

NEUTRON ACTIVATION ANALYSIS OF COLONIAL CERAMICS FROM SOUTHERN HIGHLAND ECUADOR*

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Sixty-one ceramic samples collected in Cuenca, Ecuador, were analysed by neutron activation analysis in an attempt to establish their elemental compositions. The bulk of the samples were manufactured in the region of Cuenca, with others imported from Quito in the northern highlands of Ecuador, from Panama Vieja in Panama, and from Seville in Spain. Relative to the Cuenca ceramics, the Spanish samples were separable primarily by their high Ca contents; the Panamanian ceramics by their high Cs contents; and the Quito ceramics by their high Na contents. The ceramics made within the region surrounding Cuenca are much more difficult to separate, with Ba and other elements being potentially important.

KEYWORDS: MAJOLICA, POST-MEDIEVAL, NEUTRON ACTIVATION ANALYSIS, PROVENANCE, ECUADOR, SOUTH AMERICA, CUENCA

INTRODUCTION

This paper addresses the analysis of colonial (AD 1540–1830) trade patterns in majolica ceramics along the Pacific coast of South America (see Fig. 1). In it, we attempt to source the ceramics as to their place of manufacture, and with this data reconstruct the patterns of manufacture and trade in ceramics for the Spanish colonies of the northern Andes. We identify ceramics from Seville and Panama, and provide signatures for ceramics from Quito and Cuenca, Ecuador.

Majolica ceramics, defined by their tin glazes, were the standard tableware of the Spanish colonial elite in the New World. Manufactured originally in Spain, with glaze technology imported from the Near East and Italy, majolicas are one of the most important and informative artefact categories excavated on Spanish colonial sites. These have proved useful in addressing archaeological research questions on trade patterns in the Spanish colonies, as well as issues of status and material culture use (Deagan 1998, 2001).

Initial formulations of the relationship between ceramics and ethnicity in the Spanish New World colonies tended to emphasize the ‘Spanish’ ethnicity of those using majolica ceramics, and the ‘indigenous’ ethnicity of those making and using unglazed, locally made earthenwares. As we have gained more knowledge of Spanish colonialism, however, such a simple dichotomy has been extensively challenged. Researchers are now well aware that material culture had a role to play in the creation and maintenance of complex ethnic and status boundaries throughout the colonial period (Boyer 1997; Deagan 1998; Dean and Leibsohn 2003).

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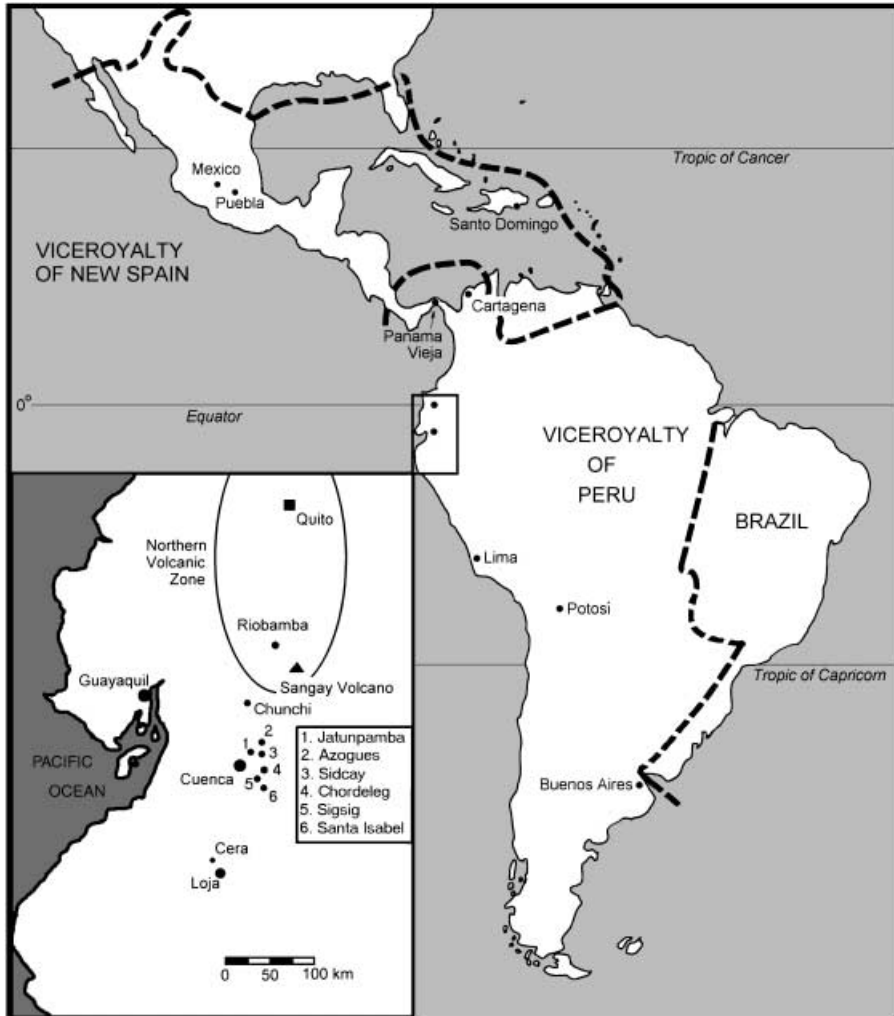


Figure 1 A map of colonial Latin America, with the places mentioned in the text.

Rather than simply presuming that a ceramic style was produced and used by a particular ethnic group in colonial society, we must instead be willing to look at all the evidence in terms of the ongoing re-evaluation of the meaning of particular ceramic styles to social actors in the colonial world (Howson 1990; Paynter 2000; Rodríguez-Alegría *et al.* 2003).

