Journal of Archaeological Science: Reports 43 (2022) 103469

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Production of Greater Antillean pottery and its exchange to the Lucayan Islands: A compositional study

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ARTICLE INFO

Keywords:
Pottery
Sourcing
LA-ICP-MS
Caribbean
Bahamas
Turks & Caicos

ABSTRACT

Archaeologists working in the Lucayan Islands (The Bahamas and Turks & Caicos) have routinely identified artifacts with non-local origins, such as pottery from the Greater Antilles. Greater Antillean pottery production is characterized by broad trends in form and decoration, with a few distinct local expressions. Given the mobility of these peoples, it is often impossible based on visual appearance alone to determine where a vessel was produced at the island or intra-island level. However, despite complex and shared geological features, there are characteristics specific to certain islands and subregions of the Greater Antilles creating unique elemental signatures within clay resources that are maintained within fired pottery. We used laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) to elementally characterize pottery production zones for Greater Antillean pottery, with pottery samples recovered from sites throughout the region. We identified nine main compositional groups, likely representing local production on each Antillean island sampled, including at least three compositional groups associated with different regions of Hispaniola. We then sourced samples imported to the Lucayan Islands back to their Antillean origins. Our results support the importance of the north coast of Hispaniola as a gateway to the Lucayan Islands.

1. Introduction

It has long been noted that Indigenous Caribbean communities had region-wide interactions, and that the sea functioned as an "aquatic motorway" connecting islands and communities (Hofman et al. 2010). These islands and communities were never really isolated, sharing material culture, mythology, and ancestry throughout the insular Caribbean. Though we know canoes were routinely used as a method of transportation, it has been a challenge to trace the actual routes taken and points of contact. The Lucayan Islands (comprising the Commonwealth of The Bahamas and Turks & Caicos Islands), located north of the Greater Antilles, fall within the Caribbean interaction sphere, but the depth and intensity of those connections are not clear. Commonly traded goods in and across the Greater Antilles and Lucayan Islands included pottery, lithics, raw materials like gold, salt, cotton, and foodstuffs. Shared culture includes common pottery motifs (Berman et al. 2013) as well as the Lucayans' appropriation of *duhos*, or wooden ceremonial seats originating in the Antilles (Ostapkowicz 2015). The term *Lucayan* is an abbreviated form of the Arawakan phrase *lukku kairi* and can be translated to "people of the islands" (Brinton 1871). We avoid the term "Taíno" in describing peoples from the Caribbean as it is an umbrella term for the various cultural groups living there, though it does reflect the political and social ties between these groups over hundreds of years (see Curet 2014).

Shared ancestry (Fernandes et al. 2021) and evidence of temporary, early Antillean settlements in the Lucayan Islands (circa AD 700–1200) indicate this close connection. Based in part on geographic proximity, material culture found in the Lucayan Islands, especially in Turks & Caicos, strengthens these hypotheses. Sites MC-6 and MC-32 on Middle Caicos had close trading relationships with Hispaniola over resources including salt, conch, and fish (Morsink 2012; Sullivan 1981). Migration and trade relationships between Cuba and the Lucayan Islands also have been proposed (Berman and Gnivecki 1995; Granberry and Winter 1995). Unfortunately, material culture, especially in the Bahamian portion of the archipelago, has provided few concrete clues. Low density artifact scatters characterize sites throughout the Lucayan Islands and artifacts often are interpreted as generic or part of broadly shared Caribbean material culture series. In this paper we recover concrete evidence for these inter-archipelago interaction networks through pottery carried and traded throughout the region.

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https://doi.org/10.1016/j.jasrep.2022.103469
Received 30 January 2022; Received in revised form 25 April 2022; Accepted 30 April 2022
Available online 17 May 2022
2352-409X/

Was Hispaniola the primary gateway and trading partner to the Lucayan Islands? To directly address this question, we consider the nonlocal pottery found in the Lucayan Islands. As one of the few durable materials people carried with them, pottery provides tangible evidence for evaluating and analyzing these movements of people and objects. Most sites in the Lucayan Islands contain only one type of locally-produced pottery, called Palmetto Ware, which is visually distinguished by its red color and shell temper. In addition, pottery with noncarbonate tempers is found at low frequencies throughout the islands (Keegan et al. 2022a). This nonlocal ("imported") pottery contains igneous and metamorphic rock inclusions that must originate outside the Bahamas in the Antilles (e.g., Cordell 1998).

Looking beyond shared visual attributes, we conducted elemental sourcing of pottery to identify compositional groups associated with specific geological regions. Given successful elemental sourcing projects conducted elsewhere in the Antilles (e.g., Bloch 2019; Bloch and Bollwerk 2020; Hauser 2008; Kelly 2008; Siegel et al. 2008; Conrad et al. 2008), we hypothesized that there would be unique elemental signatures tied to specific geological formations in the Greater Antilles, and that these signatures would be retained within the fired pottery. The ability to trace a vessel from its production site to where it was ultimately discarded makes it possible to map connections to the Lucayan Islands. Here, we couple compositional data on pottery recovered from across the broader Greater Antilles with data on vessels imported to the Lucayan Islands.

We analyzed a total of 94 sherds from 40 locations across five islands in the Greater Antilles and six of the Lucayan Islands to better understand regional and island interactions. Samples collected for this project reflect a broad range of origins, production methods, and styles. By combining Antillean reference samples with samples of unknown origin, we have established Hispaniolan and other Antillean compositional groups as potential sources for vessels transported to the Lucayan Islands. Our findings include evidence for at least three distinct Hispaniolan compositional groups, and additional island-specific and inter-island Antillean groups. We discovered evidence for movement of pottery vessels from Hispaniola to the Lucayan Islands, with limited evidence for Cuban trade. We also found evidence of intra-archipelago trade in the Greater Antilles.

2. Background

2.1. History

The Ceramic Age settlement of the Caribbean began with people reaching the Greater Antilles 2500 years ago (Napolitano et al. 2019) and the Lucayan Islands 1300 years ago (Schulting et al. 2021). Recent genome-wide DNA analyses demonstrated that Ceramic Age colonists share a single genetic ancestry (Fernandes et al. 2021). Irving Rouse's (1992) classification of Indigenous groups via ceramic assemblages (Table 1) provides a useful, if limiting, view of emerging cultures in the circum-Caribbean. Originally conceptualized as sequential periods, decades of research have demonstrated that these categories are not temporally exclusive, with mixed or overlapping ceramic assemblages at various sites that suggest interactions over long periods of time (Keegan and Hofman 2017). Though requiring deeper evaluation and context, the categories developed by Rouse continue to be applied for basic identification purposes in the region. We provide a brief cultural history here, with greater detail on pottery styles below.

Table 1
Cultural traditions and potential origins from Keegan and Hofman (2017).

