Use of natural resources for indigenous ceramic production in the Lesser Antilles during the Ceramic Age and Early Colonial Period

Stienaers, A

Chapter 6: Results of chemical analyses

In the previous chapter, the petrographic groups were defined and described. In this chapter, the results of the chemical analyses on the ceramic samples belonging to these groups and on clay samples from the corresponding islands are presented.

F01 and F22 (Antigua), F04, F18 and F19 (Barbados), F06 and F26 (St. Vincent), F07, F12, F20 and F21 (Trinidad), F08 (Guadeloupe) and F13 (St. Kitts) were only found on a single island. For these groups, the focus of the chemical analyses will be to ascertain whether their chemical compositions are consistent with the local geology, comparing both petrographic and chemical data to clays and the geological and soil information outlined in chapters 2 and 3.

For the other groups, chemical analysis will be used to further elucidate the mechanisms behind their occurrence on different islands. This will rely on the aforementioned comparison with geological and soil data, combined with the criterion of abundance (Quinn 2013, p. 119), which postulates that fabrics are usually most numerous close to their source location. This means that if a great majority of a certain fabric which is also consistent with a local origin from a compositional perspective occurs on a specific location but also a few instances of this fabric occur on another location, it being local to the first location is the more plausible option.

The datasets will be split into Trinidad, Barbados, Windward Islands and Leeward Islands because apart from F03, F23 and F27 (in total 15 samples), the fabrics occur exclusively within these islands or island groups and form separate petrographic entities. The former three fabric groups to which this divide does not appear to apply, are discussed separately. A cluster analysis is additionally run to statistically check the findings from petrography and chemistry and is discussed in more detail at the end of this chapter.

Trinidad

The results summarised below were also previously published more extensively in Stienaers et al. 2020 (see appendix). Generally, there is a good match between clays and ceramics for major elements. F20 displays strongly elevated CaO levels, but this is to be expected because of its shell temper and calcareous matrix. Figures 71 and 72 are facet plots which visualise the major element chemistry of Trinidad clays and ceramics.

A similar pattern emerges for the trace elements (see fig. 73), of which Sr and Zr are selected because they are reliable in both datasets and have shown that across the islands, these have the highest discriminatory power. Linked to the CaO, Sr is elevated in F20 and also in certain samples of F07 (grog group), due to their lime rich nature.

F16 (plagioclase and quartz) is the only Trinidadian group containing igneous inclusions. These can likely be linked to the "Cretaceous pluton, mostly intermediate to silicic" indicated as number 1 on the geological map of Trinidad (cfr. supra).

Except F03 (*caraipé* group), all groups encountered are exclusively found on Trinidad, display a good match in terms of chemistry and contain inclusions which are consistent with the local geology. This makes local production highly likely.

Despite this local production, no further differentiation within the island is possible on chemical grounds alone. The integration of these results with conclusions from literature will be discussed in the next chapter and can also be found in Stienaers et al. 2020.

