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BACK TO THE SOURCE: PROVENANCE AREAS OF CLAYS AND TEMPER MATERIALS OF PRE-COLUMBIAN CARIBBEAN CERAMICS

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Current knowledge regarding the provenance of pre-Columbian ceramic raw materials, i.e. clays and temper materials, and the identification of exchange wares is largely insufficient. Only in rare cases have technological aspects such as the temper constituents of the pottery been analyzed, and even then rarely combining conventional and archaeometric techniques. In this paper the methodology of a project that started at Leiden University in 2004 will be discussed and illustrated by the preliminary results obtained from a micro-regional case study carried out in southern St. Lucia. Potsherds from three archaeological sites have been analyzed. The results show that pre-Columbian potters on the island made use of both locally available as well as non-local clays.

Leiden University initiated ceramic technology research in the Lesser Antilles in the late 1980s. Results of these studies, mainly based on conventional methods involving workability tests, fabric analysis, and thin-sectioning have been published ever since. This research formed the impetus for a PhD project on the provenance and exchange of ceramics (raw materials and finished products) within the Lesser Antillean archipelago combining conventional and archaeometric techniques. The project is part of the pluri-annual VIDI-program on Mobility and Exchange in the pre-Columbian Caribbean (started in 2004 and funded by the Netherlands Foundation for Scientific Research. It is directed by Professor Corinne L. Hofman).

The main objective of the PhD project is to identify clay sources on the islands and reconstruct contact and/or distribution networks in the Lesser Antilles between 400 BC and AD 1492.

A combined approach is chosen to tackle these objectives. These are the collection of clay and pottery samples from the various islands, testing the workability properties of clays, determining the mineral constituents of both clays and pottery samples, and analyzing the chemical composition of the clay and pottery by means of conventional as well as archaeometric techniques such as X-ray fluorescence (XRF), and in the future, thermal ionization mass spectrometry (TIMS). In combination, these methods complement each other rather than cancel each other out (see Arnold et al. 1991; Bishop et al. 1982).

Contemporary clay sources have been sampled and clays and potsherds from several islands of the Lesser Antilles have been subjected to this combined approach (see Stark 1966; Hofman et al. in press for similar sampling methods). To date, 210 clays and 600 potsherds have been collected from twelve islands in the Lesser Antilles. These are currently being submitted for analysis at the laboratories of the Faculty of Archaeology at Leiden (Laboratory of Ceramic Studies) and at the Faculty of Life and Earth Sciences at the Vrije Universiteit Amsterdam.

So far, the collection of clay samples and potsherds, needed for the project, has been completed. The analysis of all clay samples and of the potsherds, from the northern Lesser Antilles, has also been finalized. All analyses on the clay samples and the potsherds that are described in this paper are finalized[1]. Analyses of the remaining samples will be conducted during the coming year and are expected to provide an overall picture of the provenance and distribution of ceramic raw and/or finished products throughout the Lesser Antilles.

Clay Sampling Strategies

Between 2004 and 2006 three field trips were made in order to collect clay and pottery samples from various islands in the chain. In addition, pottery samples were obtained from fellow institutions such as Yale University, the University of the West Indies, Trinidad, the Florida Museum of Natural History, Calgary University, the Barbados Museum and Historical Society, the St. Lucia Archaeological and Historical Society, the University of Vermont and the Antigua Museum. This was accomplished with the cooperation of many colleagues: Reg and Nicky Murphy, Mary Hill Harris, Peter Harris, Bill Keegan, Joe Moravetz, John Crock, Birgit Faber Morse and Eric Branford.

