Instrumental Neutron Activation Analysis of Palmitopamba Archaeology Project Ceramics

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Introduction

Instrumental neutron activation analysis (INAA) was undertaken on 94 ceramic specimens and 2 clay samples at the Missouri University Research Reactor Center (MURR). A preliminary report (Speakman and Glascock 2003) on 56 specimens included a description of our analytical and statistical procedures. Enclosed are several plots and tables that document the results of the INAA of 40 additional pottery specimens from Ecuador. This report includes a discussion of the results and our interpretation of all the data submitted.

Results and Conclusion

The original two-group structure of the ceramic data with the identification of the distinct Cosanga and Palmitopamba compositional groups previously reported was once again recognized in the reanalysis of these data. Two new compositional groups were identified: Sierra Inca 1 and Sierra Inca 2. One clay and fourteen ceramic specimens are unassigned.

The four compositional groups are visible both in principal component (Figures 1-2) and elemental space (Figures 3-4). Principal component scores were based on a variance-covariance matrix. Five principal components, which accounted for 90.29% of the variance in the chemical data, were used to statistically test the membership of the ceramic compositional groups. Generally, a cut-off of 1% was used when deciding membership. Tables 1-3 include the Mahalanobis distance-based probabilities for the memberships of the various groups. Note that because the Sierra Inca 2 group only has four members, it could not be properly statistically tested (but see Table 4), however, it can be shown to be a distinct compositional group (Figures 1, 2, 4).

The Cosanga (n=27) compositional group is enriched in rare earth elements compared to the three other groups, which is characteristic of mica-tempered pottery (Figure 1). The Palmitopamba (n=37) compositional group, on the other hand, whose ceramic members are tempered with predominantly with sand and grit, is depleted in the rare earth elements when compared to the other groups. Sierra Inca 1 (n=12) and Sierra Inca 2 (n=4) are compositionally intermediate in their elemental abundances compared to the Palmitopamba and the Cosanga compositional groups. Both Sierra Inca groups are also enriched in some of the alkaline earth metal elements, such as calcium, barium, and strontium. We hypothesize that these four compositional groups represent different clay sources.

There are spatial, temporal, typological, and compositional relationships in these ceramic data. All but one (RDL003) of the Cosanga type-sorted ceramics are members of the Cosanga compositional group. Similarly, all of the Yumbo-typed ceramic specimens have membership in the Palmitopamba composition group and were all collected from the site of Palmitopamba. In contrast, Cosanga pottery is more geographically widespread, denoting exchange of ceramics. All of the Sierra Inca 2 ceramics assayed were collected from the Milin Pujili site; all but three Sierra Inca 1 ceramics were collected from Milin Pujili. In addition, all of the members of both Sierra Inca compositional groups derive from dated contexts post-dating Inca conquest into the area.

There is a possibility (0.581%) that clay specimen RDL001 resembles the chemical characteristics of Sierra Inca 1 compositional group (See Figure 3, 4; Table 6). If indeed the Sierra Inca 1 ceramics have affinity with the region from which RDL001 was collected, then it can be argued that they were locally made. Given the close compositional similarity between both Sierra Inca groups, we would also conclude that Sierra Inca ceramics were made with similar local clays in the region. The other clay sample (RDL002) does not chemically resemble any of the ceramic groups.

Once again, we plotted the results of your INAA study with that of Maria Masucci and Earl Lubensky whose ceramic data originate primarily from the Guyas region of coastal Ecuador (Figure 5). As expected, ceramics from these two regions differ significantly (Figures 6 and 7). As mentioned in the previous report, because the results of these analyses have not been published, please consult Masucci if you wish to present or publish any of these findings.

In summary, the chemical distinctions between the ceramics submitted are unambiguous and it is possible that there is a clay match for the Sierra Inca 1 compositional group. We hope you find these results interesting and plan to publish these exciting results. Much can be said about the production and distribution of these ceramics. If we can be of any assistance, please let us know.

References Cited

R. J. Speakman and M. D. Glascock
2003 *Instrumental Neutron activation Analysis of Ceramics and Clays for the Palmitopamba Archaeology Project, Ecuador*. Missouri University Research Reactor Center, Columbia, Missouri.

