns most probably corresponded to contemporary communication routes. The results clearly indicate that a multi-method approach is necessary for sourcing marble from Honduras.*

*KEYWORDS:* ULÚA, HONDURAS, MAYA, MARBLE VASE, PETROGRAPHIC, STABLE ISOTOPES, LATE CLASSIC, TRAVESÍA

## INTRODUCTION

This paper presents results from a study of Late Classic marble vases (Table 1 and Figs 1 and 2) and potential sources from the Ulúa Valley of northwestern Honduras (Figs 3 and 4). The goal is to explore implications of increasing social complexity during the Classic period archaeometrically, with a primary focus on the sources used to produce luxury marble vases. Previous studies of these marble vases have been descriptive, focusing on their stylistic qualities (G. B. Gordon 1898, 1920, 1921; Stone 1938; Schaffer 1992). Over the years, the predominance of these vases in the Ulúa Valley has been taken as evidence for a local tradition, similar to the production of fancy Ulúa polychrome ceramics; the circulation of the vases outside of the valley has been taken to indicate long-distance ties. Through an analysis using stable isotope and petrographic analyses of potential marble sources, this study provides additional evidence for local, centralized manufacture.

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Table 1 *Regional chronology*

| *Time* | *Period* | *Lower Ulúa Valley phase* |
|---|---|---|
| 1600 | Colonial | Colonial |
| 1500 | | |
| 1400 | | |
| 1300 | Late Post Classic | |
| 1200 | | |
| 1100 | Early Post Classic | Botija |
| 1000 | | |
| 900 | Terminal Classic | Santiago |
| 800 | Late Classic | Ulúa |
| 700 | | |
| 600 | | |
| 500 | Early Classic | |
| 400 | | Chamelecón |
| 300 | Late Formative | |
| 200 | | |
| AD 100 | | |
| 100 BC | | |
| 200 | | |

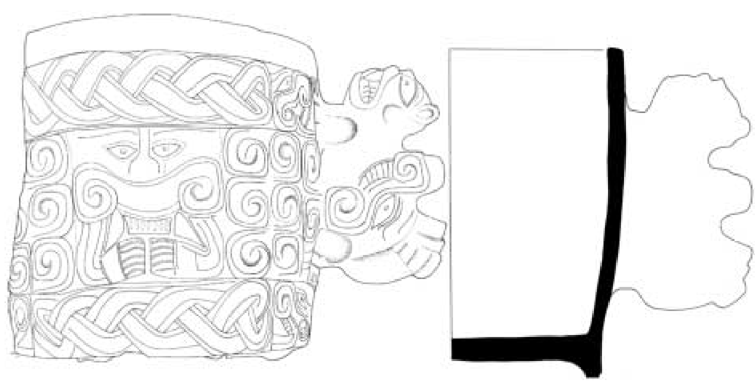

Figure 1 *An Ulúa marble vase fragment from the Humuya River (drawn by C. Luke; Museo Etnografico Castello D'Albertis, Genoa, Italy).*

This research program is the first in the study of white stone vases and other white stone artefacts from ancient Mesoamerica (Luke and Tykot 2001, 2002; Luke 2002; Luke *et al*. 2002). Building on studies of Pre-Columbian jade (Lange 1993), obsidian (Clark 1987; Braswell 1992) and ceramics (Beaudry 1984; Reents-Budet 1985, 1994, 1998; Reents-Budet *et al*. 1994, 2000; Foias and Bishop 1997), we document patterns in the production of marble vases using data from both potential sources and artefacts. While workshops for stone vase production are not known from the Ulúa Valley, the distributional data have led researchers over the years to argue that production of this specific white stone vase style must have been centred in

Figure 2 *An Ulúa marble vase from Santa Ana (courtesy of the Middle American Research Institute, Tulane University).*

the Ulúa region (G. B. Gordon 1920, 1921; Stone 1938; Kidder 1947, 36–7; Hirth 1988, 319; Schaffer 1992; Hirth and Hirth 1993, 188). Distributional and stylistic results point to Travesía as the artisan hub (Luke 2002), and the results presented here confirm this interpretation.

## METHODS

This research programme incorporates stable isotope and petrographic analyses to fingerprint marble vases and potential marble sources. Based on research conducted in the Mediterranean region, where marble was a key resource for artefacts and architecture in antiquity, stable isotope analysis of carbon 13 and oxygen 18 is an effective method for attributing marble artefacts to potential sources (Herz 1990, 1992; van der Merwe *et al.* 1995; Tykot *et al.* 1999; van der Merwe *et al.* 1999; Lazzarini and Antonelli 2003). In addition to stable isotope analyses, macroscopic and petrographic methods are good secondary approaches to augment stable isotope results (Lapuente 1995; Lazzarini *et al.* 1995; Lazzarini and Antonelli 2003). Petrographic research allows for a more fine-tuned study of grain size, crystal structure and fossil evidence—all factors that may be unique to each source. Furthermore, petrographic analyses allow for a more detailed understanding of local geology.