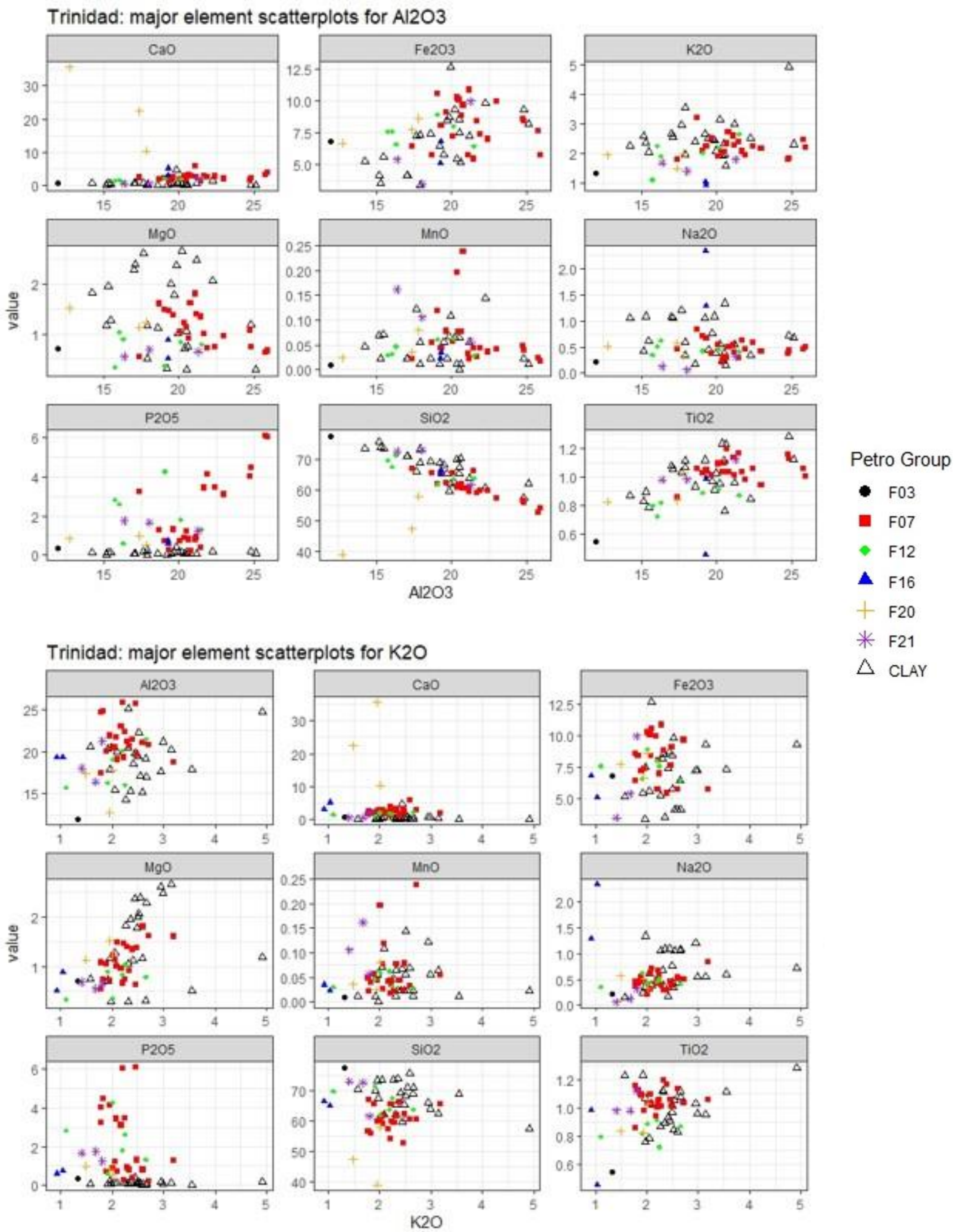

Fig. 71: Facet plot of Trinidad major element chemistry. Major oxides displayed in wt%. All major oxide chemical data is consistent with local production.