Series/Ware	Time Period (AD)	Origin
Saladoid	800–200 BCE	Venezuela
Ostionoid	600	Hispaniola or Puerto Rico
Meillacoid	850	Central Hispaniola
Chicoid	950	East Dominican Republic
Palmetto Ware	950	Caicos Islands

Archaic communities lived in the Caribbean as early as 4000 BCE in Hispaniola and Cuba (Wilson 2007), largely defined by an absence of pottery (but see Rodríguez Ramos et al. 2008). The Early Ceramic Age in the Caribbean began with the migration of Saladoid communities into the Caribbean. Saladoid communities came out of the Orinoco River Basin of Venezuela from the Upper Amazon in Brazil. They arrived in the Antilles sometime between 500 and 200 BCE, and mostly remained within modern-day Puerto Rico and the northern Lesser Antilles (Keegan and Hofman 2017). The Ostionoid tradition developed in Puerto Rico out of Saladoid communities or out of interactions with Archaic Age groups in Hispaniola around AD 600 (Keegan 2006; Rouse 1992). Ostionoid then spread into the rest of the Greater Antilles and the southern Lucayan Islands, but notably never appeared in Cuba (Keegan and Hofman 2017). Next, Meillacoid cultural motifs developed in central Hispaniola and became dominant in the region by AD 950 (Keegan and Hofman 2017). Finally, a distinct Chicoid tradition developed in the southeastern Dominican Republic and was common in the Dominican Republic, Haiti, and eastern Cuba by CE 1300.

In some places, these distinct series existed contemporaneously, and some sites have mixed assemblages indicating the transition of cultural traditions or interactions with other communities (Keegan and Hofman 2017). For example, the El Flaco site in the Dominican Republic shows mixing of Ostionoid, Meillacoid, and Chicoid ceramic assemblages (Ting et al. 2016).

The first evidence for human occupation of the Lucayan Islands was far later than the Greater Antilles. Around AD 700–800, people began to travel northward from the Greater Antilles to create outposts and short-term settlements, bringing their pottery with them (Berman et al. 2013; Keegan 1997). The development of locally produced pottery, named "Palmetto Ware," marks the beginning of the Lucayan period, although imported pottery continued to be found at many of these sites as evidence of either early occupation or continuing interactions with their Antillean neighbors.

2.2. Regional geology

The geology of the Caribbean has shaped human habitation in many ways, especially the mix of soils, some rich and others poor in nutrients, which were used for a variety of purposes (Crock 2000). Specific to our purposes, the underlying geology impacted available clay and mineral resources for pottery production. The identification of pottery from different islands and subregions requires an understanding of the geology that contributes to the elemental signature retained in clays and pottery.

Broadly speaking, the Greater Antilles and inner Lesser Antillean archipelago are of volcanic origin, with crustal uplift, metamorphism, and significant carbonate rock accretion in certain parts. In many places, ultramafic (low silica) bedrock has weathered into reddish iron and aluminum-rich laterite soil in the tropical Caribbean environment. Laterite soils are high in clay minerals, and may be enriched in elements including nickel, copper, and chromium. Coastal areas tend to be dominated by undifferentiated sediments from erosion processes, resulting in deposits of mixed geological origins.

Cuba, the largest island of the Greater Antilles, has the most complex geology, sitting astride the Caribbean and North American plate with multiple periods of orogeny and carbonate accretion producing distinct geological provinces. In eastern Cuba, soils are elevated in copper, nickel, chromium, and antimony due to ultramafic rocks (Rodríguez Alfaro et al. 2015), with active mining industries for nickel and chromium ores (Nelson et al. 2011). In West Cuba, Havana-Matanzas ophiolites contain chromitites rich in aluminum and chromium (Llanes Castro et al. 2015).

Hispaniola (comprising modern day Haiti and the Dominican Republic) shares some of the same geological formations as Cuba. Northern

Dominican Republic is mostly sedimentary rock, but also has inliers from the Northern serpentinite mélange that extends through to Cuba (Saumur et al. 2010; Lewis et al. 2006). The Puerto Plata Complex contains both volcano-sedimentary units and mafic–ultramafic igneous rocks (Saumur et al. 2010; Ting et al. 2016). The Duarte area, which also makes up part of the Dajabon subcomplex, is mostly basic to ultrabasic volcanic rocks. A study conducted in this complex found that rocks from Dajabon were low in titanium and magnesium oxides (Draper and Lewis 1991). To the west, sedimentary rock dominates Haiti's surface geology (Woodring et al. 1924). Cap Haïtien, which lies roughly 12 km east of the archaeological site En Bas Saline, sits on a narrow alluvial shelf. The main rock groups around Cap Haïtien are alluvium, volcanic rocks, clayey limestone with beds of chert, and white limestone. The site of Desmarreaux is located near Port de Paix and Norde Ouest, the former follows the Los Trois Rivieres south into central Haiti (Woodring et al. 1924), with abundant sandstone and shale. The Trois Rivieres Valley also consists of corals, limestone, beds of marl, and basaltic rock outcrops. The Tiburon Peninsula in south Haiti includes both cretaceous basalts and sedimentary rocks (Mann et al. 1991). The Massif de la Hotte area of the peninsula additionally includes dolerites, limestones, cherts, and siltones (Giunta et al. 2002).

Jamaica is also a part of the Great Arc of the Caribbean (Mitchell 2020), including rocks from the Caribbean Large Igneous Province, schists formed in a subduction zone, and arc volcanics. Two-thirds of the surface is limestone, with a series of 27 cretaceous inliers spread throughout (Donovan 2003). Mitchell (2020) divided these inliers into four terranes: the Western Jamaica Terrane, the Western Blue Mountains Terrane, the Northeast Blue Mountains Terrane, and the Southeast Blue Mountains Terrane. Red laterite soils are common, and significant bauxite deposits have been mined to produce aluminum ore.

Isla de Mona (hereafter Mona) is a small 55 km^2 island that lies in between Hispaniola and Puerto Rico. The island sits on a carbonate platform, and is well known for its large caves facing towards the sea with visible stalagmites and stalactites (Mylroie et al. 1994). Cliffs make up most of the perimeter of the island, except for beaches to the south (Samson and Cooper 2015). There are also reports of red laterite soils deposited in depressions and solution holes within Mona's limestone surface (Kaye and Altschuler 1959; Pérez-Buitrago et al. 2016).

The northern coast of Puerto Rico is a coastal plain with mainly marine rocks (Bermudes and Sieglie 1969). Like Mona, the northern coast of Puerto Rico is mostly made up of Oligocene to Miocene aged limestone (Asencio 1980; Bermudes and Sieglie 1969). The Cordillera Central area contains the oldest rocks in Puerto Rico ranging from igneous rocks like granite to metamorphic rocks like amphibolite. Southern Puerto Rico includes more marine rocks and limestone, with intrusions of older complexes (Asencio 1980; Kaye 1957).

2.3. Pottery production

Pottery made in the Pre-Columbian Caribbean was hand built, including coil-built vessels and slabs used as griddles. Pottery identification in the Greater Antilles typically focused more on form and stylistic differences than composition (cf. Rouse 1939), despite abundantly available clay resources and tempering agents weathered from igneous and metamorphic formations. Pottery made in the Greater Antilles contains a wide range of mineral inclusions based on the specific regional geology, described above (e.g., Casale et al. 2022; Ting et al. 2016). Sherds of pottery imported from the Greater Antilles are found alongside locally made Palmetto Ware in the Lucayan archipelago. The occurrence of these imports is greatest at archaeological sites in the Turks & Caicos Islands, and declines steadily as one moves north (Keegan et al. 2022a; Sears and Sullivan 1978). By defining the composition of pottery from the Greater Antilles, we can determine where imports recovered in the Bahama archipelago source to.