Acknowledgments

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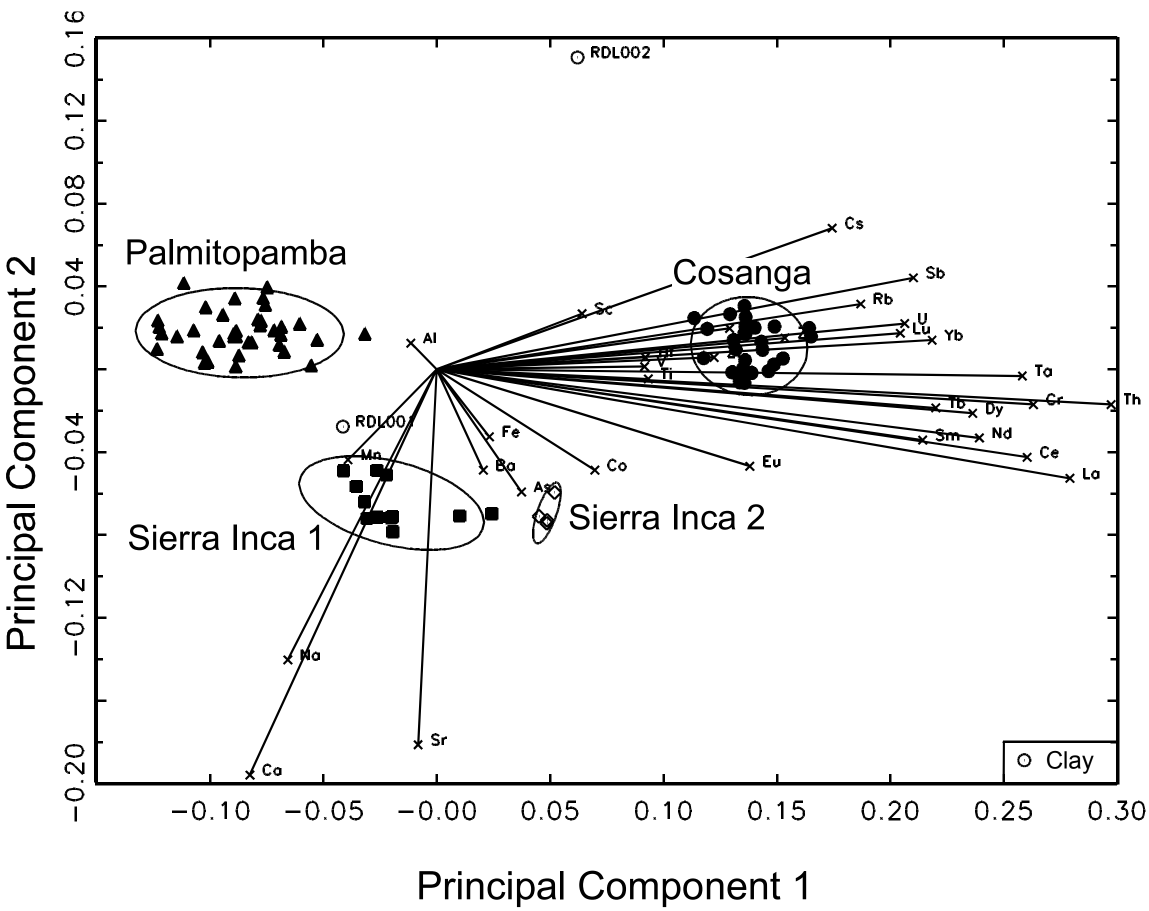

Figure 1: Biplot of principal components 1 and 2 displaying the four compositional groups and clay specimens. Ellipses represent 90% confidence level for membership in the groups. Vectors denote elemental influences on the ceramic data. Unassigned samples are not shown.

