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Dear Tom:

As you may have realized from my email address, I have moved universities. In February I was hired as an Assistant Professor of Anthropology at Stephen F. Austin State University (beginning July 2007). However, before I left the University of Missouri, Michael D. Glascock and I decided that it would be best for me to analyze your third dataset and write the subsequent report. I am still the one responsible for the content, and if you should have any questions, please feel free to contact me at [cecillg@sfasu.edu](mailto:cecillg@sfasu.edu).

Below is a report of the chemical analysis of the 28 ceramic samples (TDD333-TDD360) and the four clay samples (TDD329-TDD332) that were most recently submitted (2007). These data were compared to those of the pottery previously submitted under the project title "Araucanian Polity Formation in the Southern Cone." According to an email, you stated that these 28 samples represented a special class of exotics that may not be statistically valid, but that were culturally and historically important. As a result of this analysis, we can suggest that some of these exotics are statistically valid.

Sample preparation, irradiation, and statistical manipulation of these data are more or less identical to those reported to you in previous reports and are not repeated in this report. However, if you like, I can email a copy of our boilerplate which contains these details.

The 28 ceramic samples were compared to the three compositional groups previously identified (report dated January 2, 2007). Seventeen of the sherds were assigned to one of the three regional composition groups (Table 1, Figures 1 and 4). Table 2 provides the Mahalanobis distance probabilities for sample membership into Group 2 and Group 3. Table 3 presents the sample assigned to Group 1 and demonstrates that none of the clays have statistical membership in Group 2 or Group 3. This table also shows that 11 pottery samples cannot be statistically assigned to the two largest reference groups. Principal component eigenvalues and explained

variance are presented in Table 4. Figures 1-3 illustrate group separation and the elements that are responsible for the substructure variability. Figures 4-6 are bivariate plots of elemental logged concentrations that further demonstrate the sub-group partitioning discussed below.

**Compositional Group 1:** One sample, ceramic type 5 from PU-165, was assigned to this compositional group. This compositional group is still identified by its higher concentrations of arsenic, chromium, cesium, and titanium, but with the addition of more samples this group can also be characterized by high concentration of antimony.

**Compositional Group 2:** Four samples, three from PU-165 and one from PU-42, were assigned to this compositional group. Two of the samples are ceramic type 14 and one is ceramic type 4 (the fourth sample does not have a ceramic type indicated). This compositional group has higher concentrations of some of the transitional metals and the alkali and alkaline earth metals. With the addition of the new dataset, there is some possible sub-group structure (see Figure 4). Five samples (TDD062, TDD129, TDD290, TDD342, TDD355) have higher thorium, hafnium, barium, and sodium concentrations. When these samples are separated from Group 2 and plotted as a separate group, their structure does not hold and they continue to be statistical members of Group 2. It is possible that petrographic analysis can suggest the reason behind the variation (possibly the difference in sand tempers).

**Compositional Group 3:** The majority (n=12) of the samples were assigned to Group 3. These samples were excavated from PU-165 and PU-5 and represent ceramic types 4 and 14 (when designated). Group 3 separates from Group 2 because of higher concentrations of the first-row transition metals. As noted in the previous report, there is some possible sub-structure in Group 3 exists as a result of higher concentrations of chromium and arsenic (TDD002, TDD011, TSS012, TDD014, TDD022, TDD031, TDD037, TDD059, TDD066, TDD078, TDD098, TDD111, TDD112, TDD116, TD293, TDD300, TDD340, and TDD358). This sub-structure does not yet result in an additional compositional group because it is not statistically different from the majority of the samples in Group 3.

**Clay Samples:** Statistically, none of the four clay samples are members of the three reference groups (Table 3). While they are not statistical members, they do consistently plot in or near Group 3 (Figures 3 and 6). The majority of the clay/sand samples submitted for this project are either statistical members of Group 3 or they plot near Group 3.

**Unassigned Samples:** Eleven of the pottery samples could not be statistically assigned to a reference group. None of the PU-122, LU-19, and LU-45 samples submitted for this analysis could be assigned to a reference group. Additionally, six samples from PU-165 also were not able to be assigned to a reference group. While the 11 samples could not be assigned statistically to a reference group, Figure 5 demonstrates that all but two samples (TDD360 and TDD336) plot near Group 3. Additionally, those samples higher in thorium may have some affinity to those in Group 2 with higher thorium concentrations, but they do not compose a rigorous compositional group. Samples TDD334, TDD343, and TDD344 are lower in thorium and higher chromium and may have some similarities to the sub-structure discussed for Group 3. Again, this sub-group did not withstand statistical testing necessary for establishing a new compositional group.

Given that the samples submitted for this analysis are composed of a special class of exotics, it is surprising that more samples were not unassigned. Of those that could be assigned, the majority of the samples belonged to Group 2 or Group 3. Therefore, we suggest that some of the exotics were made from local resources and possibly at or around PU-165 in the Rio Lumaco valley.