In order to effectively address such questions we must, then, separate out issues of ceramic stylistic change from those of manufacturing location. One of the most basic, yet important, questions for Spanish colonial archaeologists is to identify where individual majolica specimens were manufactured. This is usually addressed by visual inspection of paste colour, vessel form, decorative pattern, and glazes. In the 16th century, soon after the founding of cities such as Mexico City and Puebla in Mexico, and Panama Vieja in Panama, manufacturing centres for majolica were set up to supply ceramic tableware to New World colonists (Lister and Lister 1978, 1984; López Palacios

et al. 1995; Jamieson 2001; Rovira 2001). Majolicas were also imported from Spain to the colonies of the Spanish Caribbean and Florida (Goggin 1968; Deagan 1987).

An essential problem is that ceramic sherds manufactured in different places can appear to be identical on the basis of visual inspection only. This problem has been addressed for archaeological samples of the Caribbean and Central America using several physical and chemical tests. Gamma-ray induced thermoluminescence has been used to distinguish majolica samples imported to the Caribbean colonies from Spain, Holland, Italy, Panama and Puebla, Mexico (Vaz and Crucent 1975). The most successful results have been with instrumental neutron activation analysis (INAA). Using INAA, researchers have been able to successfully distinguish specimens of majolica manufactured in Spain, Mexico City, Puebla and other centres (Olin *et al.* 1978; Maggetti *et al.* 1984; Olin and Blackman 1989; Olin and Myers 1992).

There is little historical knowledge of the starting dates or locations of majolica manufacturing centres in Andean South America. Only a few archaeological projects have focused on historical archaeology in Andean South America (Smith 1991; Rice 1996; Gasco *et al.* 1997; Van Buren 1999; Jamieson 2000), and INAA data from historic ceramics from the region are non-existent. It is currently believed that Andean majolicas in the early colonial period were imported from Panama Vieja, and that these were later replaced by ceramics made in various Andean cities, including Quito, Lima and Cuzco (Lister and Lister 1974; Jamieson 2001; Rovira 2001). By definitively sourcing the places of manufacture for ceramics found in Ecuador, these issues can be more authoritatively discussed.

Our current model suggests that imported Panamanian majolicas supplied the Andean colonies with the majority of their needs until the end of that industry in the 1670s (Jamieson 2001; Rovira 2001). The beginnings of local majolica production in Andean colonial cities are still poorly understood. Lister and Lister (1974) suggested that highland centres such as Quito, Cuenca and Cuzco began producing majolica in the mid-18th century. These products are uniformly described as thinly glazed, with low tin content in the background glaze, and decorations in green and brown. They appear to have been created to supply local markets, in contrast to the situation in New Spain, where high-quality majolica from Mexico City and Puebla supplied wide areas of the empire (Lister and Lister 1987).

Visual differentiation of some varieties of Andean majolicas is possible, but a chemical characterization of various Andean majolicas is vital to our understanding of regional manufacturing and trade. This would allow us, and other researchers, to verify our visual identifications, and securely identify imported ceramics from Panama or other areas. INAA has proved ideal for securely sourcing majolicas from other colonial-period excavations in the Americas, and there is a pressing need in the Andes to undertake chemical characterization of colonial ceramics. Such studies will allow us to create a history of colonial ceramic manufacture and trade throughout the region.

This is the first Andean study to contribute to the growing corpus of data on Spanish colonial ceramic sources in both Europe and the Americas, and provides baseline data on colonial ceramic trade patterns in northwestern South America. It is our sincere hope that future studies will build comparable data for other Andean regions.

LOCATION AND GEOLOGY

The city of Cuenca (2°50'S, 79°0'W) was founded by the Spanish in 1557, on the ruins of the Inka centre of Tomebamba (Poloni Simard 1997; Idrovo Urigüen 2000; Jamieson 2000). It is located in the Tomebamba River Valley in the southern highlands of Ecuador. Cuenca is located in the northern

part of the 'Quaternary volcanic gap', a region of the Andes between 2°S and 15°S that has no active volcanoes. To the north, the first active volcano encountered is Sangay (1°58'S, 78°25'W). The Sangay Volcano is 125 km north-east of Cuenca, and marks the southern limit of a 'northern volcanic zone' in Ecuador, running from 2°S to 1°N, which contains several currently active volcanoes, including those in the immediate surroundings of the city of Quito (Beate *et al.* 2001).

Potters are still producing majolica ceramics in the San Sebastian neighbourhood, in the northwestern part of the city of Cuenca (González 1991; Sjöman 1992; Castillo 2003). They acquire their clay from local alluvial deposits in the neighbourhood, which are eroded from the surrounding Late Miocene Tarqui and Turi Formations (Hungerbühler *et al.* 2002). The chemistries of these older, weathered sediments should be differentiable from sediments used by potters in centres such as Quito, where volcanic activity is ongoing.

When attempting to distinguish amongst multiple local ceramics, a potential source of trouble in sorting the ceramic data comes from the variability of elemental concentrations in different sediment horizons at a single location—let alone at different geographical locations (Mahaney *et al.* 2000a,b, 2001a,b). This is especially so in volcanic regions such as highland Ecuador, where the chemistries of successive eruption ejecta may be radically different (Stim-mell *et al.* 1982). It also occurs in mountainous regions that have seen differential corrosion of the parent rocks over geological time.