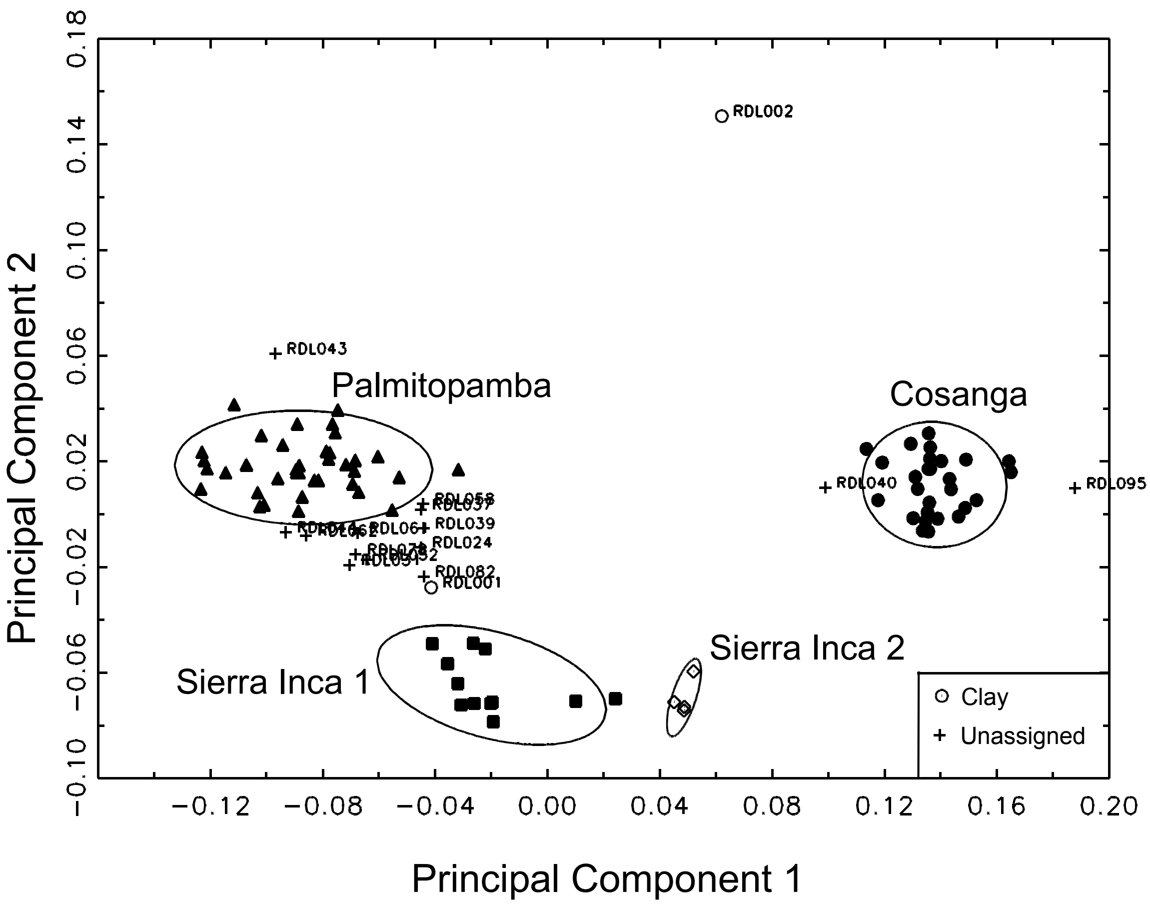

Figure 2: Bivariate plot of principal components 1 and 2 displaying the four compositional groups, clay specimens, and unassigned specimens. Ellipses represent 90% confidence level for membership in the groups.