The first phase of this research programme concentrated on stable isotope and macroscopic methods for attributing vases to marble sources. Variation in hand samples from a number of the sources proved to be too great to rely on macroscopic identification for narrowing potential sources used in antiquity. Furthermore, the extent of modern quarry activity has depleted much of the marble, and, thus, the feasibility of using hand samples from sources is not relevant in most cases. With these obstacles in front of us, we turned to stable isotope analyses.[1] To

[1] Towards the end of this project, researchers began using inductively coupled plasma mass spectrometry (ICP–MS) in marble studies with good success. ICP–MS is able to isolate specific elements with greater success than neutron activation analysis (NAA), the preferred method for elemental analysis in the early 1990s. Preliminary NAA results from Honduran sources were inconclusive and, thus, the approach was abandoned (Luke and Tykot 2002, fn. 4), and the work concentrated on stable isotopes. Our future work will concentrate on elemental analysis using LA–ICP–MS.

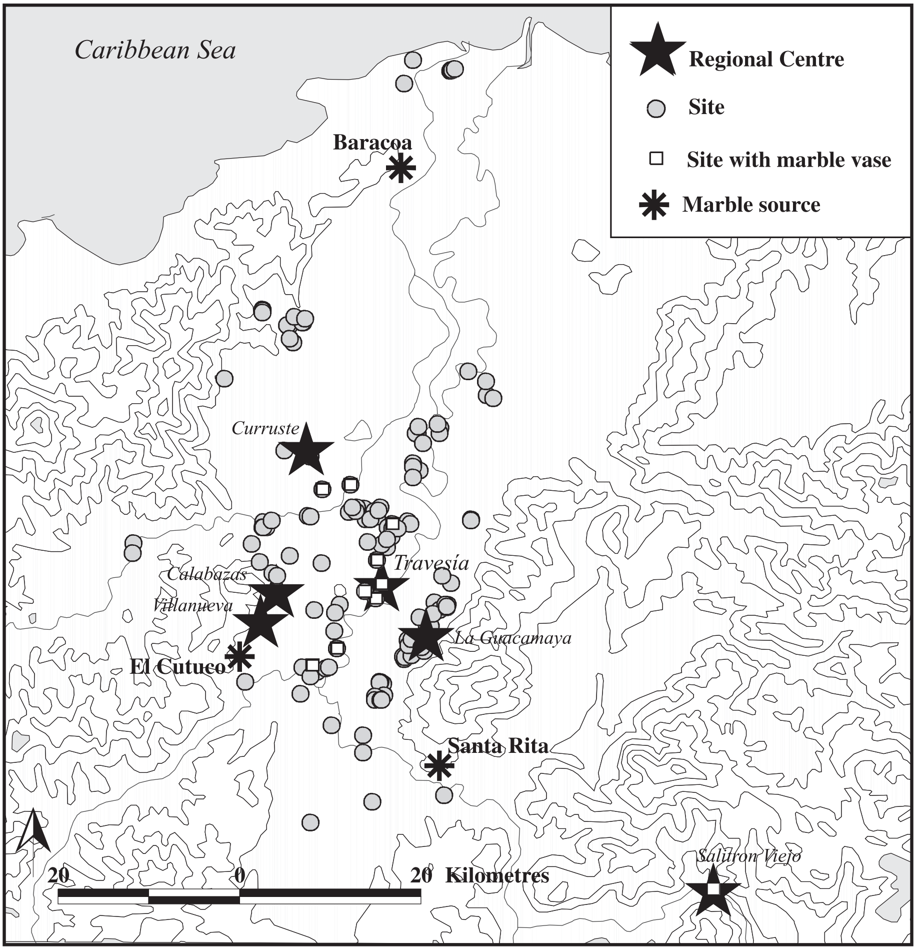


Figure 3 *The locations of Late Classic sites and marble sources in the Lower Ulúa Valley. Ulúa marble vases have been found at the sites shown in italics.*

ensure a good range of isotopic variability within each source, we tested at least 20 samples from each source, with three samples from the same location to confirm homogeneity. The results from 14 potential sources showed substantial overlap. In order to distinguish among these sources, petrographic analyses of each source were conducted. These analyses proved to be pivotal in the research program because most sampled sources, save one (Baracoa), appeared to be limestone, not marble. Yet, petrographic results from 11 Ulúa-style marble sherds confirmed that these sherds were produced from pure marble; however, this marble did not match (petrographically) the Baracoa marble source. Finally, our initial results also indicated that three additional marble vases isotopically matched the limestone sources. In our publication of these results, we argued that the isotope signatures of the limestone protolith must be similar to the subsequent metamorphosed limestone, the marble (Luke and Tykot 2002). That is, since recent quarry activities (1950 to present) in the valley have depleted the