As a potter digs deeper in the earth, more weathered sediments may be found in the same clay pit. With different relative mineral mixtures in sediments of different ages, elemental concentrations may vary by at least a factor of two at a single location. For very fine wares, this tends not to be a problem. It is also less of a problem when ceramics are made from material from large river systems, where the sediment mixing tends to be thorough, resulting in clay deposits that are more uniform.

SAMPLES

The samples to undergo INAA analysis came from a variety of sources. The majority were excavated archaeologically from urban contexts in the city of Cuenca, in the southern highlands of Ecuador. Majolica sherds collected in Quito by Ecuadorian government archaeologists were also included. One sample of local raw clay from Cuenca, and three sherds of modern ceramics purchased in the Cuenca market, provided baseline comparisons. All sample collection work was performed under permit from the Instituto Nacional de Patrimonio Cultural del Ecuador, the government agency charged with the protection of Ecuador's archaeological resources. Several samples from each visually identified category were analysed in order to show the range of concentrations of certain elements in ceramics thought to be manufactured in the same centre.

Majolicas are still manufactured in Cuenca, Ecuador, as well as in the town of Chordeleg, 30 km east of the city. Unglazed coarse earthenwares are also still produced in villages throughout the southern highlands of Ecuador and sold in Cuenca markets. These would include items from Jatumpamba, 22 km north-east of the city, and Cera, 120 km to the south of Cuenca (Sjöman 1989, 1992). Documents from the 16th and 17th centuries provide clear evidence that ceramics were being produced in many southern highland villages during the colonial period, including Sidcay (10 km north-east of Cuenca), Azogues (25 km north-east), Chordeleg (30 km east), Sigsig (30 km south-east), Santa Isabel (50 km south-east) and Chunchi (70 km north) (Paniagua Pérez and Truhan 2003, 554–8). It is assumed that most, if not all, of these rural potters would have produced unglazed coarse earthenwares. This is an

incomplete list, both in terms of modern, and colonial, ceramic production centres in southern highland Ecuador. Many rural villages throughout the region in the colonial period included potters in their communities, and some still do.

EXPERIMENTAL PROCEDURE

Powdered ceramic samples (≈ 1100 – 1400 mg) were prepared in 1 ml plastic vials (Hancock 1984) for instrumental neutron activation analysis (INAA) at the SLOWPOKE-2 Reactor Facility of the Royal Military College of Canada. Elements that produce short-lived radioisotopes, such as U, Dy, Ba, Ti, Mg, Na, V, Al, Mn, Ca and Cl, were detected in the samples that were irradiated serially for 30 s at a neutron flux of 5.0×10^{11} n cm⁻² s⁻¹ (following procedures established by Hancock, 1984). After about 19 min, and the decay of ²⁸Al to acceptable limits, each sample was assayed using 5-min counts with on-site gamma ray spectrometers. The samples were recounted for 5 min the next day for Eu, Ga, Na and K. All samples were later batch irradiated for 4 h at a neutron flux of 5.0×10^{11} n cm⁻² s⁻¹. After 7–8 days, the concentrations of Sm, U, Yb, La, As, Sb, Br, Sc, Fe and Na were determined, using 10-min countings of each sample. Sodium was used to cross-check the first and second analyses. After two weeks, the samples were recounted and the concentrations of Nd, Ce, Lu, Ba, Th, Cr, Hf, Sr, Cs, Ni, Th, Sc, Rb, Fe, Co, Ta and Eu were determined using 5000-s counts. Again, Fe and Sc were used as cross-checks with the third phase of the analysis. Multi-elemental calibrations were confirmed using international rock standards.

RESULTS AND DISCUSSION

Chemical group sorting of the data was done prior to the sharing of the physical appearance information of the ceramics, from which the samples were taken. This information helped define the origins of some of the samples, and was used to see if chemical groupings made archaeological sense. Prior to the data sorting process, data from elements, such as Br, Cl, Dy and Ni, that generated many or all detection limits were eliminated, leaving data for 29 elements in 61 samples. Chemical group separation was achieved by eye, taking into consideration that the average variability for many elements was a factor of three, a not unusual occurrence for sedimentary material (Mahaney *et al.* 2000a,b, 2001a,b). Four elements (As, Ca, Cs and Mn) varied by over a factor of 10, while seven elements (Ba, Ce, Cr, K, La, Na and Rb) varied by a factor of four to five. These 11 elements tend to be diagnostic.

The first clear chemical grouping, with very high Ca and Cr, contained samples 20–22 and sample 61 (Table 1). Samples 20–22 were from unglazed olive jar (Deagan 1987, 30–5) fragments excavated in late 16th or early 17th century Cuenca archaeological contexts (Jamieson 2000). These have long been assumed to have been made in the Triana neighbourhood of Seville in Spain (Lister and Lister 1987, 80–1). Sample 61 was an olive jar sherd with green interior lead glaze (Deagan 1987, 33) from the same context. This may be surmised from its chemistry to have been made in the same location.

The second clear grouping (14, 27–30, 46, 47, 51, 52 and 62) included samples with very high As and Cs concentrations (Table 2). Most of these had been visually identified as Panama blue-on-white and Panama plain majolicas (Deagan 1987, 92; Jamieson 2001; Rovira 2001). Samples 47 and 62 were not visually identified as Panamanian majolica, because the paste colour seemed to be too light an orange, but the chemistry shows they are in fact Panamanian in manufacture.