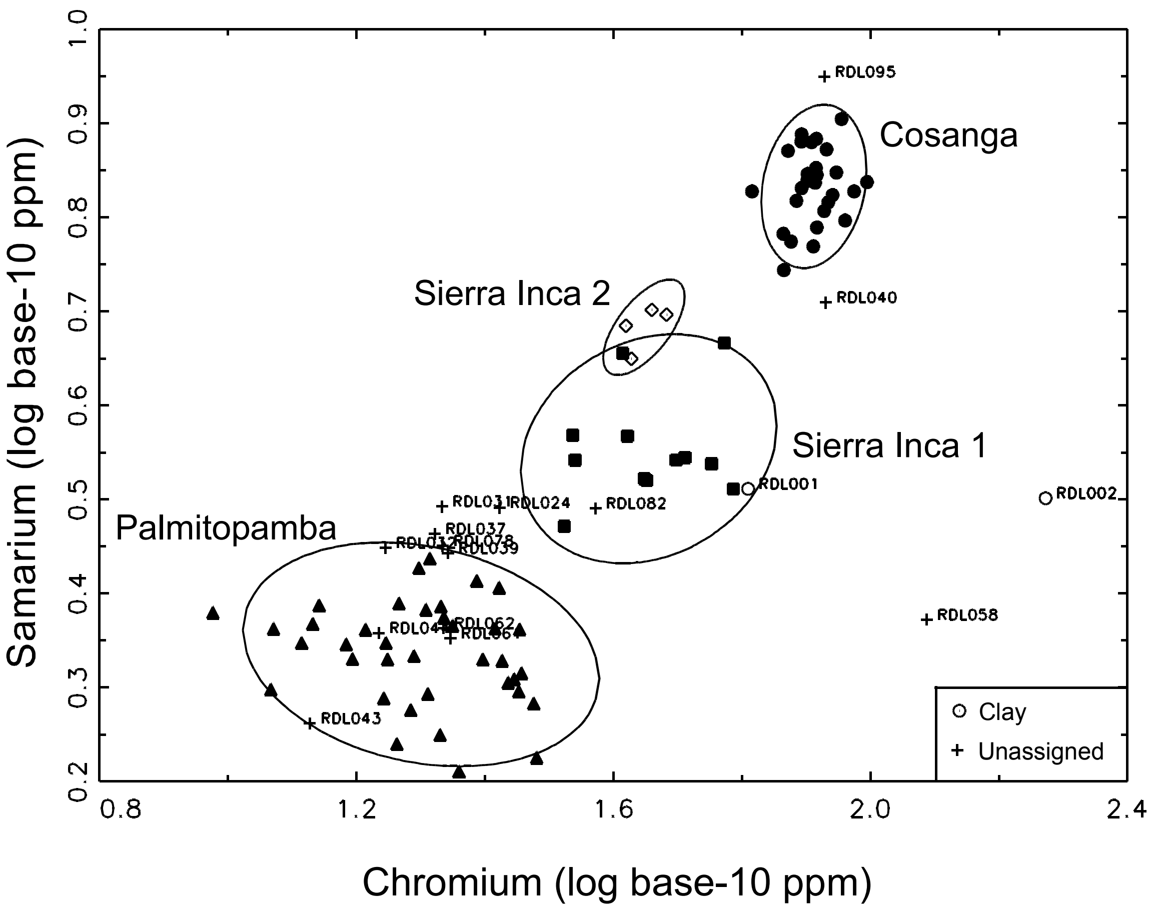

Figure 3: Bivariate plot of base-10 logged chromium and samarium concentrations showing the four compositional groups, clay specimens and unassigned specimens. Ellipses represent 90% confidence level for membership in the groups.