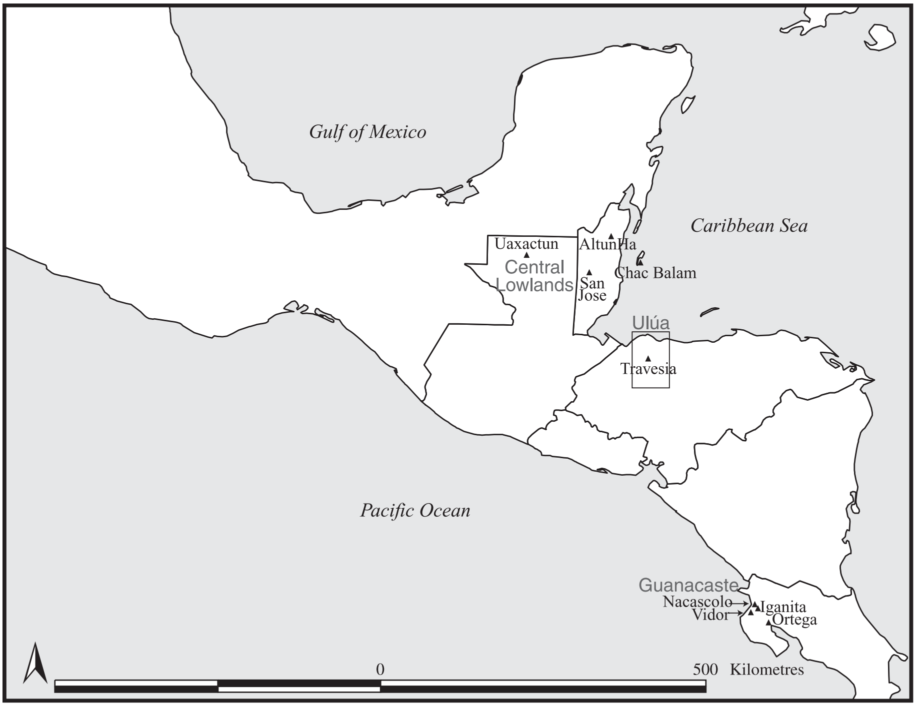


Figure 4 *Sites with Ulúa-style marble vases in Guanacaste and the central Maya Lowlands.*

available marble sources, isotope values from the parent limestone may be used to locate procurement zones exploited for the marble vases produced in antiquity.

This paper seeks to explore in more detail the local geology, specifically the likelihood for variation in isotopic signatures of the parent limestone and its derivative marble. In order to determine which sources were most probably used in antiquity, we focus on the local geology and petrographic analyses of three sources. Two of these sources show evidence of metamorphosis within the parent limestone and one is pure marble. Therefore, our focus here is a more fine-tuned analysis of three local sources with petrographic evidence for marble, the corresponding isotopic signatures of these three sources, the isotope signatures from the 11 vases[2] previously studied only petrographically, and additional isotope signatures from 58 vases.

After a brief introduction to the archaeology and the significance of the marble vases in antiquity, the paper shifts to a detailed discussion of the geology and the formation of limestone and marble in the region. We then turn to the geological survey and the results.

## THE STUDY AREA

The Ulúa Valley is located in northwestern Honduras and comprises approximately 2400 km$^2$. This large alluvial plain has three major rivers. The Ulúa is the largest and it flows through the centre of the valley, with two major tributaries. The Comayagua flows from the imposing

[2] The large sample size needed for petrographic thin sections precludes a wide sampling of whole vases or vase fragments.

southern mountains, while the Chamelecón River drains the western Naco, Quimistán and Sula Valleys. These major river systems provide for an extremely lush and fertile plain that supported large populations in antiquity. Ideal conditions for maize as well as for one of the most sought-after commodities in ancient Mesoamerica, cacao, are found in the valley.

Remains from the Formative through the Post Classic periods indicate a broad culture history in the region (Henderson *et al.* 1982; Henderson 1984, 1988; Joyce and Henderson 2001). The Late Classic represents the most prosperous period documented in the region, with sites more differentiated than ever before, and a wide range of artistic styles and technologies. Several large centres—La Guacamaya, Villaneuva, Calabazas, Currusté and Travesía—are distributed more or less evenly in the valley, with smaller centres and hamlets found interspersed among these larger centres (Joyce 1991, 130–3; Henderson 1992a,b; Lopiparo 2003).

Archaeological survey and excavation in the immediate vicinity of the centre of Travesía and the neighbouring sites of Santa Ana, La Mora, Mantecales and Cerro Palenque confirm that it was a prosperous area during the Late Classic period, with Travesía as the main polity hub (Fig. 3) (Joyce 1991, 131–2). A 'downtown' area reflects the typical characteristics of a Mesoamerican centre, with large mounds flanking open plaza areas, caches, stone monuments and a ballcourt (Stone 1941; Joyce 1983; Joyce 1991, 118, 124, 132, 137). Like the other regional centres, the Travesía community included smaller centres, residential sites and even hamlets, perhaps properties of wealthy landowners.