Saladoid, Ostionoid, Meillacoid, and Chicoid are the four main pottery series recognized in the Caribbean today based on Rouse's original classifications (Table 1; Fig. 2). Saladoid pottery exhibits the highest diversity of vessel forms and decoration, often characterized by white-on-red painting, zoomorphic adornos, and, less common, incised decoration (Keegan 2007). Red painted Ostionoid pottery, in some places called "redware," includes straight sided vessel forms (Wilson 2007). Meillacoid series pottery does not include red paint, in contrast to the Ostionoid series (Keegan 2007). Thin walls with hemispherical and boat shapes characterize Meillacoid pottery. Decoration types include cross-hatching, appliqué and modeled adornos, punctation, incised oblique parallel lines, and more. The surface of the vessel may reflect the texture of woven baskets (Wilson 2007). Chicoid pottery is highly decorated, including engraved adornos, lozenges, and line-and-dot and curvilinear incisions. Adornos were significant in Chicoid pottery (Keegan and Hofman 2017; Wilson 2007). The vessels typically curve inwards, except for Île à Rat where vessels curve outwards, and flare outward with large, decorated handles and elaborate incisions. Bottles are common.

3. Methods

3.1. Sample selection

To define the compositional variation in pottery sources of the Greater Antilles, we sampled across the archipelago, from Cuba to Puerto Rico, with an emphasis on Hispaniola. Our goal was to identify regional production zones rather than individual site signatures. We analyzed 69 total samples recovered from five islands of the Greater Antilles and 25 samples of imported pottery recovered from six Lucayan Islands (Fig. 1; Table 2). The majority of samples were recovered by Florida Museum curators and staff during field expeditions over the past 70 years; others represent loans or donations to the Caribbean Archaeology program. Some samples were surface collections recovered during pedestrian survey, while others from extensive excavations, thus there is high variability in the data recovered (including radiocarbon dates) and site interpretation. Contextual data regarding some ceramics, particularly those from legacy collections, are absent other than general location information. Furthermore, many of these sites have long and complicated occupational histories.

Our emphasis in sampling was to achieve breadth of coverage geographically, rather than temporally or stylistically, as clay resources may be persistent over time and ceramic tradition. Nevertheless, we also incorporated sites and samples associated with different ceramic series to investigate potential temporal or cultural variation in interaction spheres. Styles reflect Saladoid, Ostionoid, Meillacoid, and Chicoid pottery series. Samples recovered in the Lucayan Islands tend to be very fragmentary and heavily weathered, making style assignment often difficult. All ceramic samples were fragments of vessels, with the exception of two griddle fragments. It is possible that one sherd recovered from Abaco had been repurposed into a net weight. When sampling multiple sherds from a site, we took care not to sample the same vessel more than once, based on visible attributes (thickness, surface treatment, form, etc.).

The aplastic inclusions, as identified under 10X magnification were highly variable, both within sites and across samples. Individual specimens often included metamorphic, volcanic, and sedimentary inclusions. Quartz, feldspars, granites, and aphanitic volcanic rocks were common. Inclusion shape, grain size and abundance were also highly variable. Previous studies also noted inclusion heterogeneity for Antillean pottery even within limited geographic areas (e.g., Casale et al. 2022; Hauser 2008; Ting et al. 2016), a factor which has limited the utility of sourcing based on optical mineralogy. However, Cordell's (1998) petrographic study of pottery from Hispaniola and the Bahamas found mafic inclusions tended to be associated with Meillacoid pottery, while felsic inclusions were more common in Chicoid pottery.

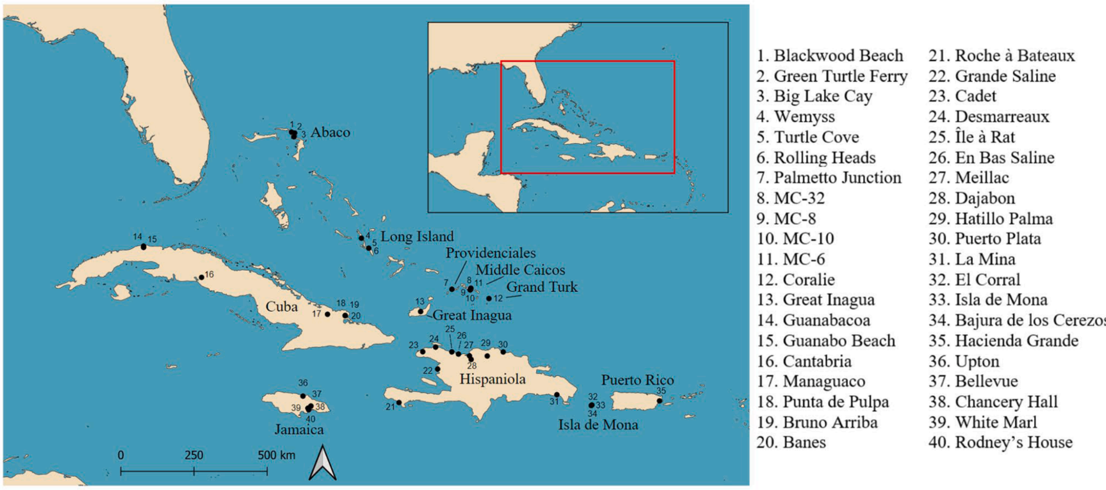

Fig. 1. Map of the distribution of ceramic samples across 40 sites in the circum-Caribbean.

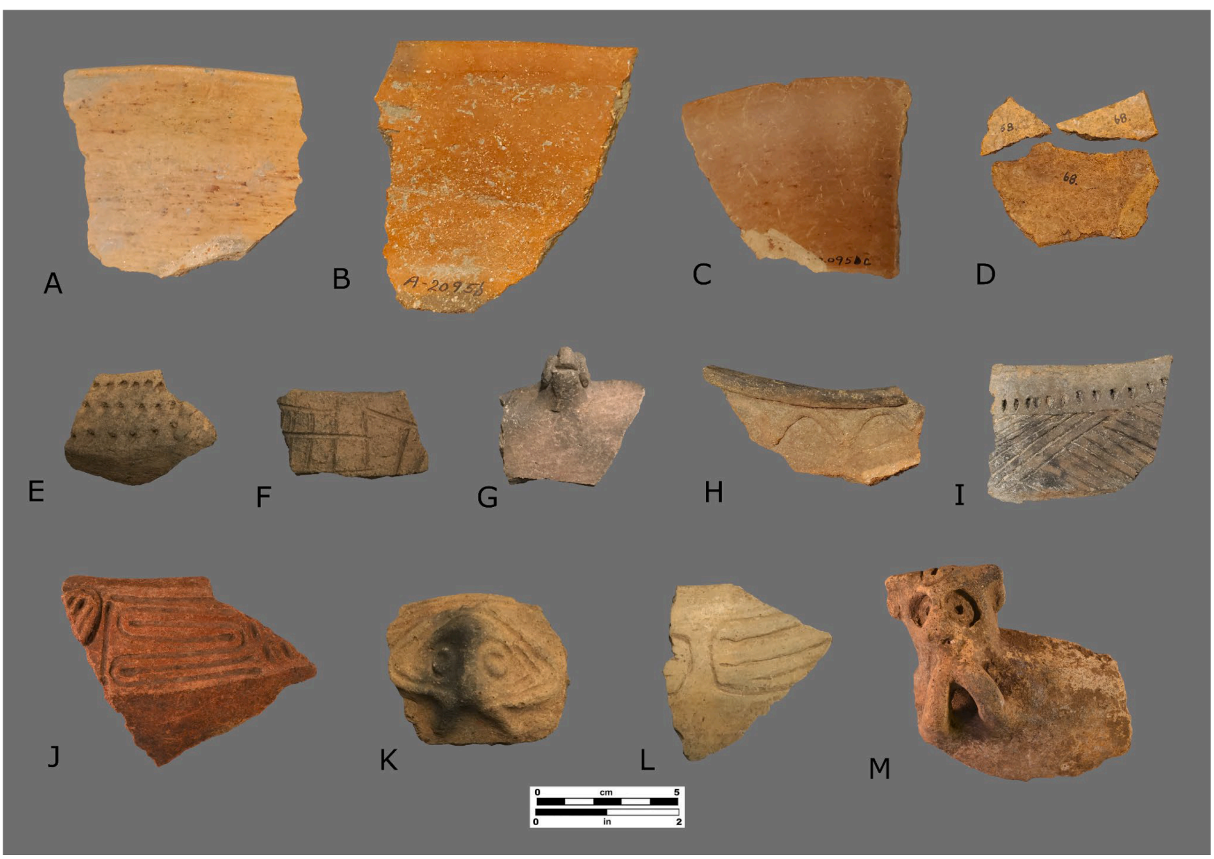

Fig. 2. Pottery styles of the Greater Antilles. A-C: Saladoid; D: Ostionoid; E-I: Meillacoid; J-M: Chicoid.