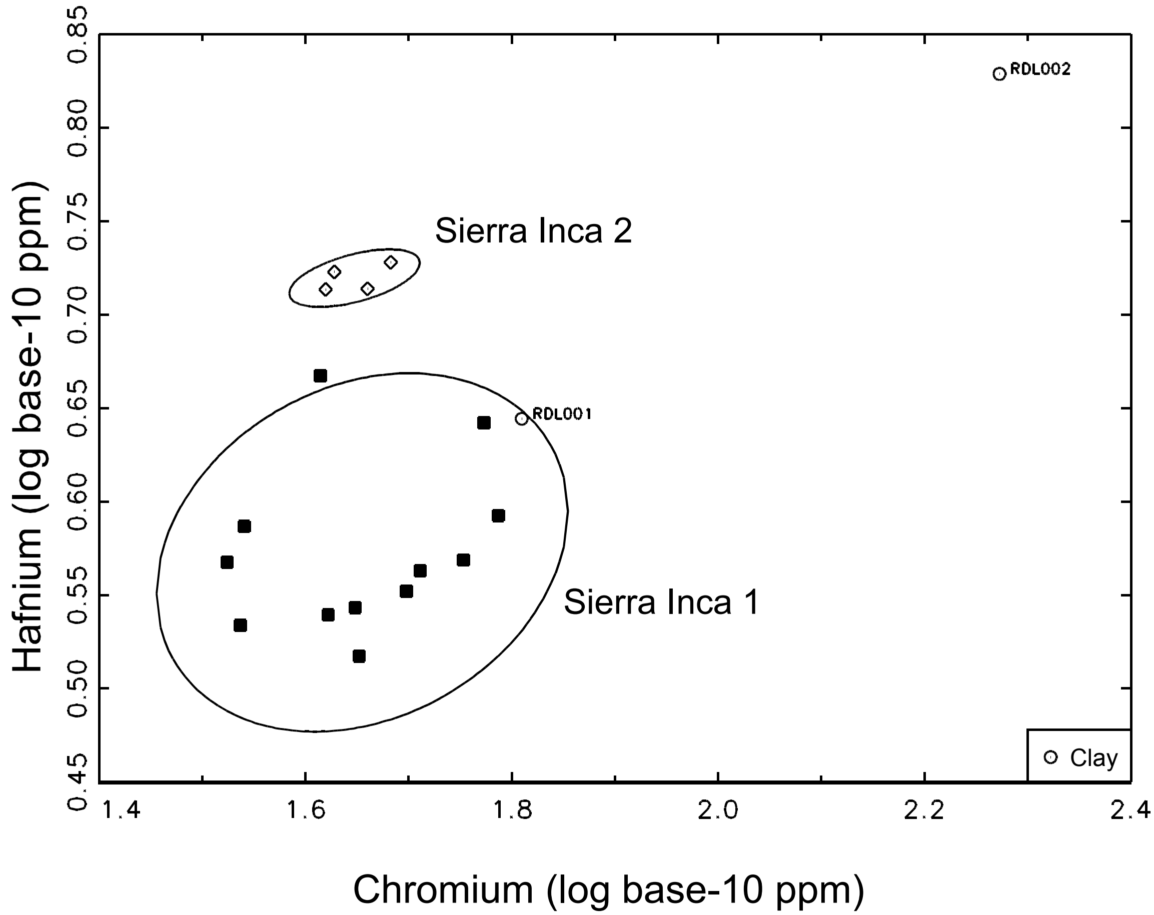

Figure 4: Bivariate plot of base-10 logged chromium and hafnium concentrations showing the two Sierra Inca groups and the two clay specimens. Ellipses represent 90% confidence level for membership in the groups. Unassigned samples are not shown.

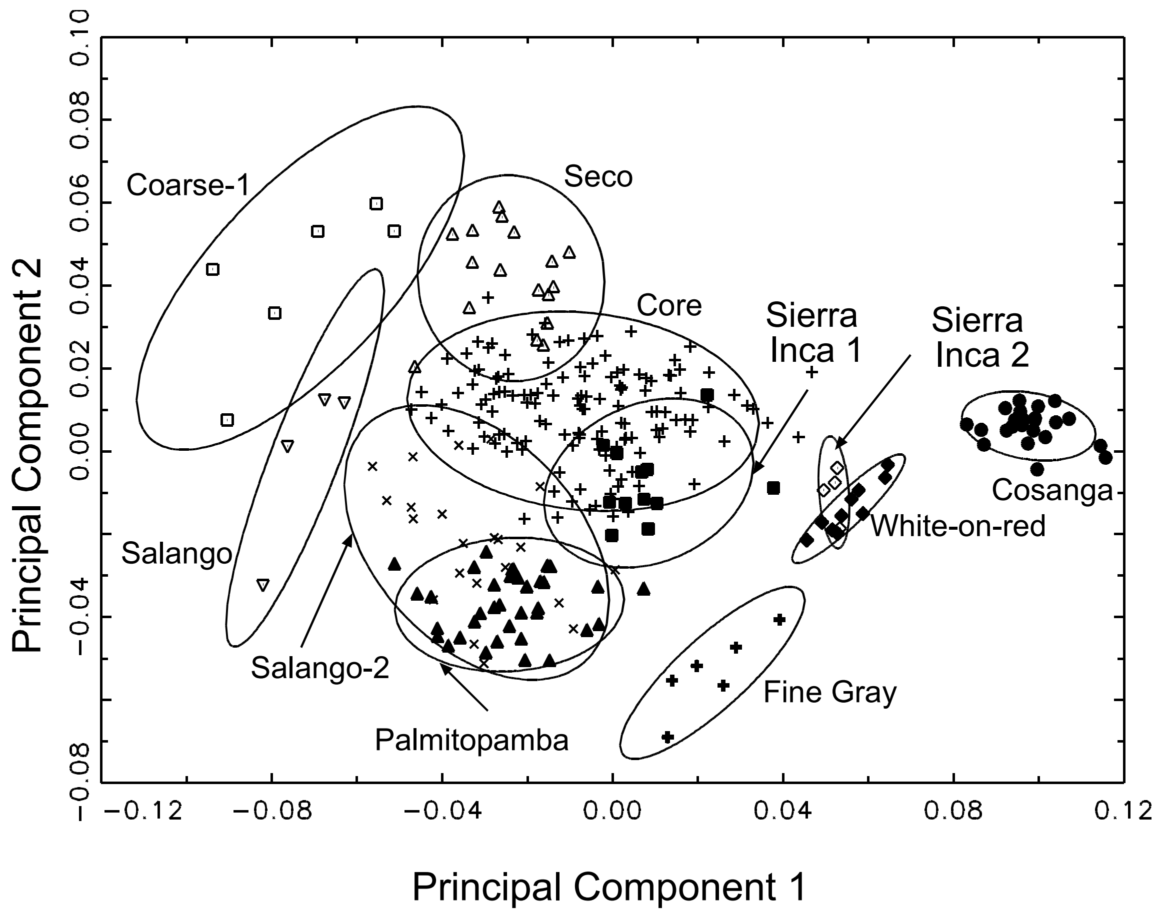

Figure 5: Bivariate plot of principal components 1 and 2 displaying the Palmitopamba, Cosanga, Sierra Inca, and Masucci ceramic compositional groups. Ellipses represent 90% confidence level for membership in the groups.