Although social complexity increased dramatically during the Late Classic period in the Lower Ulúa Valley, at no time does it appear that one of the regional centres controlled the whole area. Rather, a number of interacting social and political networks can be traced through specific artefact classes. Unlike fancy polychromes in the central Maya Lowlands (Ball 1993; Reents-Budet 1994, 1998; Reents-Budet *et al.* 2000), elaborate Ulúa polychromes (Viel 1978; Joyce 1993) are not believed to represent a definitive elite good, nor do they represent competing polities. Polychromes are found in all types of contexts from high-status burials with jades and marble vases to domestic trash deposits. Evidence suggests local decentralized production of these elaborately decorated wares (Beaudry *et al.* 1989; Joyce 1993), similar to the production of Copador ceramics (Beaudry 1984). Unlike local polychrome ceramics, Ulúa marble vases represent a luxury good used by one specific site to affirm its place in the region, similar to the function of fancy polychrome ceramics from the central Maya Lowlands. Therefore, marble vase association with high-status items, limited distribution in special purpose contexts, rarity, and standardized forms and iconography point to its status as a key artefact in understanding the emergence of an elite social class and the production of luxury goods in the region.

### *Ulúa marble vases*

Ulúa style marble vases are just one of the various regional styles of Mesoamerican Late Classic white stone vase traditions (Luke 2003 and forthcoming). Previous research on Ulúa marble vases has focused on a limited number of vases (G. B. Gordon 1920, 1921; Stone 1938; Schaffer 1992). The results presented here incorporate a much broader corpus, including fragments, and take into consideration the available contextual and distributional data. Among the more salient questions that we hope this research will contribute to answering is how and why marble vase production during the Late Classic period compares with the decentralized production of fancy Ulúa polychrome ceramics. Marble vases are stylistically related to Ulúa polychromes over the vast 200-year production period of both artefact classes (Luke and Tykot

2001; Luke 2002, 87–96; Luke 2005). Yet, in the case of the marble vases, artisans explored a significantly new approach to iconography as well as material.

Of the known corpus of approximately 166 Late Classic Ulúa marble vases currently stored in excavation depots and institutional collections, almost half have a site provenience, including those vases from the Ulúa Valley, neighbouring regions, and the regions of Guancaste-Nicoya and the central Maya Lowlands. In the central valley, 19% of those vases with provenience are from the Travesía area, including the sites of Santa Ana and La Mora. Vases from smaller, nearby hamlets were most probably part of the greater Travesía polity. These include the two vases from the elaborate assemblage from Peor es Nada (Stone 1972, 141), with two marble vases, polychromes and a number of exquisitely carved jades, and the assemblage from Santa Ana, which includes two marble vases: the largest of these vases had a jade hand and gold figure placed inside (Luke 2002). Ulúa marble vases and exquisite jades are absent from other regional centres in the valley. This distribution pattern suggests that only the centre of Travesía and those sites affiliated with it had access to these marble vases. In the neighbouring regions, marble vases have been excavated at the regional centre of Salitron Viejo (Hirth and Hirth 1993, 178) and have been reported from El Abra (Nakamura 1987), Tenampua and Yarumela—all significant centres.

Ulúa marble vases are found as far south as the region of Guanacaste at the site of Ortega (Ferrero 1981, 88), the prominent coastal hub of Nacascolo (Stone 1977, 59) and the subsidiary sites of Vidor and Iguanita (F. Lange pers. comm., 2003) (Fig. 4). This southern network is also documented in local polychrome production incorporating Ulúan themes and styles (Joyce 1993).

To the north, Ulúa vases have been excavated in the central Maya Lowlands from the sites of Altun Ha (Pendergast 1982, 43, 114, 115; Pendergast 1990, 233, 236, 237, 238), Uaxactun (Kidder 1947, 36–7), San Jose (Thompson 1939, 167) and Chac Balam on Ambergris Caye (Guderjan 1995) (Fig. 4). Established networks of the exchange of stylistic canons and, along the northern network, the physical transfer of objects (Stone 1972, 1977; Sheptak 1987; Joyce 1986, 1993, 1996) confirm interaction between the Ulúa Valley and the central Lowlands. The variation in the styles of the marble vases exchanged to the south and north confirms also an early Late Classic southern network (*c.* AD 600–750), replaced by the end of the Late Classic period (*c.* AD 750–850) with the northern communication sphere (Luke 2002, 2005).

The place and importance of Ulúa marble vases in antiquity, then, is clear. They are rare, putative elite goods. The vases were exchanged to Lower Central America and the central Maya Lowlands, making Ulúa marble vases one of the only Maya luxury goods with such a broad, but very restrictive, distribution in antiquity. In order to understand whether vases were in fact made at Travesía, stable isotope analyses were conducted on 69 vases and potential sources were located and sampled as well. This paper now turns to the geological survey and sourcing aspect of the project.

## *Geological background*

The geology of Honduras is among the most complex in Central America and remains poorly understood, particularly in the Ulúa Valley. The northwestern and entire eastern portions of the valley are related geologically to the metamorphic rocks of the Motagua Valley in Guatemala, extending north-east towards the Bay Islands (Williams and McBirney 1969, 4–5; Elvir 1974; Donnelly *et al.* 1991). The Motagua fault line is the boundary between the northern Caribbean Maya Block and the southern Central American Chortís Block, which includes all of Honduras.