Table 1 *Spanish ceramics*

	VID	Ca (%)	Mn	K (%)	Na (%)	As	La	Sm	Ba	Ce	Co	Cr	Cs	Eu	Fe (%)	Hf	Rb	Sc	Ta	Th
20	UOJ	5.13	1180	3.1	0.55	10.8	33.2	5.07	780	65.6	24.1	109	8.1	0.73	4.50	3.73	126	15.1	1.21	10.0
21	UOJ	6.95	959	3.1	0.57	6.19	34.2	5.25	620	64.9	19.7	105	8.2	0.66	3.92	3.77	124	14.9	1.16	10.1
22	UOJ	6.48	336	2.4	0.50	7.04	33.4	5.19	1020	68.3	12.4	116	6.7	0.71	3.58	6.38	99	14.0	1.31	10.4
61	GOJ	8.38	410	1.4	1.18	4.58	33.2	5.17	670	65.4	15.8	106	9.2	0.72	3.67	3.63	100	14.7	1.18	10.2

Abbreviations: VID, visual identification; UOJ, unglazed olive jar; GOJ, green lead-glazed olive jar.

Table 2 *Panamanian ceramics*

	VID	Ca (%)	Mn	K (%)	Na (%)	As	La	Sm	Ba	Ce	Co	Cr	Cs	Eu	Fe (%)	Hf	Rb	Sc	Ta	Th
14	PBW	1.66	808	2.7	1.40	47.7	31.4	5.25	560	61.5	23.6	41	60.2	0.79	5.14	4.83	149	18.7	0.89	13.1
27	PBW	2.65	1090	2.8	1.64	47.3	30.0	4.87	700	64.0	21.8	35	46.2	0.79	5.14	5.03	164	18.8	0.89	13.8
28	PP	1.71	892	2.2	1.82	48.4	28.4	4.83	580	56.6	20.6	31	87.8	0.74	4.68	4.98	151	18.1	0.79	14.2
29	PP	1.97	936	2.3	1.78	40.4	28.4	4.88	590	57.5	21.7	28	61.1	0.69	5.17	4.84	153	19.5	0.79	15.7
30	PP	1.49	776	2.2	1.82	52.1	27.4	4.62	560	54.3	18.7	33	76.8	0.73	4.48	5.26	139	16.7	0.75	13.0
46	PP	1.68	654	2.3	1.67	36.2	27.8	4.66	510	54.9	19.2	30	43.4	0.65	4.31	5.61	132	17.3	0.98	14.1
47	UID	1.91	1010	2.6	1.90	42.6	25.8	4.55	590	54.4	18.5	29	58.2	0.71	4.57	4.93	136	16.9	0.94	13.2
51	PP	1.87	871	2.7	1.92	37.1	29.7	4.67	590	59.1	20.1	32	99.8	0.82	4.84	5.12	178	18.4	0.86	14.2
52	PP	1.65	868	2.1	1.83	38.8	30.3	4.89	610	60.0	19.4	30	69.8	0.77	4.87	4.92	150	19.1	0.92	14.5
62	UID	1.73	749	2.2	1.67	40.5	28.6	4.84	650	58.6	19.8	32	93.2	0.81	4.74	4.85	148	17.9	0.86	13.9
31	UID	2.68	1260	2.2	1.81	20.9	26.6	4.83	590	53.0	21.8	36	17.1	0.60	5.34	4.28	114	19.7	0.68	12.6
35	RW	2.64	1360	2.3	2.00	21.8	27.1	5.02	400	36.0	16.2	26	10.4	0.49	3.86	3.10	78	14.9	0.51	8.2
36	RW	2.77	971	2.6	1.63	19.4	25.1	4.03	550	54.1	16.1	34	22.2	0.57	4.27	4.72	137	15.0	0.96	11.6
37	RW	1.49	314	2.7	1.58	30.2	30.0	4.85	510	58.8	16.4	32	27.5	0.65	3.89	5.64	122	16.5	1.03	13.2

Abbreviations: PBW, Panama blue-on-white; PP, Panama plain; UID, unidentified; RW, redware.

A second group (31, 35–37) consists of one blue-on-white glazed majolica fragment with an orange paste (31), and three 17th century unglazed redware fragments (Deagan 1987, 38–9). From its chemistry, this group was probably made in Panama (Table 2), since all elements but As and Cs (both lower) match the first Panamanian grouping, and do not have the very high Ca and Cr concentrations of the Spanish material.

Having unravelled the foreign chemistries, the remaining 43 samples were probably Ecuadorian. The first level of sorting of the Ecuadorian ceramic data was therefore based on Na and K. This sorts samples by potentially less weathered sediments to more weathered sediments. This may represent the differences between younger and older sediments, or origins in completely different parent materials. Since the Cl concentrations were negligible (so much so that they were not included in the data set), the measured Na concentrations were considered to be NaCl contamination-free.

From the Na sorting, there appear to be three broad groupings:

- (1) Na > 1.7%, K \approx 1%;
- (2) Na \approx 1%, K = 1–2%;
- (3) Na < 0.8%, K = 1–2%.

Samples 16, 24, 25 and 38–42 exhibit high Na contents, with K contents around 1% (Table 3). Samples 38–42 were all collected from Quito in the northern highlands of Ecuador and were presumably made there. These include polychrome majolicas in green, brown and cream (38–40) as well as a blue-on-white majolica (41) and a plain white majolica sherd (42). The chemistries of samples 38–42 match rather well, providing a signature for at least one subset of majolicas produced in Quito in a variety of palettes.