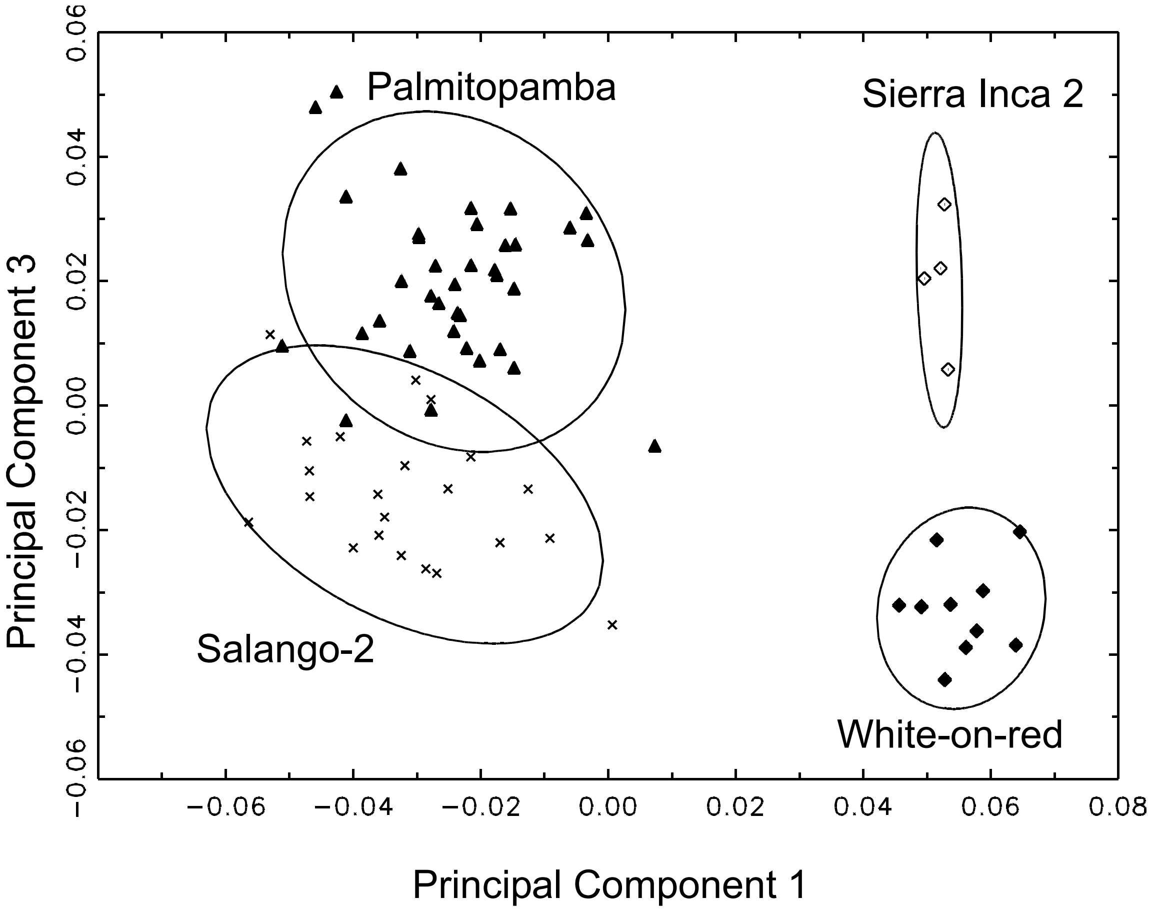

Figure 6: Bivariate plot of principal components 1 and 3 showing separation of Palmitopamba, Salango-2, Sierra Inca 2, and White-on-red ceramic compositional groups. Ellipses represent 90% confidence level for membership in the groups.