Petrographic analysis will undoubtedly provide information about the possible sub-structures seen in Group 2 and Group 3. Additionally, it will be interesting to see if the clays were treated differently for the exotic pottery even though they have similar chemical compositions.

As always, when you include this information (or information from the other reports) in your final NSF report or any publications, I would be happy to provide you with higher resolution figures and/or tables. Additionally, please include the grants under which this research was made possible in your acknowledgments. If there is any other way that I can assist your project and publications, please feel free to contact me.

### **Acknowledgments**

We acknowledge Tessa Schut for her role in preparing the samples for irradiation. Operating support for the MURR Archaeometry Laboratory was provided by a grant from the National Science Foundation (BCS-0504015). This research was also supported in part by a grant from the US Department of Energy Office of Nuclear Energy, Science and Technology Award No. DE-FG07-03ID14531 to the Midwest Nuclear Science and Engineering Consortium under the Innovations in Nuclear Infrastructure and Education program.

**Table 1: Chemical Group Assignments for Pottery from Huitranlebu, Puren, Southern Chile**

anid	Chemical Group	alt_id	county	Subregion	site_name	material	cer_type
TDD335	Group 1	Pu-165, Pitren, Bloque A, Capa 3	Puren	Huitranlebu	Pu-165	Ceramics	5
TDD342	Group 2	Pu-165, Bloque A, Capa 1	Puren	Huitranlebu	Pu-165	Ceramics	14
TDD345	Group 2	Pu-42, 5 - 12	Puren	Huitranlebu	Pu-42	Ceramics	14
TDD355	Group 2	Pu-165, BloqueB, Capa1	Puren	Huitranlebu	Pu-165	Ceramics	
TDD357	Group 2	Pu-165, 28 - 39	Puren	Huitranlebu	Pu-165	Ceramics	4
TDD333	Group 3	Pu-165, surface	Puren	Huitranlebu	Pu-165	Ceramics	4
TDD337	Group 3	Pu-165, surface	Puren	Huitranlebu	PU-165	Ceramics	
TDD338	Group 3	Pu-165, surface	Puren	Huitranlebu	PU-165	Ceramics	
TDD340	Group 3	Pu-165, Pozo2, Capa3, 30-45cm	Puren	Huitranlebu	Pu-165	Ceramics	
TDD341	Group 3	Pu-165, 46 - 13	Puren	Huitranlebu	Pu-165	Ceramics	
TDD346	Group 3	Pu-165	Puren	Huitranlebu	Pu-165	Ceramics	14
TDD347	Group 3	Pu-165 - 15	Puren	Huitranlebu	Pu-165	Ceramics	
TDD349	Group 3	Pu-5, 5 - 6	Puren	Huitranlebu	Pu-5	Ceramics	14
TDD350	Group 3	Pu-5, 5 - 6	Puren	Huitranlebu	Pu-5	Ceramics	14
TDD352	Group 3	Pu-165, BloqueA, Nivel1, 0-20cm	Puren	Huitranlebu	Pu-165	Ceramics	
TDD356	Group 3	Pu-165, 28 - 27	Puren	Huitranlebu	Pu-165	Ceramics	
TDD358	Group 3	Pu-165, B-1, ZA5	Puren	Huitranlebu	Pu-165	Ceramics	4
TDD334	Unassigned	Pu-122, cuadra NE, surface	Puren	Huitranlebu	Pu-122	Ceramics	14
TDD336	Unassigned	Pu-165, Pozo1, Nivel2 15-30cm	Puren	Huitranlebu	PU-165	Ceramics	14
TDD339	Unassigned	Pu-165, Pozo2, Capa3, 30-45cm	Puren	Huitranlebu	Pu-165	Ceramics	
TDD343	Unassigned	Pu-122, cuadra NE, surface	Puren	Huitranlebu	Pu-122	Ceramics	14
TDD344	Unassigned	Pu-122, cuadra NE, surface	Puren	Huitranlebu	Pu-122	Ceramics	14
TDD348	Unassigned	Pu-165, 6 - 14	Puren	Huitranlebu	Pu-165	Ceramics	
TDD351	Unassigned	Pu-165	Puren	Huitranlebu	Pu-165	Ceramics	14
TDD353	Unassigned	Pu-165, BloqueA, Nivel1, 0-20cm	Puren	Huitranlebu	Pu-165	Ceramics	
TDD354	Unassigned	Lu-45	Puren	Huitranlebu	Lu-45	Ceramics	14
TDD359	Unassigned	Pu-165, BloqueA, Capa1, 15-20cm	Puren	Huitranlebu	Pu-165	Ceramics	
TDD360	Unassigned	Lu-19, Maicoya, KuelA, Surface	Puren	Huitranlebu	Maicoya	Ceramics	
TDD329		Pu-166, Kuel 8, No 100	Puren	Huitranlebu	Pu-166	Clay Sample	
TDD330		Pu-166, Bloque A, Kuel 8, 90 cm	Puren	Huitranlebu	Pu-166	Clay Sample	
TDD331		Suelo Huitranlebu	Puren	Huitranlebu		Clay Sample	
TDD332		Lu-69, Pozo 1, Capa 3, 40-60cm	Puren	Huitranlebu	Lu-69	Clay Sample	