3.2. Sites

The 40 locations represented in the sample assemblage reflect a broad range of use and occupancy over time (Fig. 1; Table 2). Many of these sites were used temporarily or seasonally, while others reflect long-term settlements. Regions in the Caribbean have longer term occupation periods and more complicated histories compared to the more recent and comparatively sparsely occupied Lucayan Islands. One of the oldest sites sampled was Hacienda Grande on the northeast coast of Puerto Rico and dates as early as AD 120 ± 80 (Rouse and Alegría 1978:499). Sites on several islands date into the 17th century in the aftermath of European contact.

Sampled sites in the Lucayan Islands represent a broad chronology, including pre-Lucayan to late Lucayan sites (Berman et al. 2013). Coralie on Grand Turk was one of the first occupied sites in the Lucayan Islands, dating as early as AD 705. Coralie was a seasonally occupied Hispaniolan outpost used over four hundred years, and all of its pottery was identified as Ostionoid (Keegan 2007). The Palmetto Junction site on Providenciales was occupied for about a century (Sinelli 2015; Ciofalo et al. 2019). This site dates to the Late Lucayan Period according to Berman and colleagues (2013), which began after CE 1100.

Several samples from Middle Caicos were included from MC-8, MC-

Table 2
Samples and Available Radiocarbon Dates Across Sites in the Circum-Caribbean.

Country	Island/ Location	Site Name	Radiocarbon Dates (AD)	Citation	Samples
The Bahamas					
	Abaco	Big Lake Cay	1276–1322, 1347–1393, 1430–1522	Keegan et al. 2022b	1 unid. Antillean
		Blackwood Beach	1016–1154, 1069–1249	Keegan et al. 2022b	2 unid. Antillean
		Green Turtle Cay Ferry		Keegan et al. 2022b	1 Chicoid, 2 unid. Antillean
	Long Island	Rolling Heads	1100–1200, 1350–1485	Hanna et al. 2021:4	1 Meillacoid, 1 Chicoid
		Turtle Cove			1 Chicoid, 1 unid. Antillean
		Wemyss	1180–1279, 1305–1419, 1426–1620	Keegan et al. 2022a	1 unid. Antillean, 1 Chicoid
	Great Inagua	Unidentified			1 unid. Antillean
Turks and Caicos					
	Grand Turk	Coralie	705, 1100	Carlson 1999:185 Keegan 2007:86 Cordell 1998	3 Ostionoid
	Middle Caicos	MC-6	1437 ± 70 (uncal.), 1430–1530, 1560–1630, 1460–1660, 1473–1636	Keegan 2007:142 O'Day 2002:4 Morsink 2012:233	1 Chicoid
		MC-8		Keegan 2007	1 Meillacoid, 1 unid. Antillean
		MC-10	1130 ± 50	Keegan 2007:171	1 Meillacoid, 1 unid. Antillean
		MC-32	1290 ± 50	Keegan 2007:164	2 unid. Antillean, 1 Chicoid
	Providenciales	Palmetto Junction	1334–1440, 1425–1450	Ciofalo et al. 2019:1639 LeFebvre et al. 2018:5	1 Meillacoid
Haiti					
	Hispaniola	Cadet			2 Chicoid
		Desmarreaux			1 Chicoid
		En Bas Saline	1300, 1250–1430, 1390–1500	Keegan 2007:73 LeFebvre 2015:125	5 Chicoid
		Grande Saline			2 Meillacoid
		Île à Rat	1295 ± 70, 905–950 ± 50	Keegan and Hofman 2017:131	2 Meillacoid
		Meillac		Keegan and Hofman 2017 Rouse 1939	2 Meillacoid
		Roche à Bateaux			3 Meillacoid
Dominican Republic					
	Hispaniola	Dajabon			2 Chicoid
		Hatillo Palma	894–1452	Keegan and Hofman 2017:126	2 Meillacoid
		La Mina			5 Chicoid
		Puerto Plata			3 Meillacoid, 1 Chicoid
Cuba					
	Cuba	Banes			1 Chicoid
		Bruno Arriba			2 Meillacoid, 1 Chicoid
		Cantabria			4 Meillacoid
		Guanabacoa			2 unid. Antillean
		Guanabo Beach			2 unid. Antillean
		Managuaco			3 unid. Antillean
		Punta de Pulpa			1 unid. Antillean
Jamaica					
	Jamaica	Bellevue		Allsworth-Jones and Rodrigues 2003 Scudder 1991	3 Meillacoid
		Chancery Hall	1250–1397, 1260 ± 50 (uncal.)	Wesler 2013:7 Allsworth-Jones et al. 2001:117 Allsworth-Jones and Rodrigues 2003	2 Meillacoid
		Rodney's House		Allsworth-Jones and Rodrigues 2003 Scudder 1991	1 Meillacoid
		Upton		Allsworth-Jones and Rodrigues 2003	3 Meillacoid

(*continued on next page*)

Table 2 (*continued*)

Country	Island/ Location	Site Name	Radiocarbon Dates (AD)	Citation	Samples
		White Marl	766–1166, 809–1217, 1034–1301, 1152–1302, 1155–1389, 1206–1397, 1267–1411, 1280–1666	Wesler 2013:7 Keegan and Hofman 2017 Allsworth-Jones and Rodrigues 2003 Scudder 1991	2 Meillacoid
United States					
	Puerto Rico	Hacienda Grande	120 ± 80, 370 ± 80	Rouse and Alegría 1978:499 Roe 1985	6 Saladoid
	Mona	Bajura de los Cerezos		Alegría 1983 Samson and Cooper 2015	1 Chicoid, 1 unid. Antillean
		El Corral		Alegría 1983 Samson and Cooper 2015	1 Ostionoid
		Mona (Unspecified)	2800–1000 BCE, 1272–1387, 1420–1458, 1480–1655	Samson and Cooper 2015:41 Cooper et al. 2016:1061 Alegría 1983 Dávila Dávila 2003 Frank 1998	1 Ostionoid, 1 unid. Antillean, 1 Chicoid

10, MC-6, and MC-32. MC-8 and MC-10 were both Hispaniolan settlements predating Chicoid pottery (Sinelli 2013). MC-6, the “gateway” into the Lucayan Islands (Sullivan 1981), and MC-32 date later with strong connections to Hispaniola (Keegan 2007). Keegan notes (2007) MC-6 and MC-32 both represent Lucayan sites, with relatively high frequencies of imported pottery. Radiocarbon dates for MC-6 (Morsink 2015) extend past CE 1513, the often cited date for the complete depopulation of the Lucayan Islands (Berman et al. 2013).