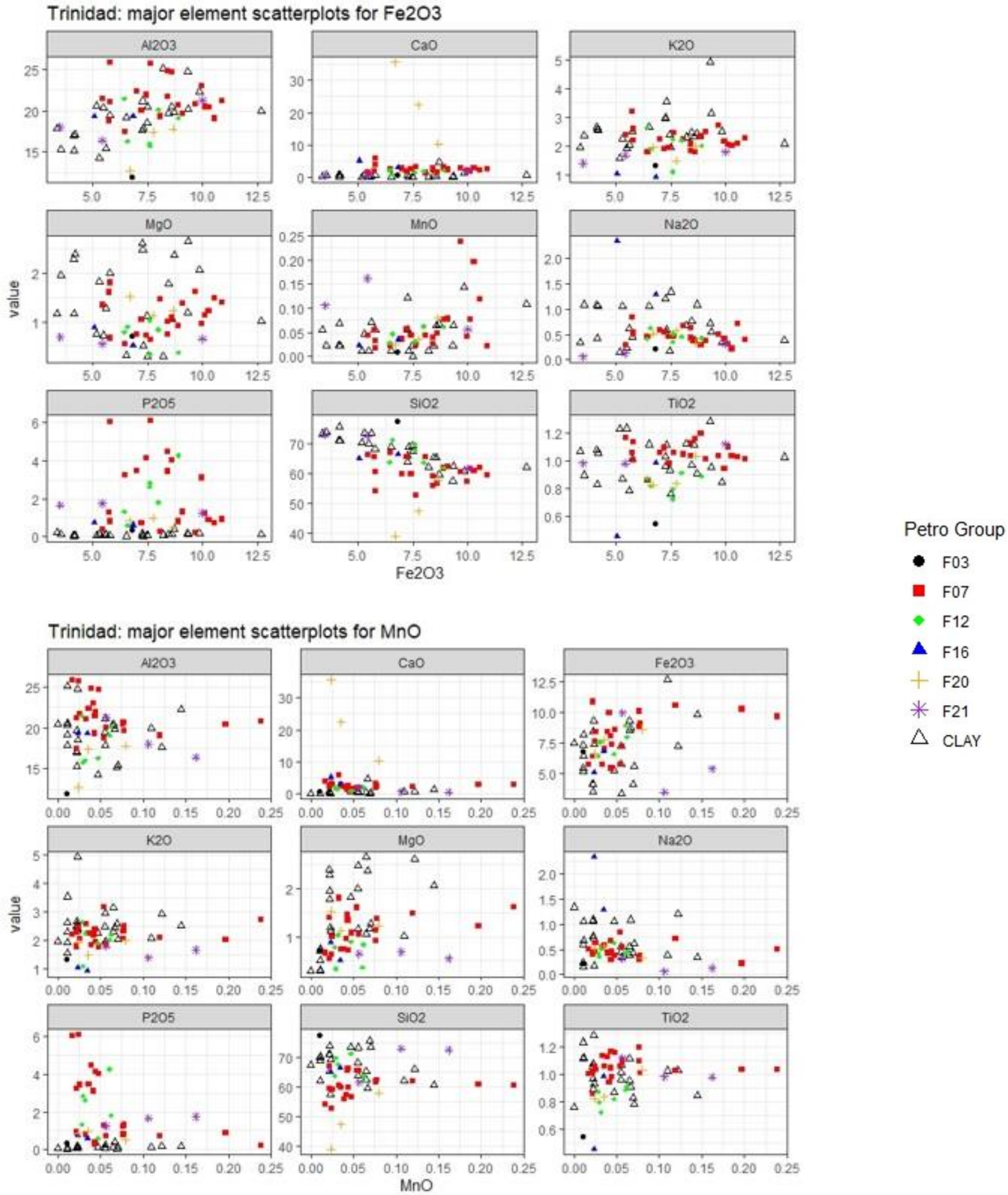

Fig. 72: Facet plot of Trinidad major element chemistry (continued). Major oxides displayed in wt%. All major oxide chemical data is consistent with local production.