**Table 2: Mahalanobis Distance Calculation and Posterior Classification of Ceramic Samples Assigned to Reference Group 2 and Group 3 from Huitranlebu, Puren, Southern Chile**

Groups are:

1	Reference Group 2
2	Reference Group 3

Variables used:

AS	LA	LU	ND	SM	U	YB
CE	CO	CR	CS	EU	FE	HF
RB	SB	SC	TA	TB	TH	ZN
ZR	AL	BA	DY	K	MN	NA
TI	V					

Probabilities are jackknifed for specimens included in each group.

The following specimens are in Reference Group 2:

ID. NO.	Probabilities:	
	Group 2	Group 3
TDD342	7.010	2.459
TDD345	13.363	0.000
TDD355	58.248	0.153
TDD357	74.476	16.322

The following specimens are in Reference Group 3:

ID. NO.	Probabilities:	
	Group 2	Group 3
TDD333	0.000	18.910
TDD337	0.012	70.260
TDD338	0.002	51.600
TDD340	0.000	1.949
TDD341	0.000	10.445
TDD346	0.001	93.702
TDD347	0.000	13.032
TDD349	0.012	95.593
TDD350	0.000	72.987
TDD352	0.000	13.572
TDD356	0.000	54.826
TDD358	0.000	0.535

**Table 3: Mahalanobis Distance Calculations for Reference Group 1, Clay Samples, and Unassigned Samples Projected Against Reference Group 2 and Reference Group 3 from Huitranlebu, Puren, Southern Chile**

Reference groups

1 Reference Group 2  
2 Reference Group 3

Variables used:

AS	LA	LU	ND	SM	U	YB
CE	CO	CR	CS	EU	FE	HF
SB	SC	TA	TB	TH	ZN	RB
ZR	AL	BA	DY	K	MN	NA
TI	V					

The following specimens are Reference Group 1:

Probabilities:

ID. NO.	Group 2	Group 3
TDD335	0.000	0.000

The following specimens are the clay samples:

Probabilities:

ID. NO.	Group 2	Group 3
TDD329	0.000	0.000
TDD330	0.000	0.000
TDD331	0.000	0.000
TDD332	0.000	0.000

The following specimens remain unassigned:

Probabilities:

ID. NO.	Group 2	Group 3
TDD334	0.000	0.000
TDD336	0.000	0.000
TDD339	0.000	0.001
TDD343	0.000	0.000
TDD344	0.000	0.033
TDD348	0.000	0.000
TDD351	0.000	0.012
TDD353	0.000	0.000
TDD354	0.000	0.004
TDD359	0.000	0.003
TDD360	0.000	0.000

**Table 4: Principal Components Analysis of Huitranlebu, Puren, Southern Chile Pottery and Clay Samples (R-Q Factor Analysis Based on Variance-Covariance Matrix)**

Ei genval ues and Percentage of Variance Expl ai ned:

	Ei genval ue	%Vari ance	Cum. %Var.
1	0. 1653	24. 4100	24. 4100
2	0. 1369	20. 2048	44. 6148
3	0. 0759	11. 2080	55. 8228
4	0. 0597	8. 8167	64. 6395
5	0. 0436	6. 4385	71. 0781
6	0. 0359	5. 3039	76. 3820
7	0. 0257	3. 7998	80. 1819
8	0. 0236	3. 4887	83. 6706
9	0. 0182	2. 6932	86. 3638
10	0. 0142	2. 0937	88. 4575

Ei genvectors (largest to smallest):