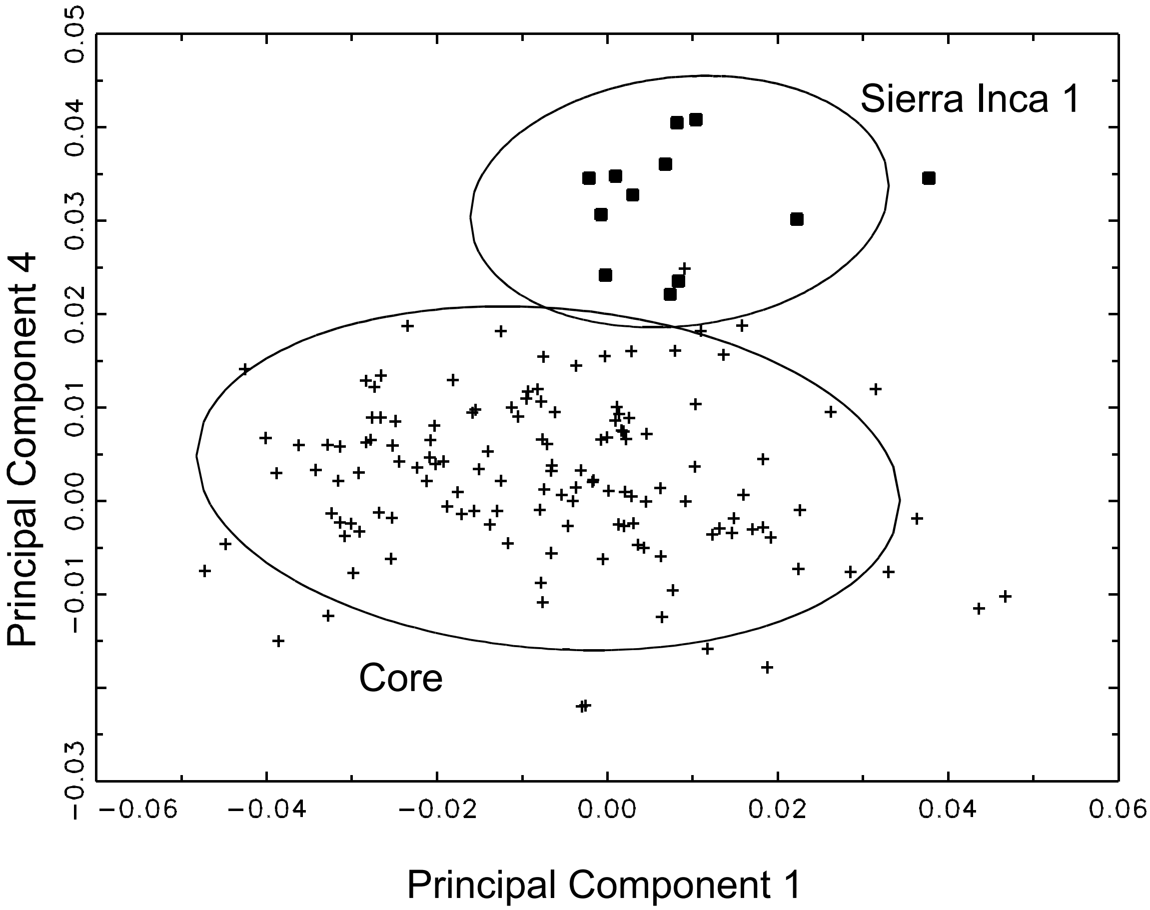

Figure 7: Bivariate plot of principal components 1 and 4 showing separation of the Sierra Inca 1 and Core compositional groups. Ellipses represent 90% confidence level for membership in the groups.

Table 1. Mahalanobis Distance Calculation and Posterior Classification for Cosanga Compositional Group Members. Probabilities are jackknifed for specimens included in each group (five principal components used).

ID. NO.	Cosanga	Sierra Inca 1	Palmitopamba
RDL004	36.389	0.002	0.000
RDL005	42.583	0.003	0.000
RDL006	79.246	0.001	0.000
RDL007	64.644	0.001	0.000
RDL008	19.409	0.001	0.000
RDL009	84.566	0.001	0.000
RDL010	27.718	0.002	0.000
RDL011	34.549	0.003	0.000
RDL012	73.265	0.001	0.000
RDL013	49.338	0.001	0.000
RDL014	54.430	0.002	0.000
RDL015	52.538	0.000	0.000
RDL016	94.411	0.002	0.000
RDL017	20.948	0.004	0.000
RDL083	46.641	0.001	0.000
RDL084	5.609	0.000	0.000
RDL085	85.146	0.001	0.000
RDL086	18.433	0.000	0.000
RDL087	42.381	0.002	0.000
RDL088	0.943	0.001	0.000
RDL089	36.361	0.001	0.000
RDL090	33.340	0.001	0.000
RDL091	12.459	0.001	0.000
RDL092	92.762	0.002	0.000
RDL093	92.473	0.001	0.000
RDL094	87.268	0.002	0.000
RDL096	53.983	0.003	0.000

Table 2. Mahalanobis Distance Calculation and Posterior Classification for Sierra Inca 1 Compositional Group Members. Probabilities are jackknifed for specimens included in each group (five principal components used).