The chemistries of samples 16, 24 and 25 are similar to, but distinct from, those of the Quito majolicas. Sample 16 was a prehispanic Inka piece of unknown origin, visually identified by its brown slip chequerboard pattern of decoration (Idrovo Urigüen 2000, 304). Samples 24 and 25 were unglazed red-slipped pieces excavated from a 19th century context in Cuenca. With this limited sampling it is not possible to tell the chemical differences, if any, between glazed majolica ceramics made in the northern highlands in and around Quito, and unglazed ceramics made in the southern highlands in villages outside Cuenca, where volcanic sediments are presumably less weathered than in Cuenca itself.

Of the 35 remaining Cuenca pottery sample data sets, the high-Ba samples are intriguing. Samples 5, 6, 8, 9, 11 and 12 form a coherent grouping characterized by a relatively high Ca content of 2.5–3.6% (Table 4). These are all unglazed pieces, with red slip, excavated from a 17th century Cuenca context (Jamieson 2000, 175–83).

The other samples (2–4, 7, 10, 34 and 50) form a clump rather than a group (Table 4). They are united only by their high Ba contents. Each differs in different elements from its neighbours. They collectively differ from the 'real' high-Ba Cuenca grouping by their relatively high Cs and Hf; often high As, Rb and Th; and low Ca. Their rare earth elements tend to be higher as well, perhaps denoting that they were made from younger source sediments. Samples 2 and 3 are 20th century Cuenca majolica sherds excavated from a kiln deposit in the *Convención del 45* potter's neighbourhood, and thus made in Cuenca at the same location as the clay sample (57) (Castillo 2003, 82–96). Samples 4, 7 and 10 are 17th century unglazed red-slipped pieces excavated in Cuenca (Jamieson 2000, 175–83). Samples 34 and 50 are 17th century unglazed roof tile fragments, and presumably local (Jamieson 2000, 151).

The 23 remaining samples' data sets form another clump (Table 5), with some chemical similarities but also with many distinct differences among them. Sample 1 is a 20th century piece excavated from a kiln in Cuenca, and is certainly of Cuenca origin (Castillo 2003, 82–96).

Table 3 *Ecuadorian ceramics from Quito or other mountainous regions*

	VID	Ca (%)	Mn	K (%)	Na (%)	As	La	Sm	Ba	Ce	Co	Cr	Cs	Eu	Fe (%)	Hf	Rb	Sc	Ta	Th
38	QPC	2.76	507	1.2	1.98	3.57	23.5	3.37	720	42.0	11.9	47	2.0	0.56	4.31	3.86	48	11.3	0.71	6.6
39	QPC	2.34	447	1.1	1.95	3.44	23.0	3.30	680	39.0	10.5	45	2.0	0.55	4.33	3.93	53	11.6	0.63	6.4
40	QPC	2.19	423	1.1	1.78	5.54	25.9	3.61	730	39.5	9.2	42	2.4	0.60	4.35	3.88	51	11.0	0.67	6.8
41	QBW	2.20	567	1.4	1.94	7.38	25.1	3.43	730	43.0	11.7	37	2.3	0.56	3.82	3.74	54	10.2	0.55	6.4
42	QP	2.13	388	1.2	1.79	3.96	21.7	3.15	690	33.4	8.4	42	1.8	0.51	4.04	3.53	46	10.4	0.54	6.1
16	IS	1.02	332	1.0	1.80	7.95	13.5	2.34	490	25.9	8.3	32	3.8	0.35	3.52	4.35	35	8.7	0.63	5.5
24	RS	2.63	641	1.2	2.10	6.45	30.5	3.96	750	55.6	13.1	45	2.0	0.63	3.64	3.90	43	11.4	0.62	7.4
25	RS	2.51	865	1.1	1.80	7.02	13.0	2.27	900	28.2	11.8	34	4.8	0.40	3.85	3.25	39	12.4	0.47	4.8

Abbreviations: QPC, Quito polychrome; QBW, Quito blue-on-white; QP, Quito plain; IS, Inka slipware; RS, red-slipped coarse earthenware.

Table 4 *The high-Ba ceramics of Cuenca*

	VID	Ca (%)	Mn	K (%)	Na (%)	As	La	Sm	Ba	Ce	Co	Cr	Cs	Eu	Fe (%)	Hf	Rb	Sc	Ta	Th
5	RS	3.07	315	1.1	1.16	10.4	9.41	1.77	1620	19.5	8.7	27	3.7	0.34	3.28	2.93	36	12.7	0.39	4.5
6	RS	2.50	1270	1.0	1.21	12.4	13.9	2.48	1500	25.5	19.6	34	3.0	0.40	4.32	3.59	32	11.9	0.72	6.0
8	RS	2.50	1070	1.0	1.45	8.9	13.3	1.99	1420	23.7	18.5	35	4.4	0.38	3.18	2.89	18	10.2	0.42	4.3
9	RS	2.94	818	1.1	1.32	9.9	11.5	1.97	1390	21.6	12.3	28	3.5	0.38	3.72	2.79	37	12.1	0.59	5.8
11	RS	2.80	798	1.2	1.28	11.4	12.3	2.14	1800	23.9	16.4	34	2.5	0.35	3.31	2.80	30	11.1	0.61	5.4
12	RS	3.57	809	1.2	1.28	12.0	11.9	2.14	1720	23.3	15.8	19	2.6	0.37	3.42	2.85	32	11.0	0.54	3.7
2	CP	0.40	736	0.9	0.62	24.1	21.1	3.31	1430	48.2	17.0	39	7.1	0.44	3.39	6.49	57	12.8	0.85	9.5
3	CP	0.55	915	1.2	0.47	18.2	17.1	2.65	1650	44.2	19.9	43	6.3	0.35	3.42	7.01	45	12.0	1.06	9.4
4	RS	1.00	602	0.9	0.42	12.4	10.8	2.02	1550	18.2	9.3	70	11.0	0.30	3.18	4.88	36	11.2	0.59	5.5
7	RS	1.28	1400	1.5	0.80	25.0	17.1	3.04	1580	30.6	17.8	27	7.2	0.38	3.36	4.73	63	12.3	0.89	8.3
10	RS	1.18	1270	1.6	0.87	22.6	13.9	2.53	1440	29.7	17.3	30	6.8	0.38	3.52	5.22	64	12.7	0.78	8.6
34	URT	0.91	656	2.0	1.26	29.0	43.6	6.62	1570	85.5	15.9	34	12.6	1.05	3.63	5.03	99	14.5	0.84	10.7
50	URT	1.09	846	1.5	0.95	21.1	17.5	2.57	1930	63.8	16.2	31	8.4	0.35	3.57	5.39	110	13.4	0.89	11.9