Sites on Long Island and Abaco, in the Central and Northern groups of the Lucayans Islands (Schulting et al. 2021; Sears and Sullivan 1978), respectively, yield similar radiocarbon dates. These dates mostly fall within the Early (AD 700/800–1100) to Late Lucayan Periods (CE 1100–1530+). On Abaco, most samples come from shoreline deposits and surface collections. Most of the sites represented on this island were likely temporarily occupied, such as Big Lake Cay. The Green Turtle Cay Ferry site has mostly eroded sherds and Blackwood Beach site is submerged at high tides as results of their placements along the coast (Keegan et al. 2022b). On Long Island, Rolling Heads was temporarily occupied while Wemyss has evidence of long-term use for over 400 years, including multiple living surfaces and two midden areas (Keegan et al. 2022a). At the Turtle Cove site, our surface collection included sherds from two different imported vessels.

3.3. LA-ICP-MS methods

We elementally analyzed samples via laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) to identify the clay composition. This point method is preferable to bulk methods such as neutron activation analysis (NAA) as it permits the user to focus on the clay matrix and avoid inclusions or tempering agents such as sand-sized rock particles that would attenuate the elemental signature related to the clay source. We carefully removed small fragments of each sample mounted them in 1″ diameter resin plugs. We polished the resin plugs using a Buehler Ecomet 6 (Buehler Ltd., Lake Bluff, IL) to expose a fresh cross-section of the pottery fragments.

Samples were then loaded into the NWR213 laser ablation system (Elemental Scientific, Bozeman, MT), coupled to an Element 2 mass spectrometer (Thermo, Waltham, MA) and an integrated camera was used to target ablation lines on each sample. Three lines for each sample were completed, 60μm wide and 600μm long. We laid the lines to avoid any obvious inclusions and voids > 30 μm, targeting only the clay matrix. Blank signal was collected before ablation of each line and subtracted from sample signal. We collected elemental intensity on 55 elements, including major, trace, and rare earth elements. Following Gratuze (1999), silicon was used as an internal standard to account for differential ablation and signal strength. After standardization, the three line readings for each sample were averaged together. Standards of known elemental composition (SRM 610, SRM 612, SRM 679) were included in the analysis. Standards were run at multiple points over the course of the day, using the same settings as for samples. The readings for standards were used to generate a response coefficient for each element, facilitating the conversion from intensity to parts-per-million values (ppm; Supplemental 1). Relative standard deviation (% RSD) was calculated from SRM readings to assess laboratory consistency and fell within acceptable limits for LA-ICP-MS (e.g., Sharratt et al. 2009:799). We analyzed the quantified data in R (V4.1.0). Element concentrations were log transformed, with missing values imputed using the program *Amelia* (Honaker et al. 2011). In general, mobile elements such as alkali metals and alkali earth metals may reflect the environment in which the ceramics were found but not necessarily the ceramic object itself. However, many of these elements, including sodium, calcium, and potassium also make up major mineral groups in the Greater Antilles. Given the potential for diagenetic enrichment of these elements, we removed these major elements from analysis and used trace elements cautiously, emphasizing those that have proven to be useful for characterizing specific clays or products (Rice 2015). The following elements were used for group determinations: Al, Si, Cr, Fe, Ni, Cu, Rb, Nb, Sn, Cs, Sm, Eu, Yb, Lu, Hf, Pb, U. We used principal components analysis to establish sample clusters representing trial compositional groups, which were then verified via the calculation of Mahalanobis distance probabilities on the first eight principal components, which accounted for 91.0 percent of total variance (probability ≥ 1.0 percent; Supplemental 2). Several of the resulting groups were small, which causes uneven weighting of individual samples. To diminish this effect, we jack-knifed the Mahalanobis distance probabilities to cross-validate group membership (Baxter 1999:330).

4. Results

We established nine elementally distinct compositional groups upheld via Mahalanobis distance probabilities (Figure 3; Table 3). Seven sherds were unable to be assigned to any compositional group. Given the

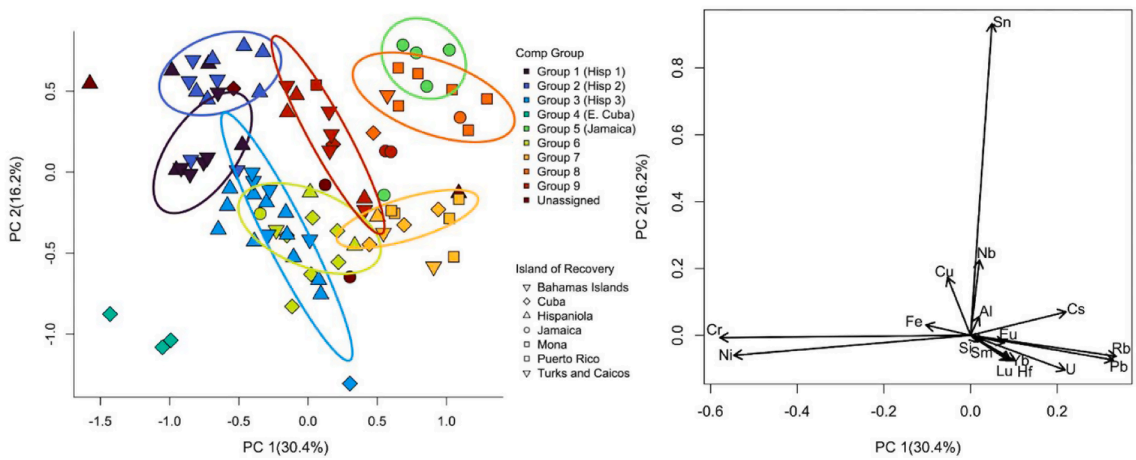

Fig. 3. Principal components analysis biplot showing Antillean compositional groups. Ellipses represent 90 percent confidence intervals. Samples ECK 119 and ECK 122 were far outliers and are not shown here.

Table 3
Sorted Compositional Groups and Islands of Recovery of Samples.

Island of Recovery	Group 1 (Hisp 1)	Group 2 (Hisp 2)	Group 3 (Hisp 3)	Group 4 (E. Cuba)	Group 5 (Jamaica)	Group 6	Group 7	Group 8	Group 9	Unassigned	Grand Total
Hispaniola	4	6	11			2	1		3	3	30
Cuba			1	3		6	3	1	1	1	16
Jamaica					5	1		1	2	2	11
Puerto Rico							5	1			6
Mona								5	1		6
Bahamas Islands	2	3	2			1	1	1	2	1	13
Turks and Caicos	3	2	3				1		3		12
Grand Total	**9**	**11**	**17**	**3**	**5**	**10**	**11**	**9**	**12**	**7**	**94**

complex and shared geology of the region and the lack of clay samples from these islands, we could not always isolate a single island as the geological source location for a given compositional group. In general, we have relied on the "criterion of abundance," assuming that a compositional group would be found most consistently in the location it was produced (Bishop et al. 1982). However, given the many shared geological features of the Greater Antilles, we recognize that multiple locations across the archipelago have the potential to yield similar compositions. Furthermore, while we identified spatial patterns in these compositional groups tied to particular regions, given incomplete spatial coverage we could not establish the full geographic extent of these groups beyond our known universe of sites sampled in this study.