As	0. 3305	0. 1095	-0. 2756	0. 2349	0. 1024	-0. 1182	-0. 3370	0. 5844	-0. 1911	-0. 1997
La	-0. 1437	0. 2818	-0. 0863	0. 1209	-0. 1121	0. 0175	0. 0058	0. 1104	-0. 1370	0. 0041
Lu	0. 0046	0. 2234	-0. 0606	-0. 0568	-0. 1053	0. 0875	0. 0613	0. 0310	0. 1175	0. 0761
Nd	-0. 1227	0. 2911	-0. 0326	0. 0324	-0. 1137	0. 0011	-0. 0041	0. 0981	-0. 0754	0. 0475
Sm	-0. 0907	0. 2743	-0. 0020	-0. 0149	-0. 1076	0. 0397	-0. 0145	0. 0687	-0. 0372	0. 0770
U	-0. 1154	0. 0598	-0. 3753	-0. 0960	-0. 0219	-0. 1173	-0. 3033	-0. 3960	-0. 3650	0. 3926
Yb	-0. 0073	0. 2381	-0. 0416	-0. 0578	-0. 1143	0. 1008	0. 0790	0. 0649	0. 1020	0. 0567
Ce	-0. 0785	0. 2694	-0. 1593	0. 0920	0. 0606	0. 0201	0. 0614	0. 0163	-0. 2067	-0. 0764
Co	0. 3364	0. 2302	0. 0988	0. 0742	0. 2776	-0. 0476	0. 0580	-0. 2337	-0. 1501	-0. 2548
Cr	0. 4678	0. 1058	0. 1876	-0. 2242	-0. 3975	-0. 3390	-0. 1334	-0. 2794	-0. 2286	-0. 1230
Cs	0. 0994	-0. 0183	-0. 0880	0. 3539	-0. 3329	0. 2798	0. 0506	-0. 1039	0. 1599	-0. 1743
Eu	-0. 1293	0. 2657	0. 0339	-0. 0872	-0. 0659	0. 0303	-0. 0224	0. 0997	0. 0063	0. 0336
Fe	0. 1443	0. 1222	0. 0986	0. 0614	0. 0676	-0. 0211	-0. 0248	-0. 0096	0. 0419	0. 0288
Hf	-0. 1545	0. 0966	-0. 1866	-0. 3409	0. 1597	-0. 1287	-0. 1033	-0. 0986	0. 2517	-0. 3237
Rb	-0. 0666	0. 0173	-0. 1268	0. 2558	-0. 1643	0. 0809	0. 0203	-0. 2400	0. 1226	-0. 1685
Sb	0. 2157	-0. 0291	-0. 2857	0. 1884	0. 0162	-0. 0082	-0. 5115	-0. 0525	0. 4927	0. 2263
Sc	0. 0624	0. 1249	0. 1620	-0. 0581	-0. 1061	0. 0013	-0. 0522	-0. 0482	0. 1453	-0. 0007
Ta	-0. 0489	0. 0811	-0. 1871	-0. 0187	0. 0419	0. 0529	0. 0362	-0. 1144	-0. 0889	0. 3610
Tb	-0. 0876	0. 3144	0. 0042	-0. 1039	-0. 1220	0. 1098	0. 0165	0. 1228	0. 0609	0. 0062
Th	-0. 1476	0. 0517	-0. 2293	0. 1403	-0. 0626	0. 0590	-0. 0478	-0. 1691	-0. 2942	-0. 3924
Zn	0. 0843	0. 0890	0. 0709	0. 1169	-0. 1998	-0. 0279	0. 0327	-0. 1115	0. 1322	-0. 0332
Zr	-0. 1629	0. 1061	-0. 1983	-0. 3689	0. 1549	-0. 1235	-0. 1458	-0. 0800	0. 2573	-0. 3597
Al	-0. 0419	0. 0457	0. 0673	-0. 0073	-0. 0733	0. 0094	-0. 0406	-0. 0616	0. 0130	-0. 0607
Ba	-0. 2073	0. 1517	0. 0678	0. 4070	0. 1333	-0. 7711	0. 2120	-0. 0231	0. 1760	0. 0949
Dy	-0. 0635	0. 2664	0. 0333	-0. 0784	-0. 1949	0. 0074	0. 0673	0. 1099	0. 0980	0. 0328
K	-0. 1815	-0. 0264	-0. 0602	0. 2894	-0. 1357	0. 0431	-0. 0340	-0. 2766	0. 0906	-0. 1652
Mn	0. 2919	0. 3478	-0. 0040	0. 0940	0. 5206	0. 2786	0. 1984	-0. 2644	0. 1035	0. 1067
Na	-0. 3006	0. 1376	0. 6046	0. 1492	0. 1632	0. 1278	-0. 5999	-0. 0692	-0. 0729	-0. 0216
Ti	0. 0891	0. 0903	0. 0142	-0. 1530	-0. 1713	-0. 0667	-0. 0086	0. 0082	0. 1903	0. 1084
V	0. 1961	0. 1328	0. 1000	-0. 0323	-0. 1194	-0. 0531	-0. 0485	-0. 0226	0. 1004	0. 0815