Abbreviations: RS, red-slipped coarse earthenware; CP, Cuenca polychrome majolica; URT, unglazed roof tile.

Table 5 Cuenca area ceramics

	VID	Ca (%)	Mn	K (%)	Na (%)	As	La	Sm	Ba	Ce	Co	Cr	Cs	Eu	Fe (%)	Hf	Rb	Sc	Ta	Th
1	CP	0.67	592	1.7	0.59	15.9	21.1	3.61	510	43.6	13.4	37	7.7	0.50	3.30	7.70	60	12.5	0.99	10.1
15	IS	1.42	285	0.9	0.89	6.6	14.6	2.40	300	25.4	7.5	35	5.7	0.35	3.99	3.94	92	10.9	0.75	7.9
17	RS	1.14	535	1.5	0.67	20.5	12.9	2.16	980	24.3	9.4	40	7.0	0.33	3.76	5.13	61	13.9	0.89	9.0
18	RS	1.61	738	1.2	1.07	12.9	15.1	2.48	800	27.8	14.8	22	3.4	0.37	4.37	4.17	31	12.9	0.52	5.0
19	RS	1.02	244	1.7	0.61	20.9	16.6	2.53	720	29.9	8.1	36	7.2	0.34	3.39	5.28	64	14.8	0.79	9.6
56	RS	0.83	743	1.4	0.63	24.1	15.0	2.53	890	30.8	14.0	35	6.4	0.35	3.30	5.50	51	13.4	0.80	9.1
23	CP	0.70	361	1.1	0.69	13.3	19.9	3.06	820	35.9	9.9	34	7.7	0.37	2.72	6.64	61	10.9	0.93	9.7
26	CP	0.41	508	0.8	0.65	9.5	18.2	3.03	430	46.0	8.9	30	5.6	0.42	2.48	6.44	50	10.0	0.86	8.0
32	URT	0.41	500	1.9	1.06	5.1	23.5	4.03	720	59.3	23.8	25	10.2	0.60	2.50	7.53	93	9.8	0.90	10.8
33	URT	0.53	813	1.8	1.16	24.9	46.1	6.65	970	97.9	22.4	35	12.7	0.97	3.74	4.84	94	13.8	0.82	10.6
49	URT	0.94	794	2.2	1.07	22.9	28.5	4.32	1100	49.3	20.2	29	7.7	0.67	3.93	5.88	86	15.5	0.74	10.1
53	URT	0.40	743	1.4	0.75	5.3	18.3	3.03	630	52.3	19.0	32	9.0	0.41	3.33	8.79	74	10.8	0.94	10.5
43	UID	0.47	399	0.9	0.28	10.8	21.1	3.37	460	34.8	7.8	38	7.0	0.43	1.59	6.29	47	11.4	0.91	8.7
44	UID	0.50	631	0.9	0.63	15.7	17.0	2.97	790	38.7	15.8	34	6.8	0.43	3.17	6.63	53	11.6	0.78	9.0
45	UID	0.49	675	0.9	0.56	13.2	16.5	2.89	1020	39.7	15.1	37	6.8	0.44	3.19	6.60	22	12.4	0.90	9.3
48	UID	0.63	444	0.8	0.55	10.7	21.3	3.56	620	42.0	9.5	45	7.4	0.54	3.32	8.36	60	13.4	1.14	10.9
54	UID	0.71	652	1.2	0.83	17.4	24.9	4.14	720	47.7	15.8	35	8.3	0.55	3.27	5.18	74	12.9	0.87	10.2
55	UID	0.57	666	1.3	0.81	20.2	29.4	5.17	640	58.3	18.5	34	10.1	0.68	3.31	5.35	78	13.5	0.81	10.1
58	CLG	0.96	78	1.5	0.86	4.4	33.1	4.10	390	62.9	2.8	29	5.7	0.45	0.93	7.93	70	8.4	1.07	11.1
59	CP	0.23	147	2.4	0.40	27.2	29.3	5.17	760	60.5	5.7	19	29.7	0.71	2.30	6.01	128	12.9	1.06	13.0
60	CRS	0.68	675	1.2	0.98	<1.0	13.8	2.79	460	34.5	17.9	50	7.9	0.43	4.31	4.82	67	15.7	1.00	6.7
57	SSS	0.32	104	0.5	0.14	13.3	12.9	2.15	710	25.4	4.6	47	7.1	0.32	4.12	6.15	41	13.8	0.97	9.0

Abbreviations: CP, Cuenca polychrome majolica; IS, Inka slipware; RS, red-slipped coarse earthenware; URT, unglazed roof tile; UID, unidentified; CLG, Chordeleg lead glazed; CRS, Cera red slipped; SSS, San Sebastian alluvial sediment.