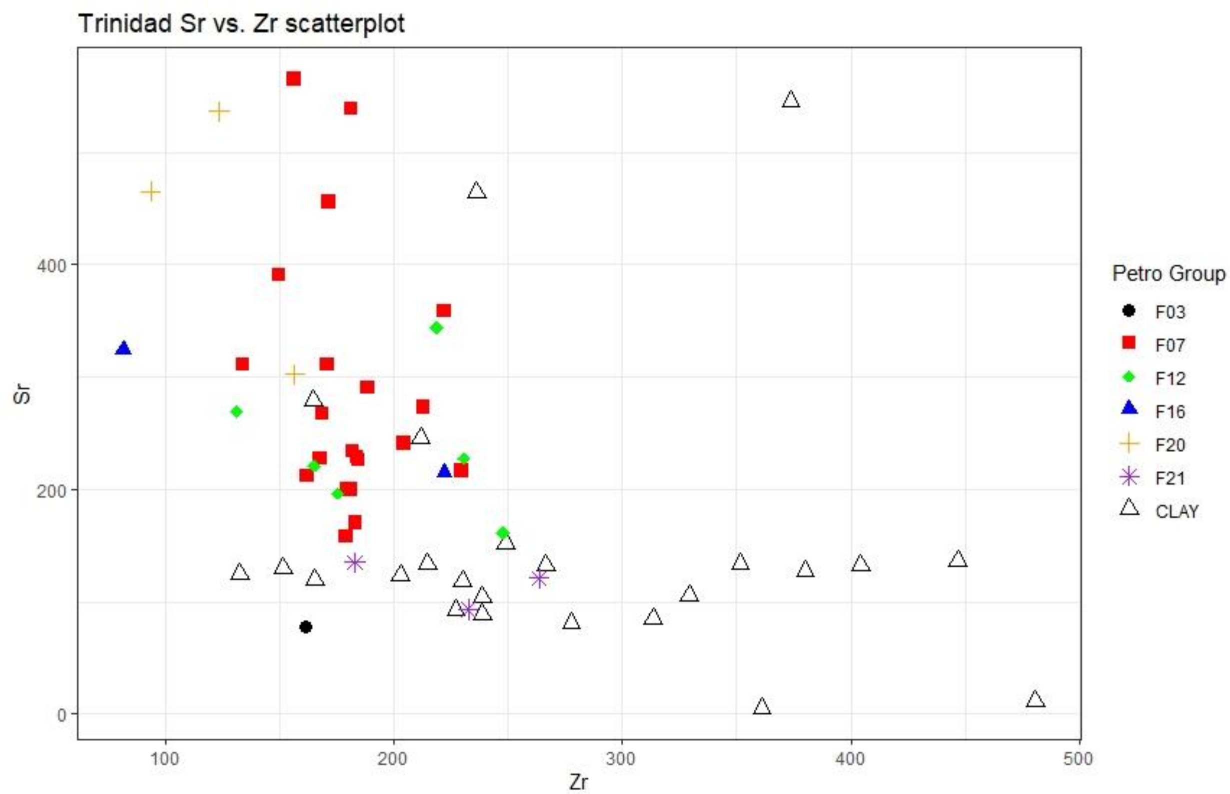

Fig. 73. Trinidad Sr vs. Zr scatterplot. Both elements shown in ppm. Although generally overlapping in compositional field, ceramic samples tend to be higher in Sr and clays higher in Zr.

Barbados

Major elements (fig. 74-76) show a good resemblance between clays and ceramics except SiO_2 (lower in clays), TiO_2 (higher in clays) and Na_2O (no systematic trend, but this is a less reliable element in our samples, cfr. p. 4.6). The discrepancy in SiO_2 can easily be explained by the silica-rich inclusions present in F18 and F19 on the one hand, being quartz sand and radiolarians respectively, and the highly calcareous nature of F04 (coral and calcareous clay) on the other hand. This may also explain the TiO_2 values since the scatterplot of SiO_2 vs. TiO_2 (fig. 6-C2) reveals that these elements are negatively correlated. There may also have been a variable amount of carbon and/or other organics present in the clays compared with the ceramics, giving rise to these slight variations in major element contents due to the closed sum effect, but since L.O.I data nor non-normalised data are available for these clays, this cannot be checked.

The Sr vs Zr plot (fig. 77) reveals that there is a very good match between the clays and the ceramics except for one F18 sample with a very high Sr value (CB14BN286). This sample has deviant values for most major elements as well, so this measurement may not have been reliable.