A landmark geological survey in the 1960s (Williams and McBirney 1969) remained the only published account until the 1990s, when work resumed again, concentrating on the Chortís Block (M. B. Gordon 1991, 1992, 1993; M. B. Gordon *et al.* 1991), the Bay Islands (Avé Lallemant and Gordon 1999) and the eastern Nicaraguan border (Scott and Finch 1999).

The northern and southern regions of the Ulúa Valley are separated by the east–west trending Chamelecón fault, once believed to represent the break between the northern Palaeozoic and the southern Cretaceous formations (Williams and McBirney 1969, 5, 10, 17). Research on limestone protoliths from Roatan (Avé Lallement and Gordon 1999) and the absence of Palaeozoic fauna from Baracoa indicate a Cretaceous date for limestone south of the Motagua fault (M. B. Gordon pers. comm., 2005).

Marble and limestone sources are abundant in the Ulúa Valley and elsewhere in Honduras. Given that the vases were produced in the valley in antiquity, the geological survey concentrated on this region. On the northwestern slope (north of the Chamelecón Fault) granites, diorites and metamorphosed sedimentary rocks, including marble, are found (Williams and McBirney 1969, 5–6). Along the southwestern slope (south of the Chamelecon Fault) late Cretaceous to Eocene Valle de Angeles and Eocene limestone, sandstone and interbedded cobble conglomerates come in contact with the early southern Tertiary rocks associated with volcanic formations (Williams and McBirney 1969, 5, 10, 17); these formations extend to the west and south-east into the Comayagua region, where marble is found.

The geological processes of marble formation differ in the northern and southern regions. Marble is recrystallized limestone, defined by a change in crystal structure. This deformation process may take place under metamorphic (usually the case) or diagenetic conditions. The metamorphic recrystallization refers to a change in texture when calcite deforms by basal slip rather than mechanical twinning. Vertical foliation of micas entrained in the northern Baracoa marble indicates that they grew during metamorphism at a minimum temperature of about 350ºC (M. B. Gordon pers. comm., 2005) and confirms that this source represents pure metamorphic limestone: clean marble. Yet, to the south of the Chamelecon fault there is evidence of limestone outcrops with varying degrees of recrystallization; many of these isolated lenses are *marble*. While sources do have remains of fossils, the process of recrystallization is clear, forming a meta-limestone. A comparable situation exists on Roatan, where limestone sources with recognizable fossils are classified as *marble*, precisely, because the sources are associated with amphibolites and other metamorphic rocks that form under temperatures high enough to recrystallize limestone (Avé Lallemant and Gordon 1999). The meta-limestone or *marble* from the southern sources shows limited recrystallization to a lesser degree than the northern Baracoa marble. This conclusion is what is found *in situ* today, and might not pertain to when marble was present in antiquity, prior to the recent quarrying by Marmoles de Honduras.

## MARBLE SOURCE SURVEY

Following previous research, it was clear that we were looking for a light marble source, as all known vases are produced from a light marble, usually white to cream with various hues of grey, blue and pink.[3] A brief reconnaissance in January 1996 determined that white stone sources were abundant in the northwestern, southwestern and southeastern regions of the

[3] All known vases are produced from white marble. A number of vases appear grey on the exterior; upon further examination, all of these known grey vases are made from white marble, the exterior having been discoloured due to heat exposure (possibly from a fire, for ease of manufacture and/or evidence of vessel function) and/or the respective depositional environments.

valley. Based on information from Marmoles de Honduras, a modern marble company, marble was once abundant at several now-exhausted modern quarries that preserve only limited marble and the limestone protolith. A follow-up survey in January 2000 focused on the western and southeastern slopes of the valley. In total, 14 white-stone sources were sampled during the survey (Luke and Tykot 2002). Follow-up petrographic research indicates that marble is found in three sources: El Cutuco, Santa Rita and Baracoa (Fig. 3).[4]

Two additional modern marble quarries were sampled and analysed: the Guymaca (Olancho) and Quimistán marble sources. These two sources are not considered potential sources for the vases. Based on settlement patterns and communication routes in antiquity, sites in these areas were not primary participants with communities in the Ulúa region. What is more, marble is locally available in the Ulúa Valley and the preliminary stable isotope and petrographic results from the Olancho and Quimistan sources did not match the vases (Luke 2002).[5]

The El Cutuco source is located along the western slope at approximately 150–200 m above sea level. At the lower elevations limestone deposits are found on the valley floor (Portrerillos), while ignimbrites are located at the higher elevations separated in places by the Matagalpa formation—andesitic and basaltic lavas of Oligocene date (Williams and McBirney 1969, 17, 21, 23, 31). This source is an abandoned modern marble quarry that was quarried by Marmoles de Honduras during the 1980s and early 1990s; the intensive and extensive quarry activity obliterated any trace of ancient quarry marks. Samples were taken from all areas of the quarry.

The Santa Rita source, near Quebrada Seca in the southeastern region of the valley, is among the most visually and topographically dramatic sources, with imposing cliffs of white stone. Marmoles de Honduras quarried this source as well in the 1960s and 1970s. The sheer cliffs and other topographic features, such as the deep ravine of Quebrada Seca, precluded Marmoles from quarrying the areas at the base of the cliffs, leaving *in situ* the natural topography. We took samples from both the upper and lower areas of the source.