There was a broad elemental distinction between pottery recovered from Hispaniola and Cuba, and that from Jamaica, Mona, and Puerto Rico. Cuba and Hispaniola share geological features such as Cretaceous metamorphic rocks that could result in similar elemental signatures (Wilson et al. 2019). The samples and compositional groups associated with Jamaica, Puerto Rico, and Mona also share elemental features indicating similar geology. Red laterite soils are common on these three islands, as well as limestone sedimentary deposits.

At least three groups likely represent production on Hispaniola. Two groups are associated primarily with sites on the north coast of Hispaniola. Group 1 (Hisp 1) is composed of samples from the north coast of Hispaniola, specifically the sites of Île à Rat and Meillac. These sites are located approximately 60 km apart, but atop shared Quaternary sedimentary features. Île à Rat is a small island off the northwestern coast with evidence of permanent occupation (Keegan 2007). Starting at its lowest levels, this site contains Archaic/Ostionoid pottery, Meillacoid pottery, Chicoid pottery, and Spanish pottery (Keegan and Hofman 2017). There is a sterile layer beneath the Chicoid pottery and above the Meillacoid pottery. We do not know whether clays suitable for pottery production are present on the small island of Île à Rat itself. Samples in this group are enriched in chromium and iron relative to other groups, and depleted in elements such as zinc and rubidium (Fig. 4). Hispaniola Group 1 contains multiple members that were imported to the Bahama archipelago including examples recovered from Abaco, Middle Caicos, and Grand Turk. Samples composing this group are visually consistent, thin (mean thickness = 5.22 mm) with grayish reduced paste. All decorated samples within this group exhibit the typical Meillacoid cross-hatched incising.

Group 2 (Hisp 2) is composed mainly of samples from the north coast of Hispaniola, particularly the site of En Bas Saline. En Bas Saline is a large village dating to the 13th century with possible connections to La Navidad, the first Spanish settlement established by Columbus (Keegan 2007; Deagan 1987). The earliest pottery is mostly Chicoid. These northwest coast sites are associated with Quaternary alluvial and coastal deposits and post-Eocene sedimentary marine deposits (Case 1980). This group is enriched in tin and zinc, and depleted in elements such as cesium and uranium. There are five sherds imported to the Lucayan Islands in this group, two recovered from Long Island, one from Grand Inagua, and two from Middle Caicos. The sherds are notably thick, with smoothed or burnished surfaces, and are significantly thicker (mean thickness = 6.61 mm; $p < 0.01$ via Tukey test) than the sherds composing Hispaniola Group 1. Most exhibit reduction or incomplete oxidation of the paste. All of the identifiable sherds in this group are Chicoid.

The third Hispaniolan group (Group 3) is composed mainly of samples from the west coast of Hispaniola (Haiti) and eastern Hispaniola (Dominican Republic). There are also five samples recovered in the Lucayan Islands, and one recovered in Cuba. Compared to the other Hispaniola groups, Hispaniola 3 is depleted in tin and cesium (Fig. 4), but enriched in hafnium. Overall, the three Hispaniola groups share

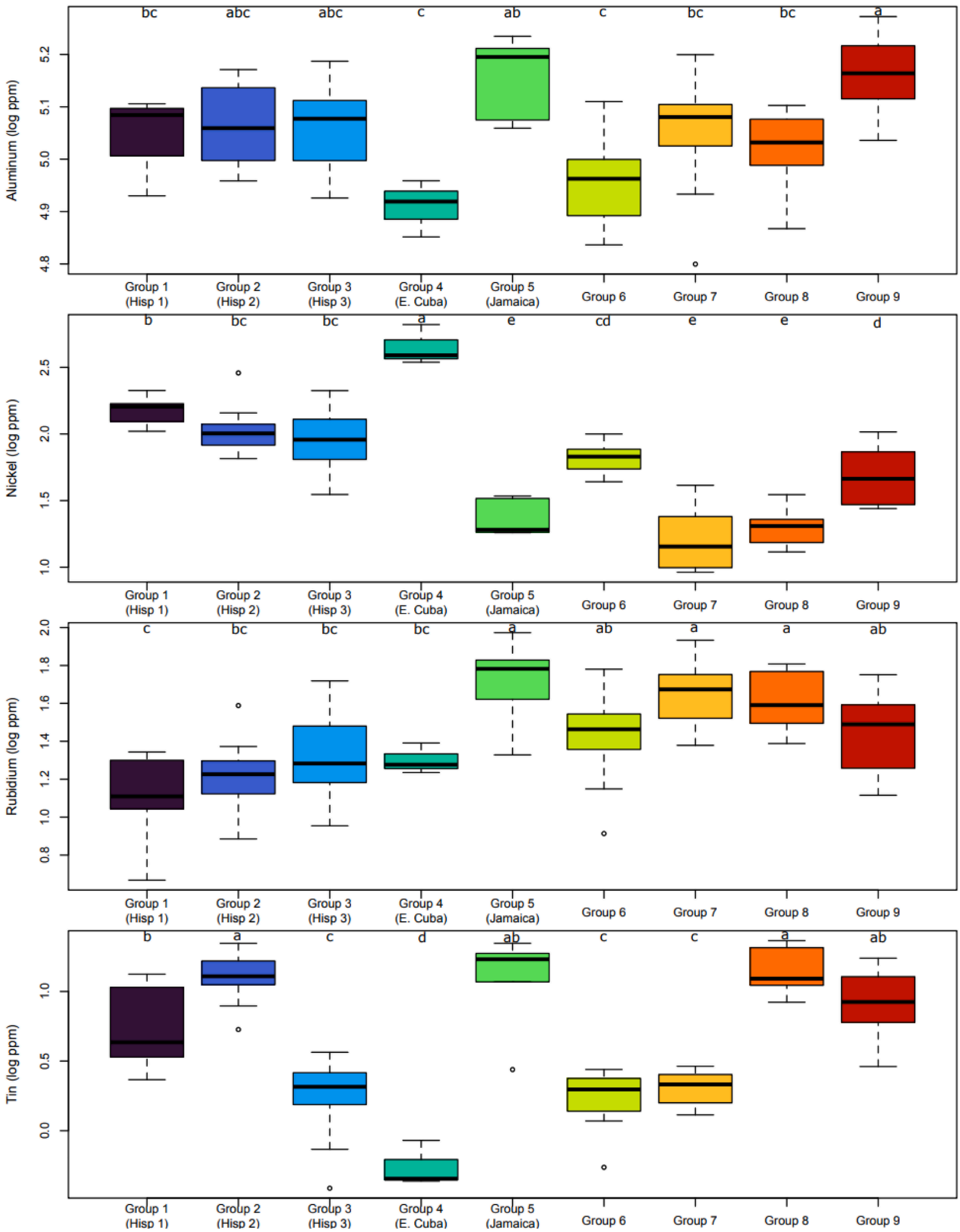

Fig. 4. Boxplots of selected elemental concentrations by compositional group. Groups with different letters are significantly different for each element as shown (Tukey's HSD, $p < 0.05$).

many similarities in elemental composition, particularly in terms of major elements (silicon and aluminum) as well as nickel and magnesium. Samples within this group exhibit variable surface treatment and are associated with multiple ceramic series.