F27 (porous volcanic) is the only group with samples from Barbados which also occurs elsewhere in the Lesser Antilles (St. Lucia). Since this group bridges a “divide”, it will be discussed further in 5.2.5.

Combining the information of the petrographic and chemical analyses, with the geological setting, a local origin for all Barbados material (except possibly F27) is highly likely. As was the case for the Trinidad material, potential further regional differentiations are reserved for the next chapter as these are impossible to make using only our data.

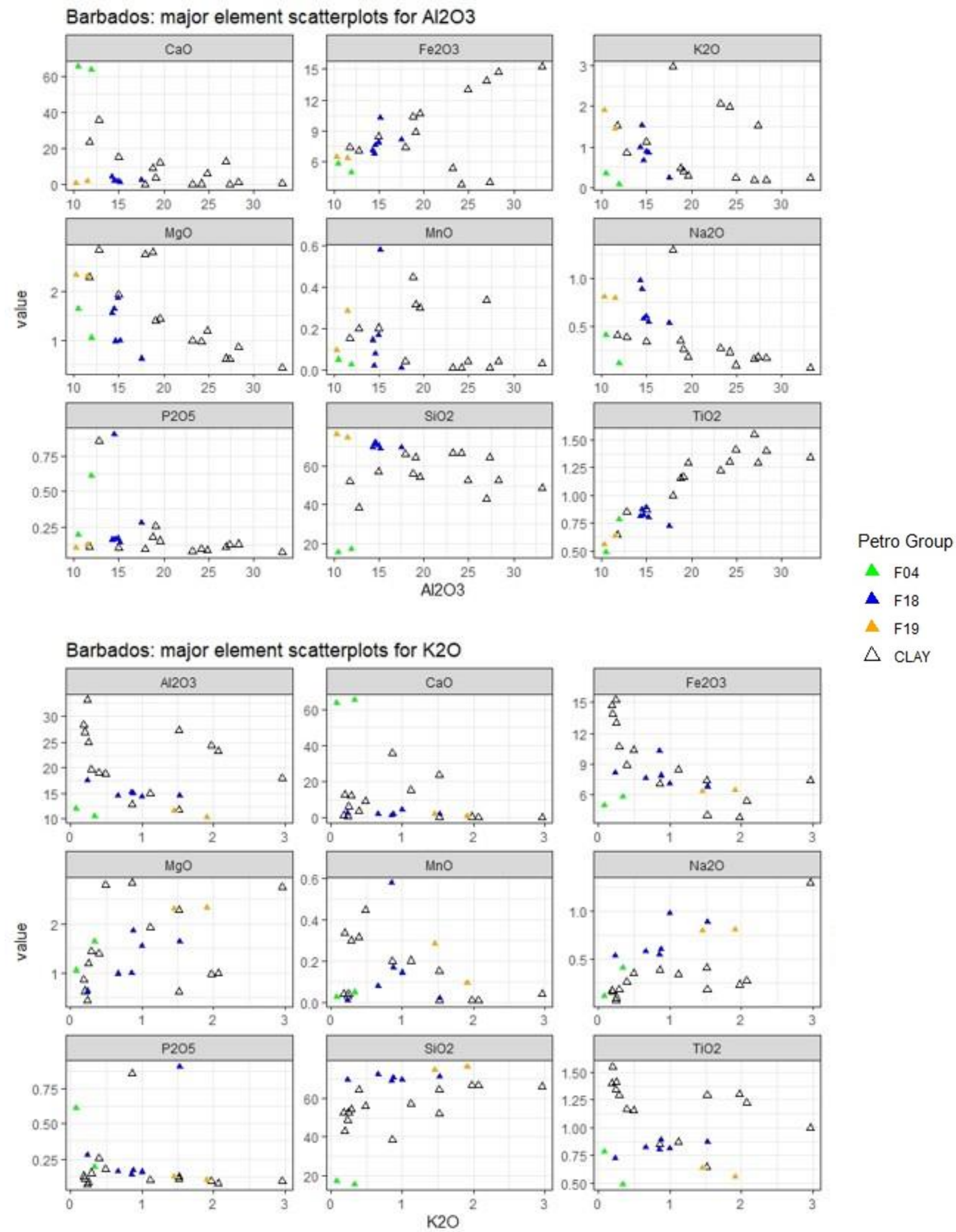

Fig. 74. Barbados major elements facet plot. Major oxides displayed in wt%. All major oxide chemical data is consistent with local production.