Sampling of clay and pottery has been carried out in the main geological regions that characterize the Lesser Antillean archipelago; the southern continental islands (Trinidad and Tobago) (Boomert 2000, van Soest 2000), the southern to central volcanic islands (Grenada, St. Vincent and St. Lucia) and the central to northern split-arc region with volcanic islands (Guadeloupe’s Basse Terre, St. Eustatius and Saba) and limestone/extinct-volcanic islands (Guadeloupe’s Grande Terre, Antigua, St. Martin and Anguilla). Barbados, the sub-aerial expression of the sedimentary wedge that overlies the southern to central part of the Lesser Antilles subduction zone, has also been included. The geological survey was conducted in collaboration with the Vrije Universiteit Amsterdam (see also Hooijkaas and Booden 2004)and the aim of the surveys was to collect a representative sample of the clay deposits on each island, by taking into account the great variability of geological formations. Sampling procedures were proposed for each island and were designed beforehand on the basis of archaeological inventories, soil maps, and geological maps. Furthermore, the sampling was aimed at establishing an overall geochemical picture of the variety in clay deposits present. A final aim was to search for specific clay sources in the vicinity of known archaeological sites.

Potsherds from three archaeological sites on St. Lucia were analyzed. These include Black Bay, a late Cedrosan Saladoid site (AD 400-600), Giraudy and Saltibus Point, multi-component sites containing late Cedrosan Saladoid and Suazan Troumassoid components (AD 400-1200).

Of the 104 clay samples that were collected on St. Lucia (Figure 1) in 2004, 12 samples are geographically associated with the three archaeological sites. Sampling of the clays was carried out according to the sampling strategy and clay sources were found in a variety of locations such as inland hillsides and valleys. Clays were often collected on roadside cuts. Furthermore agricultural fields and meadows were seen as possible sampling areas, but to avoid contamination, the samples were preferably collected on ridges, because contamination of a sample can come from fertilizers, the presence of industrial waste dumps, waste from villages such as laundry detergent, sea spray, and nearby construction sites.

Workability Tests and Experiments

To evaluate the suitability of the clay mixtures for Amerindian manufacturing techniques, the workability and plasticity properties of the clays were tested by making testpots and testbars (Hofman et al. 1993; Hofman and Jacobs 2000/2001). Of the twelve clays, five clays from Black Bay, two from Giraudy and two from Saltibus point were well suited for coil building. In the case of the Black Bay clays, the coils tended to adhere to each other easily while the paste can be smeared to fix the coils firmly together. They are also well suited for pinching and modeling. On some of the samples scraping and tapping could easily be executed. These clays contained “enough bones” and therefore probably would be suitable for coiling and the production of large vessels. The amount of natural grains prevented the clays from shrinking too much upon drying and firing of the testbars. Although, these clays already have enough plasticity, some of them might even improve in workability with aging. Two of the clay samples (STL-1 and STL-3) improved with the addition of some fine sand. Furthermore the presence of fine divided organic material in the clay is recognizable on the testbars. Testbars in this case show a black core after firing at 650°C under oxidizing conditions. Three of the clay samples (STL-2, STL-31 and STL32) contain clear quartz crystals (i.e. approx. 6%), which resembled the fabric of the analyzed potsherds from Black Bay.

The clays collected near Saltibus Point (STL-19 and STL-20) also proved to be well suited for coiling, pinching and modeling. They have good workability properties and the fabric of one of them (STL-20) resembles one of the potsherds from the Saltibus Point site (SP-175). Both the clay and the potsherds