Two additional groups could be tied to specific islands. Group 4 ($n = 3$) consists of samples from Bruno Arriba in eastern Cuba. This group is elementally very distinctive, enriched in elements such as silicon and nickel, and depleted in elements including tin and REEs. It is also enriched in chromium, which is mined in eastern Cuba (and other parts of Greater Antilles). The three samples in this group are generally well oxidized and have abundant fine inclusions of quartz. Group 5 consists of five samples recovered from Jamaica. Samples in this group are

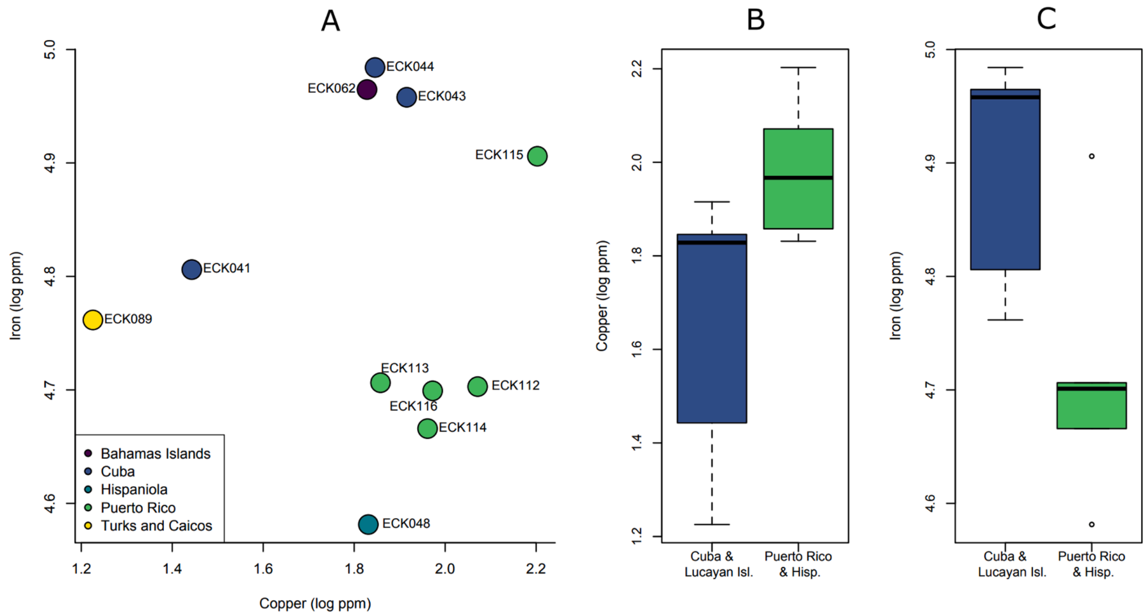

Fig. 5. (A). Bivariate scatter and (B) (C) boxplots of Group 7 showing elemental separation between subsetted western (Cuba and Lucayan Islands) and eastern (Puerto Rico and Hispaniola) members.

enriched in metals such as copper and tin, as well as cesium and rubidium. They are also high in aluminum, perhaps related to bauxite which is abundant in Jamaica. Samples are somewhat depleted in chromium and nickel relative to other groups.

The remaining four groups show varying levels of island-specific patterning, but cannot be firmly linked to a single island or source. Group 6 consists predominantly of samples recovered from western Cuba, but also several from other parts of Cuba and eastern Hispaniola, suggesting an inter-island compositional group based on shared geological features. A Jamaican sherd in classic White Marl form (navicular) also sources to this group, reinforcing the inter-island origins. This group includes a single vessel imported to the Lucayan Islands, a fragment of a white-slipped mammiform bottle recovered on Long Island. This form has been identified as originating from eastern Hispaniola (Keegan et al. 2022a; Krieger 1931).

Group 7 has poor geographic consistency. It includes five samples from the site of Hacienda Grande on the northeast coast of Puerto Rico, but also samples from Cuba, eastern Hispaniola, and imports to the

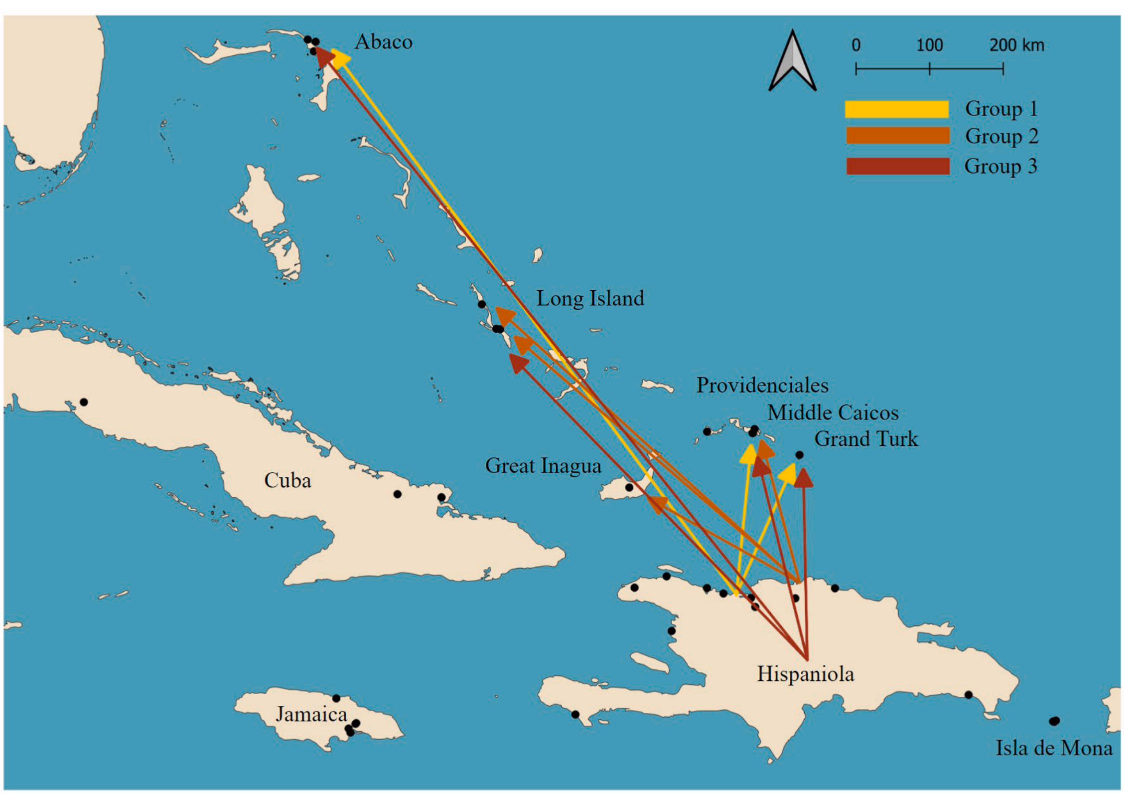

Fig. 6. Locations in the Lucayan Islands associated with vessels from the three Hispaniolan compositional groups.

Lucayan Islands. The three Cuban vessels were recovered in Cantabría in central Cuba, which, like northeastern Puerto Rico, is mostly underlain by limestone. The samples share enrichment in aluminum, and depletion in elements such as chromium and nickel (Fig. 5). Intragroup elemental variation in elements such as copper and iron suggest that there may be at least two geographic sources within this group, a western source primarily associated with Cuba, and an eastern source originating in Puerto Rico.

Group 8 consists of five samples recovered from Mona and additional samples from Puerto Rico, Jamaica, Cuba and two imports to the Bahama archipelago. It is unknown if pottery was both made on and brought to Mona. While small, Mona had large ceremonial sites including ballcourts. Inter-island interactions are thought to have taken place on Mona with people from eastern Hispaniola and Puerto Rico (Cooper et al. 2016; Dávila Dávila 2003). The extent of the geographic region associated with this group is not known. Samples in this group are enriched in REEs such as hafnium and lutetium as well as tin. This group is depleted in elements such as chromium and iron.