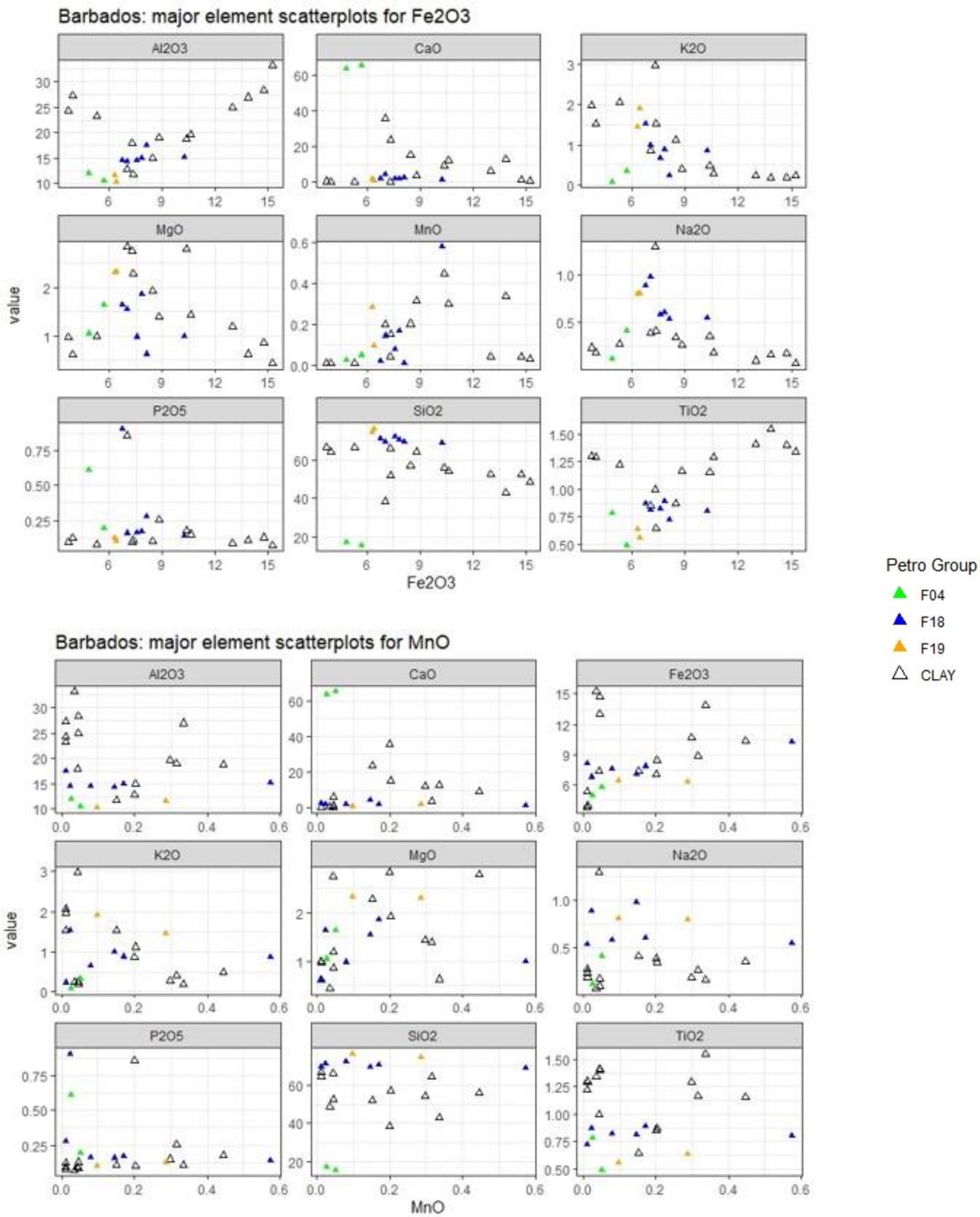

Fig. 75. Barbados major elements facet plot (continued). Major oxides displayed in wt%. All major oxide chemical data is consistent with local production.