ID. NO.	Cosanga	Sierra Inca 1	Palmitopamba
RDL054	0.000	41.193	0.000
RDL055	0.000	82.489	0.000
RDL057	0.000	79.600	0.000
RDL065	0.000	11.383	0.000
RDL068	0.000	71.449	0.000
RDL069	0.000	19.908	0.000
RDL071	0.000	35.937	0.001
RDL072	0.000	33.598	0.000
RDL073	0.000	66.711	0.000
RDL074	0.000	70.453	0.000
RDL075	0.000	20.459	0.000
RDL076	0.000	64.897	0.000

Table 3. Mahalanobis Distance Calculation and Posterior Classification for Palmitopamba Compositional Group Members. Probabilities are jackknifed for specimens included in each group (five principal components used).

ID. NO.	Cosanga	Sierra Inca 1	Palmitopamba
RDL003	0.000	0.039	1.836
RDL018	0.000	0.254	10.018
RDL019	0.000	0.045	25.680
RDL020	0.000	0.101	9.027
RDL021	0.000	0.843	82.130
RDL022	0.000	0.085	29.953
RDL023	0.000	2.717	63.426
RDL025	0.000	1.478	68.502
RDL026	0.000	0.065	7.641
RDL027	0.000	0.380	25.865
RDL028	0.000	0.082	16.016
RDL029	0.000	0.802	59.924
RDL030	0.000	0.821	73.028
RDL033	0.000	0.293	21.891
RDL034	0.000	0.680	94.897
RDL035	0.000	0.313	77.479
RDL036	0.000	0.857	43.879
RDL038	0.000	0.583	77.062
RDL041	0.000	0.339	42.346
RDL042	0.000	0.306	58.366
RDL045	0.000	0.406	85.771
RDL046	0.000	0.432	98.685
RDL047	0.000	0.049	5.003
RDL048	0.000	0.238	81.174
RDL049	0.000	0.262	49.482
RDL050	0.000	2.195	14.046
RDL051	0.000	1.079	60.271
RDL052	0.000	0.972	98.470
RDL053	0.000	0.870	95.706
RDL056	0.000	0.854	19.128
RDL059	0.000	0.035	42.779
RDL060	0.000	0.740	87.135
RDL063	0.000	0.145	78.277
RDL077	0.000	0.272	13.327
RDL079	0.000	1.064	92.607
RDL080	0.000	0.912	26.104
RDL081	0.000	0.596	21.883

Table 4. Mahalanobis Distance Calculation and Posterior Classification for Sierra Inca 2 Compositional Group Members (five principal components used).

ID. NO.	Cosanga	Sierra Inca 1	Palmitopamba
RDL064	0.000	5.268	0.000
RDL066	0.000	9.516	0.000
RDL067	0.000	0.255	0.000
RDL070	0.000	3.330	0.000

Table 5. Mahalanobis Distance Calculation and Posterior Classification for Unassigned Ceramic Specimens (five principal components used).

ID. NO.	Cosanga	Sierra Inca 1	Palmitopamba
RDL001	0.000	0.581	0.000
RDL002	0.000	0.000	0.000
RDL024	0.000	5.806	5.382
RDL031	0.000	0.024	0.087
RDL032	0.000	1.577	3.926
RDL037	0.000	2.044	22.320
RDL039	0.000	3.590	11.580
RDL040	0.001	0.002	0.000
RDL043	0.000	0.013	0.064
RDL044	0.000	2.056	25.867
RDL058	0.000	0.169	0.277
RDL061	0.000	5.908	31.212
RDL062	0.000	3.092	25.717
RDL078	0.000	0.719	2.660
RDL082	0.000	0.541	0.041
RDL095	0.751	0.000	0.000

Table 6. Mahalanobis Distance Calculation and Posterior Classification for Raw Clay Specimens (five principal components used).

ID. NO.	Cosanga	Sierra Inca 1	Palmitopamba
RDL001	0.000	0.581	0.000
RDL002	0.000	0.000	0.000