The fact that it comes from the same kiln load as samples 2 and 3, discussed above, poses interesting questions. Sample 15 is another Inka sherd, identified by its brown-on-cream slip diamond pattern (Idrovo Urigüen 2000, 302). Samples 18, 19 and 56 are from 17th century unglazed pieces (Jamieson 2000, 175–83). Samples 23 and 26 are from glazed polychrome majolica pieces, probably from Cuenca itself. Samples 32, 33, 49 and 53 are from 17th century unglazed roof tile fragments (Jamieson 2000, 151). Samples 43–45, 48, 54 and 55 are from polychrome majolica pieces, none of them stylistically typical of Cuenca, but all excavated there. Sample 58, 59 and 60 are from 20th century pieces purchased in the market in Cuenca. Sample 58 is a brown lead-glazed vessel from the village of Chordeleg, 26 km east of Cuenca. Sample 59 is a polychrome glazed piece manufactured in Cuenca. Sample 60 is a red-slipped piece from the village of Cera, just outside the city of Loja, 114 km south-east of Cuenca. Finally, sample 57 is unfired alluvial sediment from the *Convención del 45* potters' neighbourhood, in the San Sebastián parish of north-west Cuenca (Castillo 2003, 82–96). This sample was excavated from sediment identified as potting clay by the son of a ceramicist who had maintained a ceramic studio on the property. This is the same house yard where samples 1, 2 and 3 were taken from the collection of kiln wasters.

Overall, the comparison of chemical analysis to visual identification shows a generally high degree of correlation. The source of the Inka sherds (15 and 16) was unknown, and is still debatable, as sample 15 appears similar to other sherds from the Cuenca region, and sample 16 may be from Quito. The four redware samples (31, 35, 36 and 37) had origins that were under debate, and now seem definitively to be from Panama. Two red-slipped 19th century sherds (24 and 25) were assumed to be from the Cuenca region, but could just as easily have come from further north in the country. Finally, a whole series of polychrome majolicas with orange pastes (43–45, 47, 48, 54, 55 and 62) had all been visually identified as unusual, and possibly imported into Cuenca. These now all appear to be local Cuenca majolicas.

LITERATURE COMPARISONS

Given the variability of elemental concentrations in different sediment horizons at a single location, it is often difficult to clearly group the ceramics made from such sediments. By comparing data averages, one may 'smooth out' some of these effects. The comparison problem is compounded when one tries to compare analytical data generated by different laboratories at different times, since analytical miscalibrations may generate confusing data differences, on an element-by-element basis, between different laboratories. These caveats notwithstanding, inter-laboratory data comparisons may be as productive as they theoretically should be, or at least be comparable to within $\pm 20\%$ relative to the majority of elements.

The data presented in Table 6 show the joys and disasters of comparing the data from individual samples (sample SC26 and sample SC87 from Olin and Blackman 1989; PU1825 from Myers *et al.* 1992; sample 22 from this work) with group averages (Olin *et al.* 1978). The first grouping of elements (Na to Co) shows adequate similarities among the data, and compares well to our overall picture of ceramics produced in Triana, the potters' quarter in Seville, Spain (Lister and Lister 1987; Olin and Myers 1992). The second small grouping (As to Ca) illustrates data mismatches, the reasons for which are unknown. All previously analysed samples from Triana (Olin and Blackman 1989; Hughes 1991; Myers *et al.* 1992; Olin and Myers 1992) are from glazed majolica tableware. The Cuenca samples, however, are all from unglazed botijas, or olive jars. These have long been assumed to have been made in Triana

Table 6 Spanish majolica inter-comparisons

	Seville white (SC26*)	Olive jar (22)	Columbia gun metal (SC87*)	Columbia plain (PU1825†)	Jerez‡
Na (%)	0.51	0.50	0.55	0.592	0.50 ± 0.10
K (%)	2.35	2.4	0.83	1.25	1.64 ± 0.22
Mn (ppm)	—	336	—	—	370 ± 90
Fe (%)	3.43	3.58	2.82	3.29	3.4 ± 0.2
Rb (ppm)	167	99	74.5	100	86 ± 9
Ta (ppm)	1.51	1.31	0.964	—	—
Cs (ppm)	10.1	6.7	4.51	5.42	5.8 ± 1.3
La (ppm)	42.0	33.4	32.1	33.1	38 ± 2
Sm (ppm)	7.14	5.19	4.99	5.14	—
Sc (ppm)	11.7	14.0	10.0	11.7	13.0 ± 0.6
Ce (ppm)	77.1	68.3	55.7	56.6	68 ± 3
Eu (ppm)	1.07	0.71	0.998	1.04	1.26 ± 0.04
Hf (ppm)	6.03	6.38	5.26	4.70	4.7 ± 0.3
Th (ppm)	15.6	10.4	9.06	9.2	10.3 ± 0.6
Cr (ppm)	50.4	116	67.6	77.6	83 ± 16
Co (ppm)	14.7	12.4	10.4	15.0	12.2 ± 1.4
<i>Poor matches</i>					
As (ppm)	16.7	7.0	11.6	16.00	—
Ba (ppm)	511	1020	325	424	540 ± 120
Ca (%)	13.6	6.5	19.7	22.39	—

* Olin and Blackman (1989).

† Myers *et al.* (1992).

‡ Olin *et al.* (1978)—calculated from published oxide concentrations.