The Baracoa source is located on the northwestern slope. When first visited in July of 1996, dramatic white cliffs followed the natural topography and Marmoles de Honduras was quarrying areas adjacent to the modern road. At this time, samples were taken from the base of the cliffs, reached on foot from the quarry area. Upon returning to Baracoa in January 2000, Marmoles de Honduras had expanded operations, completely destroying the natural topography. Therefore, in 2000 samples were taken from the inner areas of the source. This source is most probably the Omoa source referred to earlier by George Gordon (1921, 60) and Squier (1858). Squier (1858, 189) refers to endless supplies of marble found in the hills and mountains behind Omoa.[6]

## RESULTS

### *Petrographic results*

Petrographic results from the modern quarries differentiate the sample localities into two major groups: light grey marble from the Baracoa source and grey-tan limestone from the

[4] Elsewhere (Luke 2002; Luke and Tykot 2002) these sources are referred to by their respective site IDs: El Cutuco is CR-M-5; Santa Rita is YR-M-2; Baracoa is CR-M-3/4.

[5] The Olancho source may have been used for the production of other stone vase traditions, most notably Formative traditions (see Luke *et al*. 2002).

[6] Subsequent survey of the northern areas of the Omoa range, accessed via the Caribbean coast, and the southern areas, accessed via the Chamelecon Valley, was carried out in the hope of identifying another source. We were unable to locate additional marble sources.

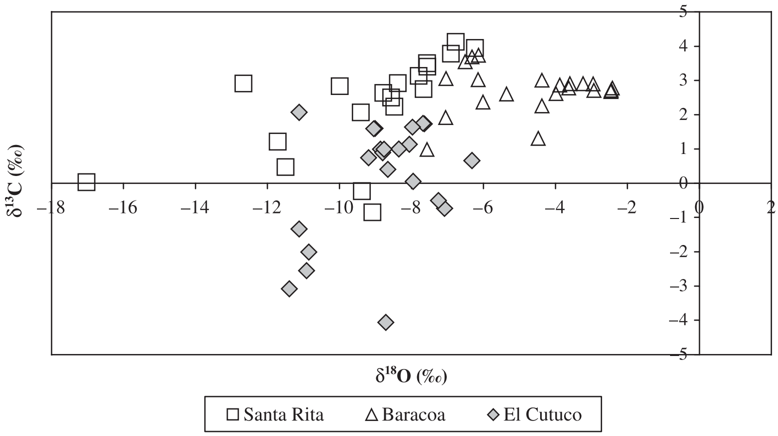


Figure 5 *Stable isotope results of three sources.*

Santa Rita and El Cutuco sources (Luke and Tykot 2002). The Baracoa samples consist of very coarse anhedral crystalline calcite with quartz inclusions; no original structures are preserved in these samples to aid in dating. Several examples from the middle Cretaceous marine limestone facies from the Santa Rita and El Cutuco sources show evidence of recrystallization to a sparry limestone that is similar to the Baracoa samples.

Eleven Ulúa marble vase sherds are pure marble more coarsely crystalline than any of the sparites collected from the quarries. Two crystalline textures, subequant and elongate, are found together in some samples; it is certainly possible that the same variation could be found in a single vase (i.e., within a single block of marble from one source). The elongate crystals may represent strain deformation from recrystallization.

The petrographic results from the sherds indicate that vases were made from limestone metamorphosed into pure marble. The modern quarry work of Marmoles de Honduras indicates that marble was present at the El Cutuco and Santa Rita sources in recent times, and the overlap of the stable isotope results from the 11 vases and these sources suggests that these sources may also have been exploited in antiquity.

*Stable isotope results*

The stable isotope results from Baracoa, El Cutuco and Santa Rita show three overlapping clusters (Fig. 5). All three clusters overlap with the sampled vases. Sources and vases are best distinguished by the stable isotope oxygen values, rather than the carbon values, which are relatively uniform. The oxygen values for the Baracoa source (–2.4‰ to –7.1‰) are less than those values for El Cutuco (–6.3‰ to –11.4‰) and Santa Rita (–6.2‰ to –17.0‰). It should be noted that oxygen values between –6.0‰ and –7.1‰ from Baracoa were taken during the second visit to the site in 2000, when the areas previously sampled in 1996 had been quarried away. The 1996 values range between –2.4‰ and –5.0‰.