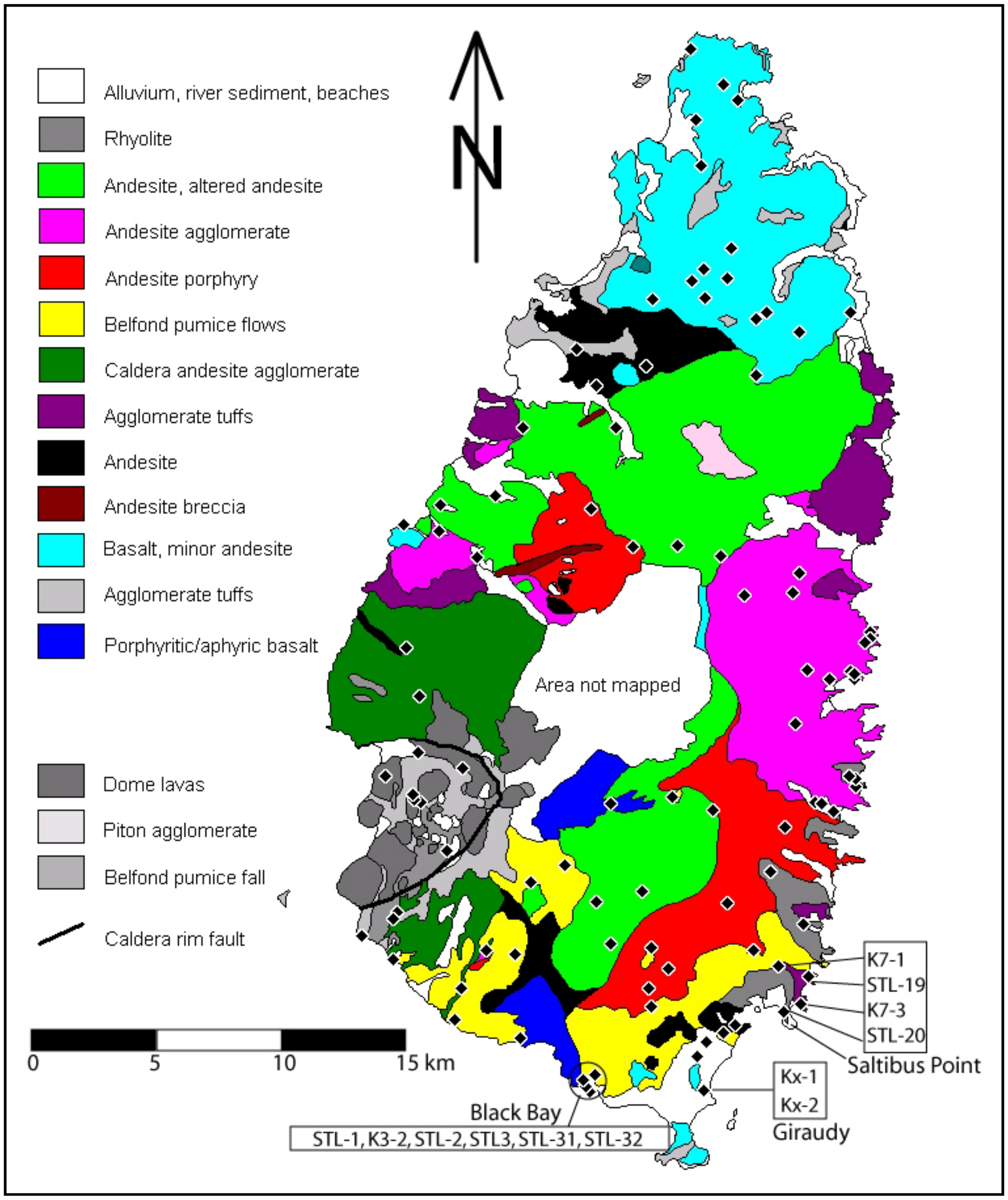

Figure 1. Geological map of St. Lucia, after Tomblin (1964). Sample sites are indicated and samples and settlements discussed are identified.

contain iron-oxide siltstone. Experiments showed that the clay's workability could be improved by the addition of a shorter clay, that is, a clay of low plasticity, or some fine sand.

The clay mixtures were experimentally fired to test their firing and post-firing behaviors and to facilitate comparison with the pre-colonial potsherds. It is remarkable that most of the St. Lucia clays could be used to produce a well-fired pottery at relatively low firing temperatures of 650˚C. This implies that the pre-colonial pottery that was manufactured with clays from St. Lucia clays also could have been fired at such low temperatures.

Fabric Analysis

Mineralogical fabric analysis[2] was carried out to identify the mineral and non-mineral constituents in the clays and potsherds as has been done in other regional ceramic studies (e.g., Bullen and Bullen 1968, 1972; Donahue et al. 1990).

Fabric analysis on 19 potsherds from the sites of Black Bay, Giraudy and Saltibus Point demonstrates that the majority of the potsherds have a mineral assemblage characteristic of volcanic islands in the region in general.