(Goggin 1960, 5; Lister and Lister 1987, 80–1; Marken 1994, 48). They appear from our analysis to indeed be from there, yet the data mismatches in Table 6 may indicate that these unglazed pieces were manufactured with a slightly different mix of clays and tempers than the majolicas made in the same community. The variation in chemical composition of ceramics with Triana provenance has previously been attributed to variation in paste composition in the more than 30 kiln sites operating in Triana in the 16th century, a circumstance that has been effectively demonstrated in modern potting communities (Olin and Myers 1992, 32; Arnold *et al.* 2000).

Similarly, Table 7 shows comparisons between single samples from Quito and Panama Vieja, analysed over 20 years apart, in different laboratories. The Quito samples show the high-Na, low-K values that differentiate Quito samples from Panama, Mexico City and Spain. More remarkably, the Panama Vieja samples of Olin *et al.* (1978) confirm the validity of Cs being a clear discriminating element for the separation of Panama Vieja majolicas from their Spanish and Ecuadorian counterparts.

Redware is still poorly understood by archaeologists of the Spanish colonies. Defined (Deagan 1987, 37–9) as unglazed coarse earthenware with an orange to brick red paste, it was used extensively for cooking vessels and chamber pots in the Spanish New World. In Cuenca, it is readily distinguished from any local coarse earthenwares because the redware has much finer paste, with fewer inclusions, and a brick red, instead of orange, colour. A number of production

Table 7 *Panama Vieja and Quito, Ecuador, comparisons*

	<i>Quito polychrome (SB45*)</i>	<i>Quito polychromes (38)</i>	<i>Panama polychrome (SB40*)</i>	<i>Panama redware (37)</i>	<i>Panama polychrome (SB42*)</i>	<i>Panama plain (51)</i>
Na (%)	2.46	1.98	1.55	1.58	1.55	1.58
K (%)	1.24	1.2	2.44	2.7	1.99	2.7
Ba (ppm)	690	720	570	510	520	590
Fe (%)	4.9	4.3	5.1	3.89	5.2	4.84
Rb (ppm)	49	48	137	122	176	178
Cs (ppm)	2.6	2.0	31.2	27.5	116	100
La (ppm)	36	23.5	39	30	26	30
Sc (ppm)	13.7	11.3	18.6	16.5	20.8	18.4
Ce (ppm)	72	42	82	59	62	59
Hf (ppm)	4.2	3.9	4.3	5.64	3.4	5.12
Th (ppm)	10.2	6.6	14.8	13.2	14.8	14.2
Cr (ppm)	57	47	34	37	35	32
Co (ppm)	18	11.9	19	16.4	23	20.1
<i>Poor matches</i>						
Eu (ppm)	1.49	0.56	1.45	0.65	1.53	0.82
Mn (ppm)	710	510	880	310	850	310

* Olin *et al.* (1978).

centres for this material are known or suspected, including Panama Vieja (Long 1967; Baker 1968) and Puebla, Mexico (Cruxent and Vaz 1980). Our analysis of four redware samples (31, 35–7) shows that the Cuenca examples came from Panama Vieja, confirming the importance of this centre in supplying the Andean colonies with both glazed and unglazed ceramics.

The confirmation of Spanish or Panamanian sourcing of all imported samples analysed in Cuenca is important, as it allows us to clarify the role of Lima in the majolica trade in Ecuador. Majolica ceramics were apparently produced in Lima during the colonial period (Stastny and Acevedo 1986), and there is at least one piece of Lima majolica mentioned in a notarial inventory from Cuenca in 1630 (Paniagua Pérez and Truhan 2003, 558). John Goggin (1968, 165) initially suggested that Panamanian majolica might actually have been manufactured in Lima and exported northwards to Panama. This was disproved through excavations at Panama Vieja (Rovira 2001), but leaves us with little understanding of the majolica industry in colonial Lima. Flores Espinoza *et al.* (1981, 52) compared Lima ceramics to a surface collection from Panama Vieja, and stated that the polychrome majolica from Lima is ‘exactly the same’ as the Panamanian sherds ‘except in the colour of the paste’, without describing how the pastes differ. Our work suggests that imported majolicas in early colonial Cuenca were largely from Panama. We have not analysed any majolica samples with proven origins in Lima, and thus have no comparative data for that location. All other colonial majolica sherds fit fairly closely with the chemical signature for the Cuenca region, suggesting that either Lima was not a major source for imports, unless the chemical signature of Lima majolicas is proved to be similar to the Cuenca signature. The apparent lack of Lima imports may be true for much of colonial highland Ecuador, although port cities such as Guayaquil, with much simpler transportation to Lima, may have imported Lima majolicas during the colonial period in larger quantities.

CONCLUSIONS

Elemental analysis of colonial ceramics has produced data confirming importation of ceramics in the 16th and 17th centuries from Triana (Seville, Spain), and Panama Vieja, Panama. The elemental analysis interpretation was consistent with archaeological classifications of the studied ceramics.

The confirmation of a Panamanian source for many imports, including both majolicas and unglazed redwares, confirms the importance of Panama Vieja's kilns in supplying the 17th century Andes with high-quality Spanish style ceramics. This leaves us with the unanswered question of whether Lima had a significant majolica industry, and if so, how far throughout the viceroyalty Lima ceramics may have been traded.

Within Ecuador, it seems that samples from the Quito area are readily separable from the southern highland Cuenca majolica wares, largely due to the different volcanic geology of the regions north and south of the 2°S latitude in the Andes. Separating Quito polychromes from unglazed ceramics made in southern highland villages is, however, more complex, as the less-weathered volcanic sediments in higher-elevation villages may mimic the composition of the recent volcanism surrounding Quito. Revealing such differences is a first step towards clarifying the poorly understood manufacturing centres for colonial ceramics in the Andean region.

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