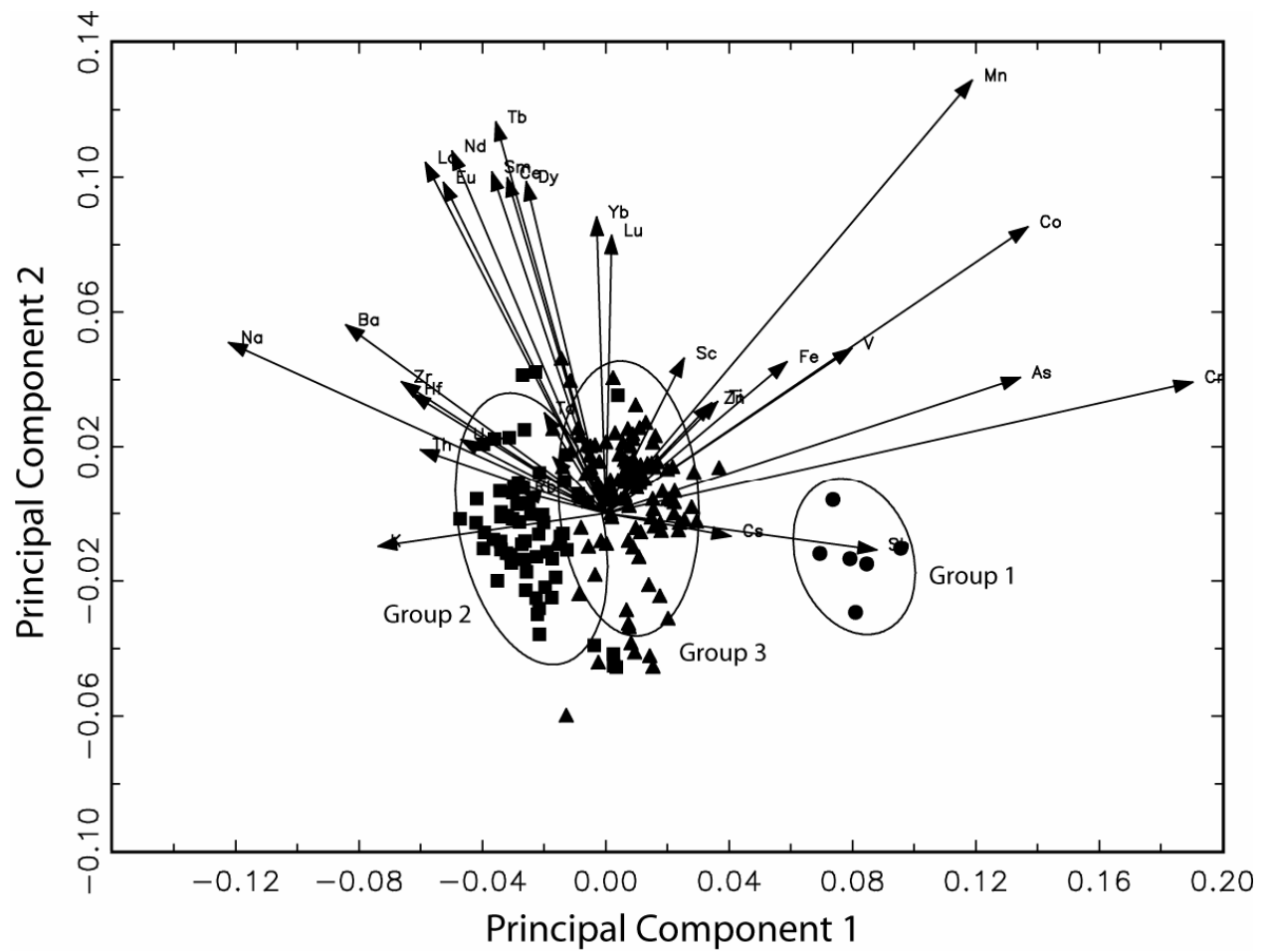


Figure 1: Ceramic samples from Huitranlebu, Puren, Southern Chile projected onto the first two principal components with vectors. Ellipses represent 90% confidence intervals for group membership.