The fabrics of the testbars that were made with these clays resemble the fabrics of the potsherds from the three sites. Typically the same grain types occur in the various fabrics. Angular crystals and broken grains of transparent quartz are abundant in all the sherds (i.e., approx. 6%). Additionally, crystalline or partly weathered grains of feldspar, kaolinite and iron-oxide siltstone are present in all the samples albeit in lower numbers (i.e., approx. 2%–4%).Dark minerals like pyroxene and amphibole were found in most of the sherds, but predominantly in relatively low numbers (i.e., approx. 4%–6%). They showed somewhat higher percentages in only a few sherds from Saltibus Point. The homogeneity of grain types suggests a local origin of the majority of the pottery from Black Bay, Saltibus Point and Giraudy.

Exceptions are several sherds from Giraudy that show a non-local origin on the basis of their fabric. For example one sherd (GIR-192, a Cedrosan Saladoid sherd) shows differences in the color of the fabric and the size and sorting of the grains. This sherd is clearly different compared to other sherds from Giraudy suggesting the use of non-local clay.

Archaeometric Techniques

Similar to instrumental neutron activation analysis (INAA), which was used for the analyses that are presented in other papers in this issue, X-ray fluorescence (XRF) can be used to determine the provenance of clay and pottery samples. In this project, XRF was preferred because of its ability to process large numbers of samples (Fitton 1997). The results will eventually be combined with those from TIMS, which determines the abundance ratio between certain isotopes within a sample. This technique will be used in the future to determine, for example, $^{87}Sr/^{86}Sr$, $^{207}Pb/^{206}Pb$ and $^{143}Nd/^{144}Nd$ ratios.

XRF is a relatively inexpensive method and sample preparation is a relatively fast process. Four grams of each sample were needed. The technique is destructive, because the material to be sampled must be in the form of a fine and homogeneous powder. However, the samples do not require any special treatment after analysis so powdering and pressing the powder to hard pellets for use in the spectrometer are the only preparation steps. There is no need to dissolve the sample chemically, and the XRF technique is insensitive to the bonding state of elements. This ensures that absorption of secondary X-rays within the sample is the only main source of error. Because most absorption is by major elements, the measured major element abundances can be used to correct for this effect. The resulting data generally have analytical precision and detection limits in the order of 2 ppm for trace elements. Analytical accuracy is within a few percent for most of those same elements, the error being mainly due to absorption of secondary x-rays by the pressed powder matrix.

A Philips Panalytical Magix'Pro XRF spectrometer was used in this study to determine the concentrations of over 30 selected major and trace elements in each sample. The resulting data are analyzed graphically and through multivariate statistical analysis[3].

Both clays and potsherds from Black Bay, Saltibus Point, and Giraudy that were submitted for fabric analyses were also submitted for analysis by XRF. Major elements were examined to determine the degree of geochemical weathering of the clays. It is important to determine the degree to which the compositions of bedrock, clays and sherds were altered in order to be able to compare potsherds to clays on the basis of their geochemical composition. In addition, the trace element ratios of elements not susceptible to chemical weathering were used to distinguish between sherds produced with different source clays.

The graphs contain the element ratios of TiO_2/Th plotted against those of Nb/Th of the whole sample[4] (Figures 2 and 3). These elements have been chosen on the basis of their immobile behavior during chemical weathering, and because they provided the clearest results. Recently the study of element ratios based on Ba, Y, and Zr abundances have also provided promising results (Hofman et al. 2005; Hofman et al. in press).

The graph shows two different "composition lines" that are defined by the majority of the samples (Figure 2). One line is defined by a majority of potsherds, and its