Stable isotope analyses of 69 vases indicate that vases do have similar isotopic ratios to each other (Fig. 6). The overlap and tight central cluster of vases argues that marble used for the vases would have come from one area, perhaps even one so-called lens: an *ancient* quarry. The majority of vase samples, 59 vases, or 84%, form a tight group, referred to as Cluster A,

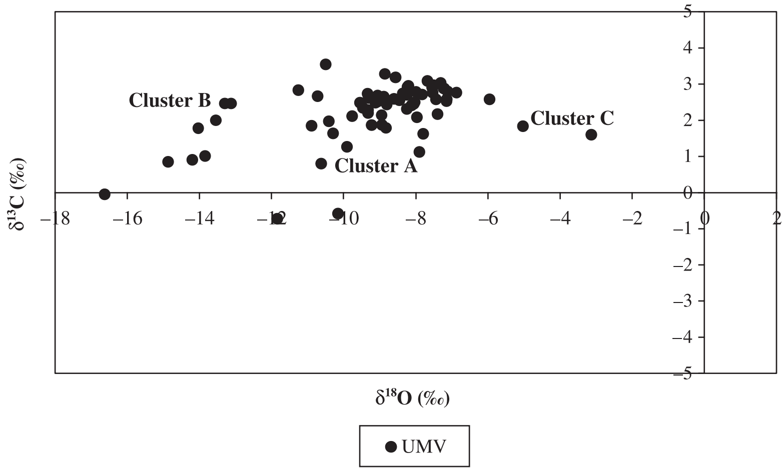


Figure 6 *Stable isotope results of 69 Ulúa marble vases (UMV).*

with oxygen values between −6.0‰ and −11.8‰. Cluster B includes eight vases, or 12%, with oxygen values between −13.1‰ and −16.6‰. Two vase fragments (4% of the sample) fall outside of these two cluster groups, forming Cluster C, with oxygen values between −3.1‰ and −5.0‰.

The range of oxygen isotope values for the vases is very great. Comparable data are from Alberta, where samples span from that of Holocene shallow-water molluscs and forams and red algae to late calcite spar in Devonian carbonates (Tucker and Wright 1990, figs 7.6 and 7.17), indicating alteration in the stone. This also appears to be the case in the Ulúa Valley. Given that the vases overlap with local sources and are archaeologically and stylistically matched to the valley, the alteration processes represented in the sources and vases were most probably the same, confirming that the vases are indeed from local sources. The mobility of stable isotopes during deformation would probably reflect the protolith, rather than the metamorphic process, particularly if the deformation occurred slowly and under relatively low temperatures; any change would most probably only be seen in the values of the temperature-sensitive oxygen isotopes. The continuous plot of the isotope values from the vases indicates that the range in values may represent subtle changes during the alteration process, specifically in the oxygen isotope values, particularly given the presence of continuous ignimbrites overlying the lenses of marble. That is, the sensitivity of oxygen isotopes to temperature changes does appear to be the defining factor in distinguishing among separate marble and limestone sources in the valley, but not for the derivative from its parent limestone.

Our results thus indicate that the limestone protolith, the meta-limestone and pure marble from a single area in the Ulúa Valley may be isotopically similar. These data suggest that the alteration process of the limestone to marble was very slow and took place under relatively low temperatures. Our knowledge of the geology in the region indicates that the marble would not have formed under strict diagenetic conditions—it would be impossible given the geology of the region—and that the metamorphic process was not particularly intense.

Finally, conclusive evidence that isotope values from marble vases match isotope values from the limestone protolith of their procurement source is best documented by the data presented in this paper. Petrographic and 'ethnographic' (information from Marmoles de Honduras) data

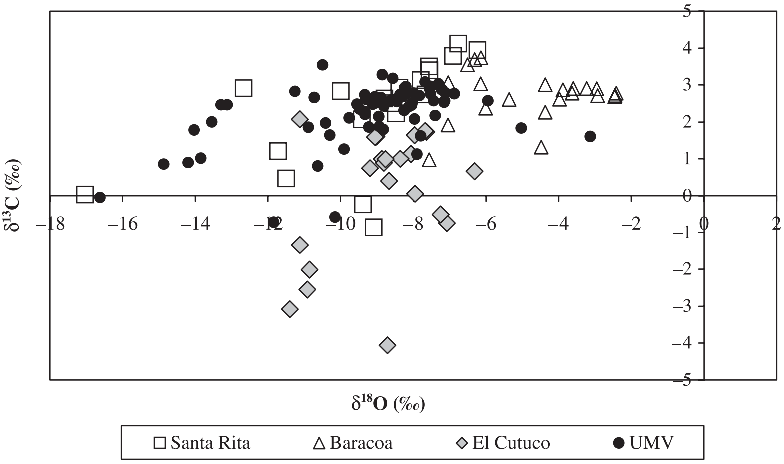


Figure 7 *Stable isotope results of three sources and Ulúa marble vases (UMV).*

confirm that marble was once located at the Santa Rita and El Cutuco sources. Isotope data from these sources match isotope values from marble vases produced in the region from the seventh to the ninth centuries AD, long before the modern quarrying by Marmoles de Honduras (Fig. 7). What is more, the isotope data from a marble source in the valley, the Baracoa source, do not overlap as nicely with the marble vases when compared to the Santa Rita and El Cutuco isotope data.

## DISCUSSION

The concentration of 84% of the sampled vases in Cluster A suggests that a single marble source was used to produce this set of Ulúa-style marble vases. The two other clusters may indicate a second location from the same source[7] or two additional sources. These data suggest that at the most three sources may have been used to produce Late Classic Ulúa-style marble vases, with a clear preference for one source.