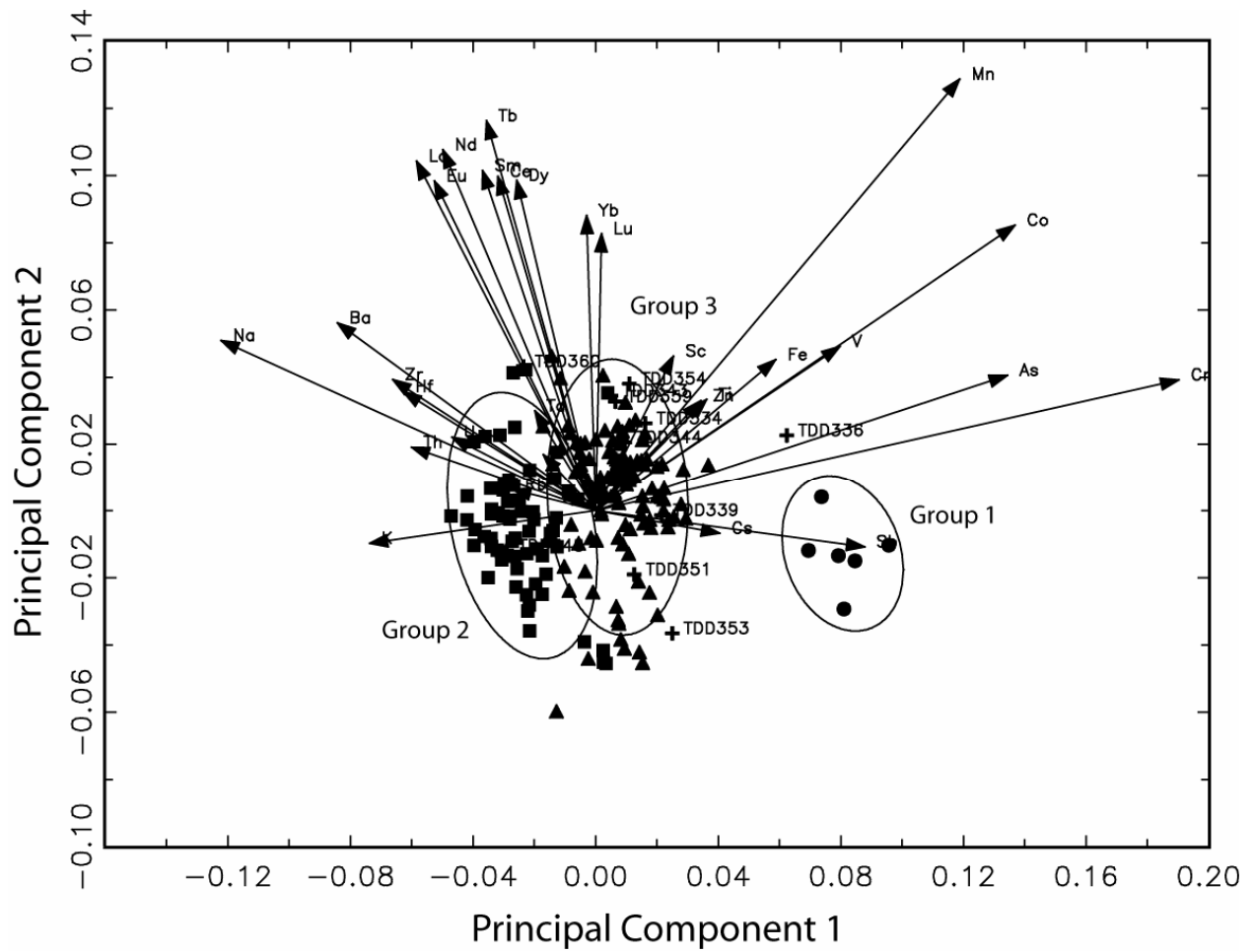


Figure 2: Ceramic samples from Huitranlebu, Puren, Southern Chile projected onto the first two principal components with vectors with the unassigned samples (identified by their ANID). Ellipses represent 90% confidence intervals for group membership.