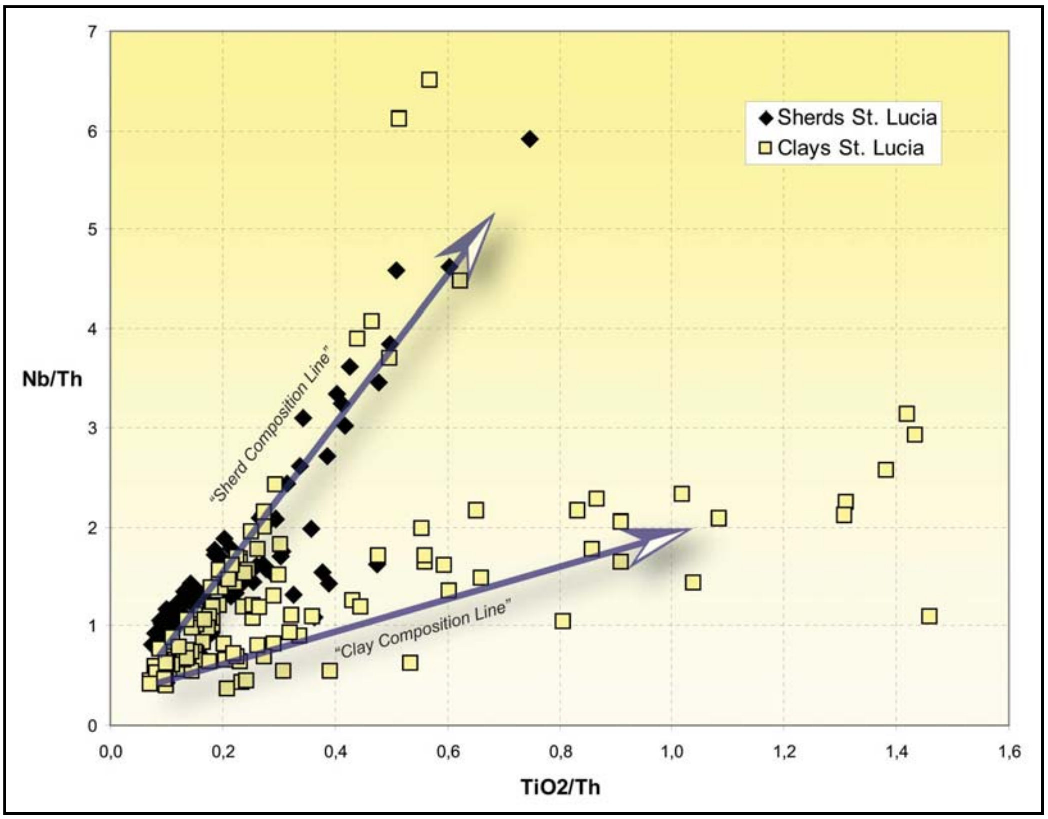

Figure 2. Graph showing the results of the XRF measurements for TiO_2/Th and Nb/Th of all clay samples and potsherds from St. Lucia.