Group 9 contains samples that have "average" compositions of many elements, as evidenced by its central location in the PCA (Fig. 3). It includes samples from most of the islands tested, and may represent pottery made from secondary weathered clays, given the high aluminum concentration. Calcium concentration is low. Overall, it is most similar in composition to Group 6.

5. Discussion

Despite complex and shared geological features within the Greater Antilles, there are elemental differences in clay composition that appear to be specific to particular islands and island regions. Additionally, there are broader inter-island compositional groups. However, lacking samples of raw materials to specifically tie pots to production locales, the delineation of specific sources cannot be made. Within the Antilles, and particularly on Hispaniola, the majority of the pottery seems to have been produced on the island on which it was recovered.

Two examples in the assemblage provide the best evidence for inter-Antilles trade: ECK033, a sherd recovered from northeastern Cuba that was likely produced in western Hispaniola based on group assignment (Group 3), and ECK048, a Chicoid sherd recovered from southeastern Hispaniola, which may have been produced in Puerto Rico (Group 7). Intra-archipelago trade of pottery may have been limited or largely unnecessary given the abundance of pottery clay on these islands. Despite limited evidence of specific trade of vessels, decorative motifs clearly were being shared. It is notable that Palmetto Ware has not been reported outside of the Lucayan Islands. As a more expedient and less durable product, it likely did not achieve the status of a trade item.

Overwhelmingly, the vessels imported to the Lucayan Islands were produced on Hispaniola. Northwest Hispaniolan compositional groups were dominant, though examples consistent with the broader western and eastern Hispaniola group also were found (Fig. 6). We anticipated that northwest Hispaniola would be an important source for vessels bound for the Lucayan Islands given geographic proximity to the southern end of the archipelago, but it was still surprising to find that samples recovered on Abaco in the northern Bahamas also originated from Hispaniola.

Though connections between Cuba and Bahamas have been hypothesized (Berman and Gnivecki 1995; Granberry and Winter 1995), few lines of concrete evidence have been recovered. We anticipated that Cuban vessels would comprise some part of the imports to the Lucayan Islands, but only two samples, ECK062, a Chicoid sherd recovered on Abaco, and ECK089, an unidentified imported sherd recovered on Middle Caicos exhibited elemental characteristics consistent with pottery from central Cuba.

While the small number of imports in the Lucayan Islands and their fragmentation limited the sample size of sherds identified by series, there is some evidence for different Hispaniola sources tied to cultures. Group 1/Hispaniola 1 is dominated by Meillacoid pottery, while Group 2/Hispaniola 2 is dominated by Chicoid pottery (Fig. 6). This suggests potential waves of migration or interaction from Hispaniola to the Lucayan Islands. The earliest wave appears to have started from a small area on the northwest coast, associated in our samples with the site of Meillac. Vessels in this compositional group reached Abaco, in the northern extent of the archipelago. Samples associated with Chicoid sites on the northwest coast of Hispaniola reached at least as far north as Long Island. The samples selected from Middle Caicos also reinforce the idea that Group 1/Hispaniola 1 represents an earlier wave of movement into the Lucayan Islands. MC-8 and MC-10 sherds sorted into Group 1/Hispaniola 1, while sherds recovered on MC-32 sorted into Group 2/Hispaniola 2. MC-8 and MC-10 were both early Hispaniolan settlements, consisting of mostly imports and predating Chicoid pottery (Keegan 2007). MC-32 was a Lucayan settlement, dating later than MC-8 and MC-10, with close ties to Hispaniola. Samples from broader Hispaniola (Group 3), which spans Ostionoid to Chicoid series also reached the full extent of the archipelago from Abaco to Grand Turk.

All samples from Green Turtle Cay Ferry on Abaco sort into Group 1/Hispaniola 1 whereas the Coralie samples, which were entirely imports, sort into both Group 1/Hispaniola 1 and Group 3/broader Hispaniola. Sherds from Green Turtle Cay Ferry may represent an isolated event or down-the-line exchange with the northwest coast of Hispaniola while Coralie attracted people from different places across Hispaniola, with more intensive and prolonged connections.

We were optimistic that the groups generated from elemental analysis would have visual similarities as well, but this was only the case for Groups 1 and 2. These two groups were similar in decoration, thickness, paste oxidation, and to a lesser extent, inclusions, matching the patterns Cordell (1998) found for Meillacoid and Chicoid pottery. For most other groups, there were no dominant shared visual attributes. For the most part, there was no clear relationship between source group and inclusion type. The sherds within most compositional groups were highly variable in terms of the type and density of visible mineral inclusions. However, petrographic analysis would provide much more fine-grained data, and perhaps identify specific minerals that have narrow geological ranges in the Greater Antilles. Furthermore, we recognize that clay specimens from the Greater Antilles should be collected and elementally analyzed to more firmly define the geographic boundaries of our proposed compositional groups.

6. Conclusions

Our evidence shows that northwest Hispaniola was likely the primary source for imported pottery recovered throughout the Lucayan Islands. Imported pottery recovered from the Lucayan Islands sorted predominantly into compositional groups associated with Hispaniola. This finding reinforces other lines of evidence linking this region of Hispaniola to sites of interaction in The Bahamas and Turks & Caicos. The Lucayans and groups in the wider Caribbean clearly maintained relationships across the archipelagos through trade and other social interactions. The surprising lack of evidence for direct trade with Cuba, at least through pottery, suggests that navigation to the Lucayan Islands was constrained or controlled by social or environmental factors that we have yet to identify.

By generating the first dataset to elementally assess pottery production across the Greater Antilles, we have established a baseline for future studies. We anticipate expanding this analysis to include clay and other geological specimens, as well as more complete coverage of the archipelago and pottery styles. Finding shared elemental signatures across islands, our results emphasize the importance of geographically broad datasets to adequately sample the potential range of variation, or lack thereof, within a research area. Further research into chronological variation of Antillean imports may provide better evidence for the peopling of the Lucayan Islands and subsequent interactions between the Lucayans and their neighbors to the South.

7. Data Statement

All of the data are reported in this article. The samples are curated in the Caribbean collection at the Florida Museum of Natural History. Additional information can be requested from the corresponding author.

Funding

Funding was provided by the National Geographic Society (NGS-55292R-19), and the Island Archaeology Endowment, Florida Museum of Natural History.

CRediT authorship contribution statement

Emily C. Kracht: Conceptualization, Investigation, Formal analysis, Writing – original draft. **Lindsay C. Bloch:** Conceptualization, Investigation, Formal analysis, Writing – original draft. **William F. Keegan:** Conceptualization, Resources, Funding acquisition, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Permission to conduct this research was provided by the National Museum of the Bahamas/Antiquities, Monuments, and Museum Corporation. We appreciate the assistance of Ms. Kim Outten-Stubbs (Acting Director) and Dr. Grace Turner (Archaeology Director). Funding was provided by the National Geographic Society (NGS-55292R-19), and the Island Archaeology Endowment, Florida Museum of Natural History. We are indebted to the many individuals who contributed to the recovery of samples we analyzed, especially Roberto Valcárcel Rojas who provided pottery samples from Cuba. We also thank and appreciate the valuable feedback of our anonymous reviewers. We thank Nicolas Delsol and Rose Esqueda for their assistance with French and Spanish abstracts (Supplemental 3).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2022.103469.

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