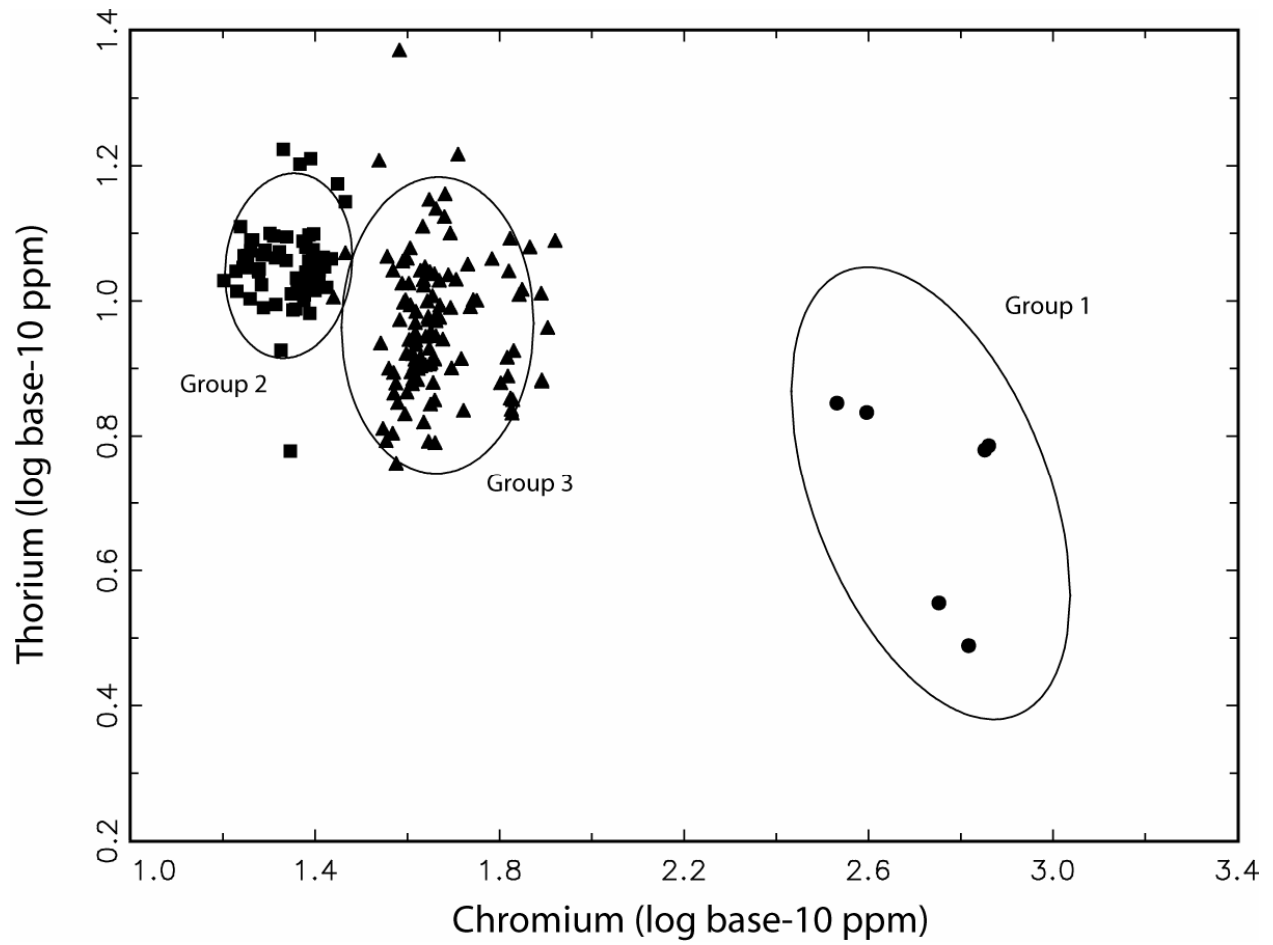


Figure 4: Plot of chromium and thorium base-10 logged concentrations showing the separation of the three ceramic groups. Ellipses represent 90% confidence intervals for group membership.