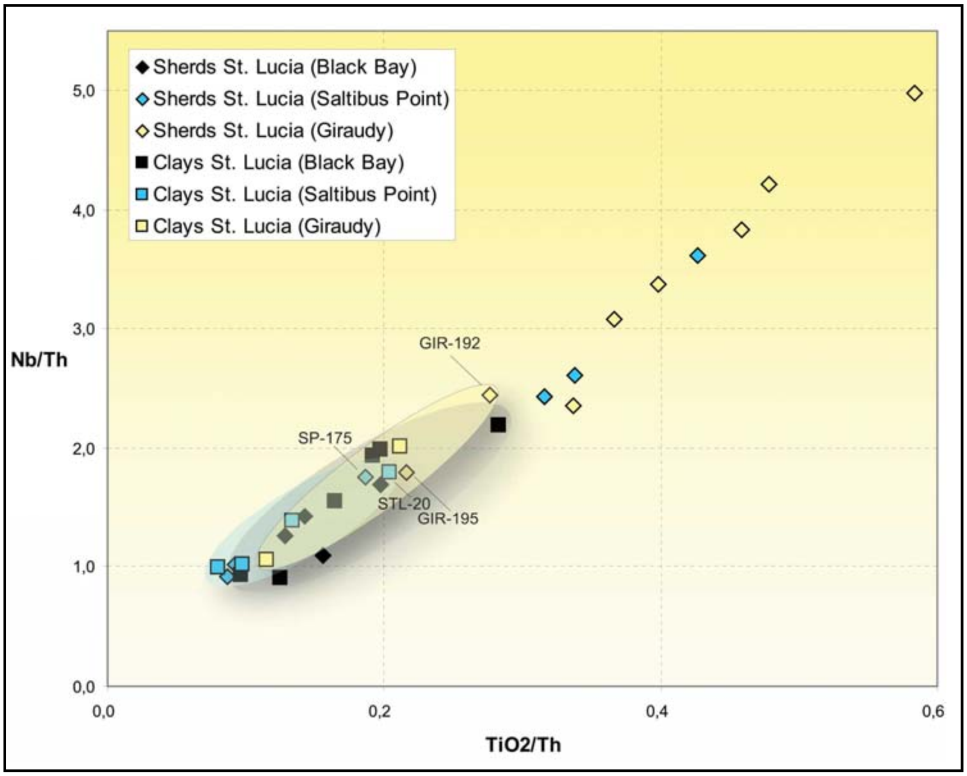

Figure 3. Graph showing the results of the XRF measurements for TiO_2/Th and Nb/Th of clay samples and potsherds selected from the sites Black Bay, Saltibus Point and Giraudy.

lower end, by a minority of clays ("sherd composition line"). The other consists of few sherds and mostly clays ("clay composition line").

Four sherds from Black Bay fall on the clay composition line. Their chemical composition is similar. The clays plot at different positions in the Southern End Member range. The associated sherds are scattered within the same range but mostly plot at positions intermediate between the clay samples. This indicates that these sherds were all produced from mixtures of locally available clays and temper materials.

Seven of the sherds from Giraudy plot on the sherd composition line in the graph shown in Figure 2. These sherds are apparently mixtures between clays from the Southern End Member range and an as yet unidentified clay source. The two clays from Giraudy plot in the Southern End Member range, but all except one sherd plot outside this range on the high-Nb/Th array (see Hooijkaas and Booden 2004). These sherds are characterized by very low Th contents. It is possible that the sherds are mixtures of Southern End Member clay and a low-Th component, which would suggest import of material. Low-Th material is found on St. Lucia in the Sulphur Springs hydrothermal crater. Sulphur Springs-type material is a potential explanation. Alternatively, the results could suggest that Th bearing phases may have been preferentially removed from the clay or temper components during production. The majority of sherds from Giraudy form a distinct group. Two sherds

(GIR-192 and GIR-195) do not plot in this group. These are also the only Giraudy sherds that do not have a low Th concentration.

Seven sherds from Saltibus Point fall on the sherd composition line indicating a mixture of southern clay and either one of the anomalous clays that fall on that line or an unknown clay, presumably from the Sulphur Springs area. Figure 3 provides a view on the composition line of potsherds from the archaeological sites that are discussed in this paper and the clay samples that were geologically associated with these sites. As opposed to Figure 2, Figure 3 only shows the results of part the sample and not the whole sample.

In summary, the majority of the pottery from the three St. Lucian sites appears to be of local origin, as is to be expected, given that sources providing excellent clays for the production of pottery are abundant on this island.

Three main provenance areas can be distinguished on the island based on ratios of immobile trace elements in clays: the northern, central and southern parts with increasing Nb/TiO_2 ratios. The majority of the sherds, showing a relatively uniform geochemistry, are made of clays with a southern St. Lucia provenance. Several sherds, however, have compositions suggesting that they were manufactured with non-local clays or that their constituents have been imported from as yet unidentified sources in other parts of the island.

Concluding Remarks

The islands in the Lesser Antilles are very diverse geologically. This diversity is responsible for the variation in availability of clay sources on the various islands. Volcanic islands such as St. Lucia are extremely rich in suitable clays whereas in general limestone islands such as Anguilla offer a more limited number of clay sources. This differential availability of clays must have entailed the establishment of a network for the procurement and distribution of pottery raw materials and/or finished products, which probably paralleled similar networks in which lithic raw materials, exotics, perishable materials and ideas were carried throughout the archipelago.

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Notes

[1]Fieldwork in 2006 was generously funded by the Byvanck Fonds.

[2]Mineralogical fabric analysis was performed with a binocular microscope with the use of direct light. Samples were first cut with a diamond saw and treated with sandpaper to obtain a flat surface. Additionally they were re-fired at 700˚C under oxidizing atmosphere before analyzing them under the microscope.

[3]Geochemical analyses were performed at the Faculty of Earth and Life Sciences of the Free University Amsterdam under the responsibility of Prof. Gareth Davies.

[4]Zr/Th and Hf/Th have also been plotted against Nb/Th, but TiO_2/Th–Nb/Th provided the clearest results.

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