Those vases with petrographic results all cluster isotopically within the main field of Cluster A (Figs 5–7). Given that Cluster A overlaps perfectly with the main area of the Santa Rita source, we suggest this source as that most probably exploited in antiquity. The extended field of this source also incorporates the small outlying Cluster B. We suggest that this may represent a secondary procurement area from the Santa Rita source. The remaining outlying vases, Cluster C, overlap with the Baracoa source samples and indicate a third potential source.

Archaeological and stylistic data corroborate this interpretation. The stylistic data from 166 whole vases and fragments indicate a very standardized iconographic program with standardized vessel forms and sizes, both evidence of a single workshop (Luke 2002). Pre-Columbian workshops producing luxury goods are believed to have been small, with a limited number of apprentices working under a master artisan (Reents-Budet 1994; Reents-Budet 1998). In addition,

[7] Pike's (2005) research on Pentelic marble very clearly demonstrates that specific areas of this quarry have homogenous signatures, while the entire signature of a given quarry may be very broad. Artefacts have been attributed to specific zones in the quarry, many with ancient quarry marks.

in such focused workshops, resources are usually limited in their diversity (Clark and Parry 1990). The excellent correlation between the limited stylistic variability and the similar isotope analyses for both the vases themselves and a matching procurement zone points to a single workshop operating with a very limited number of artisans, procuring marble predominantly from one known source.

Stylistic and distributional data from those vases within Clusters B and C indicate that, over time, procurement choices may have expanded to accommodate workshop demands. Several of those vases from Cluster B incorporate subtle stylistic innovations within the Late Classic Ulúa marble style (Luke 2002). These unique choices may indicate expansion of procurement at the main source during the height of production, the period during which one would expect stylistic innovations by an increased number of artisans, as documented for central Maya polychromes (Reents-Budet 1994). Meanwhile, the fragments from Altun Ha (Belize), forming Cluster C, may indicate a shift in procurement zones following changes in communication networks.

An alternative hypothesis based on the data is that El Cutuco was the main source for those vases in Cluster A. The Santa Rita and Baracoa sources would have been secondary sources used to produce those vases in Clusters B and C, respectively. Under this scenario, procurement from the secondary sources was directly influenced by the southern and northern exchange networks. The isotope data from the Ulúa marble vase handle fragment from Chac Balam (Ambergris Caye, Belize) confirm that the primary source continued to be used during the later period of production when communication networks shifted north; thus, within this hypothesis, the northern Baracoa source was not used exclusively for vases that eventually found their way to the central Maya Lowlands.

A final hypothesis is that Baracoa was the primary source. While the petrographic data from sampled areas of this quarry do not match the 11 vases for which we have petrographic results, and while the stable isotope values (particularly those from the 1996 sampling) do not overlap the majority of the isotopic values from the vases, the variation in the isotope values from the 1996 and 2000 samplings suggests that oxygen values from marble sources in the Ulúa Valley may vary considerably within one source. Thus, it remains possible that areas from Baracoa now obliterated by the massive quarrying of Marmoles de Honduras had oxygen values matching the vases found in Cluster A. Even with such a degree of variation, however, the isotopic data from the other sources suggests that it would be unlikely for the range of oxygen values to vary to such a great extent as to include also Cluster B (i.e., from −2.4‰ to −16.6‰). Therefore, while it is possible that Baracoa was the primary source, there must also have been a secondary source, most probably Santa Rita.

Regardless of which source served as the primary procurement area, the isotope data from the vases indicate that vase producers relied on one source, with one or two possible secondary sources. The largest concentration of marble vases comes from the sites of Travesía and Santa Ana and smaller surrounding hamlets. The standardized forms and iconographic programs suggest a single workshop in this area. Thus, the stylistic and distributional data corroborate the stable isotope data for *one* preferred main source. This result follows the proposed models for centralized craft production, whereby luxury items are produced in relatively small workshops with a master artisan and several apprentices following a specific design stipulated by the patron (see Clark and Parry 1990; Costin 1991; Reents-Budet *et al*. 2000; Inomata 2001). Building on known locations of marble and previous marble carving traditions (Luke *et al*. 2002), artisans in the Travesía community crafted these elaborate vases. Used as markers of an increasingly prominent and socially powerful community in the region, marble vases incorporated imagery associated with pan-Mesoamerican ritual and political themes. These vases provided the Travesía community with a luxury good meant to impress in both local and foreign spheres.

## CONCLUSION

Our work demonstrates that a multi-method approach is mandatory for sourcing marble in Honduras. The distribution of Ulúa marble vases indicates one centralized location for vase production in antiquity, Travesía. Stable isotope results of the vases indicate a primary source. The stable isotope analyses of white stone sources indicate a number of different possible procurement locations for this primary source. Detailed petrographic work allowed us to narrow potential sources to three. This research demonstrates that while stable isotope analyses are viable for sourcing marble, they are best augmented by additional methods. In this case, petrographic work confirmed the presence of marble in sources that isotopically match these marble vases. Finally, this work has set the stage for future work of white stone vases from Mesoamerica.

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