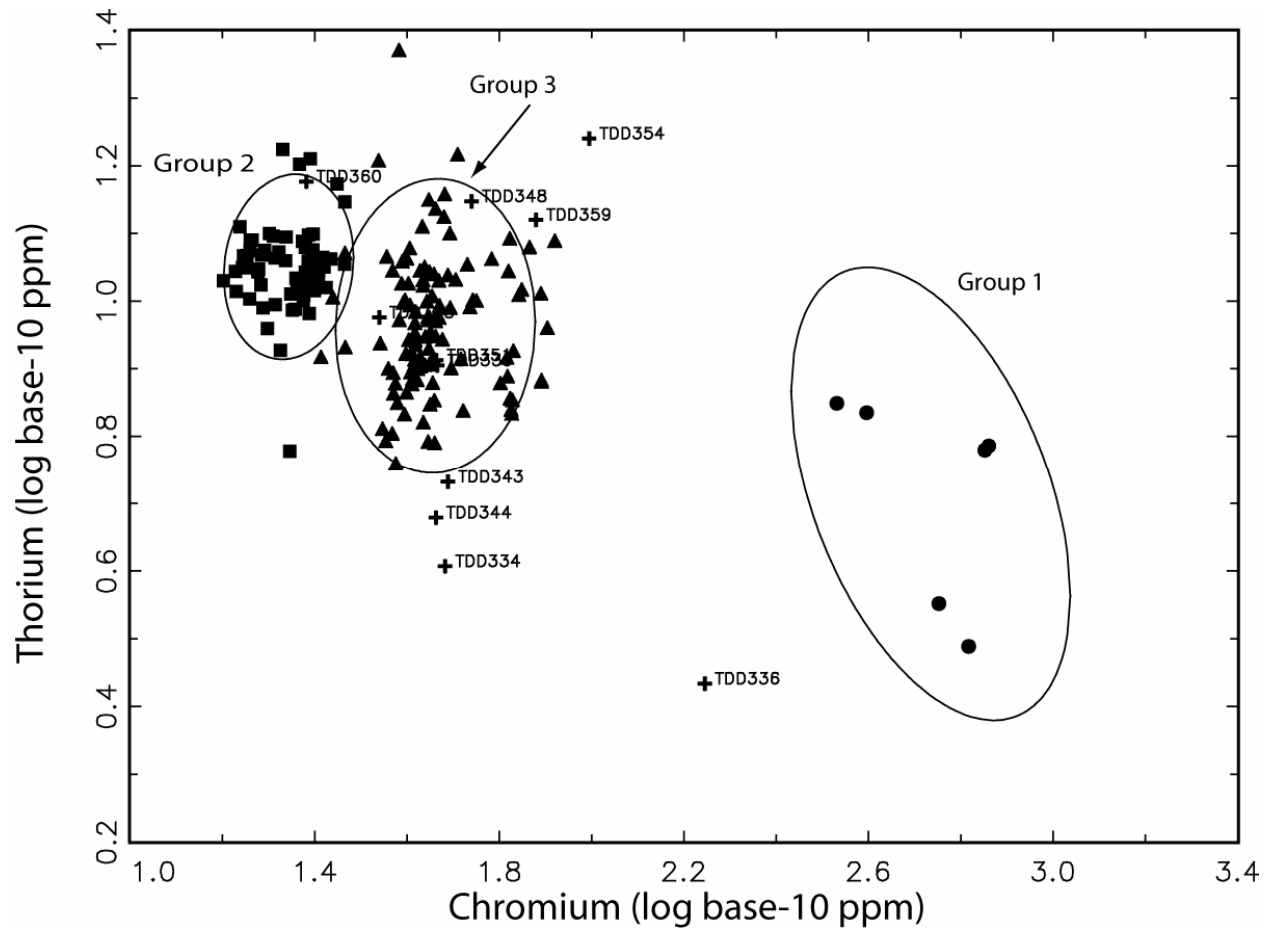


Figure 5: Plot of chromium and thorium base-10 logged concentrations showing the separation of the three ceramic groups and the unassigned samples (identified by their ANID). Ellipses represent 90% confidence intervals for group membership.

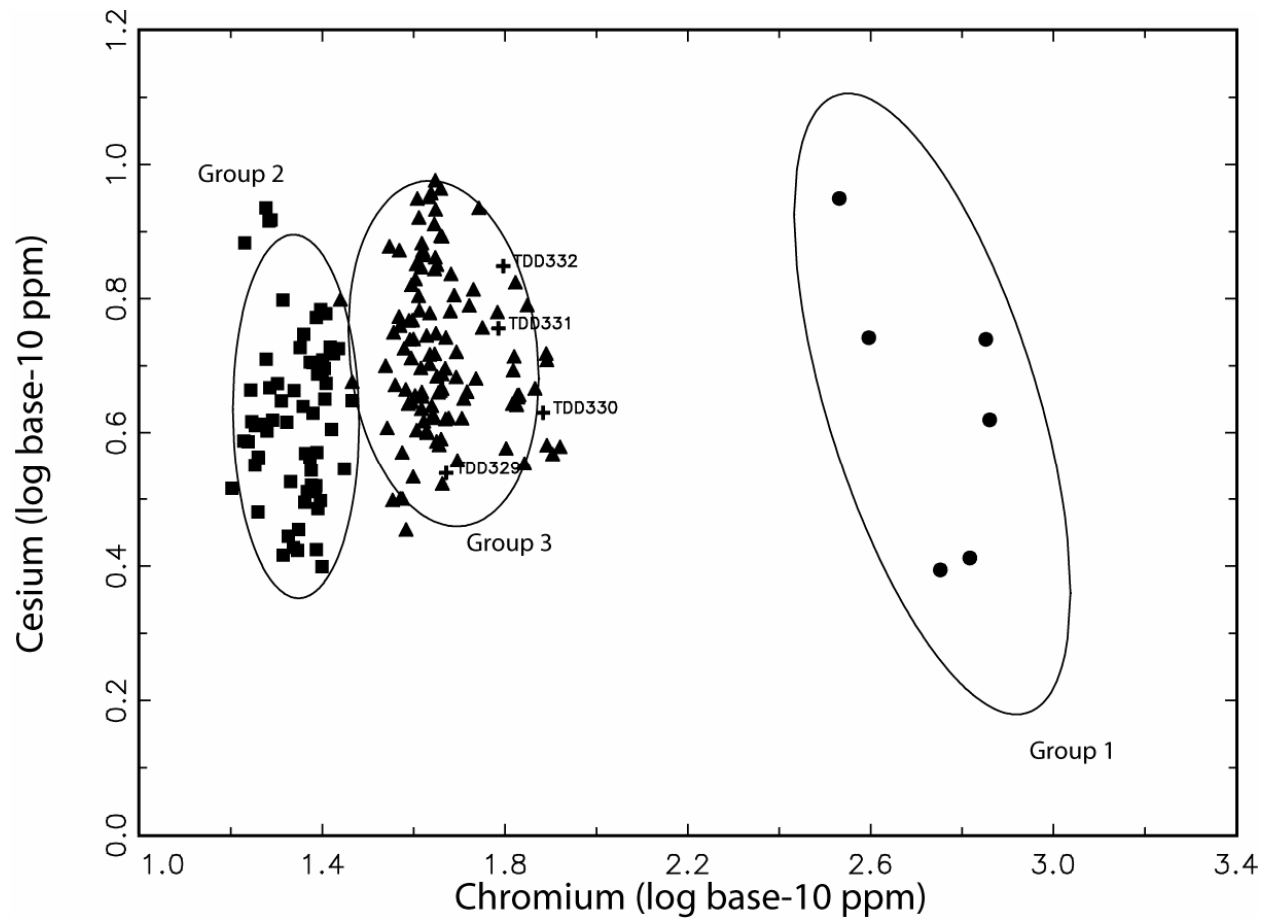


Figure 6: Plot of chromium and cesium base-10 logged concentrations showing the separation of the three ceramic groups and the clay samples (identified by their ANID). Ellipses represent 90% confidence intervals for group membership.