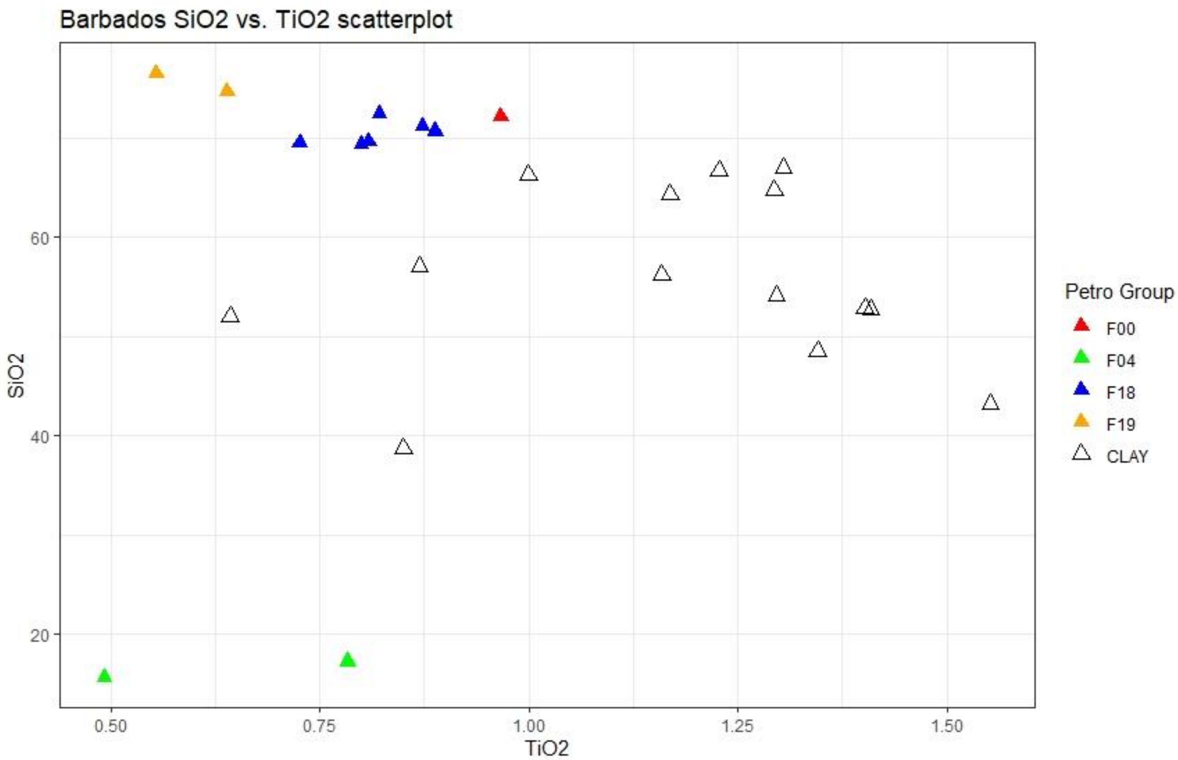

Fig. 76. Barbados SiO_2 vs. TiO_2 scatterplot. Both shown in wt%. The negative correlation is visible through the line from te top-left corner to the middle of the right side of the plot.

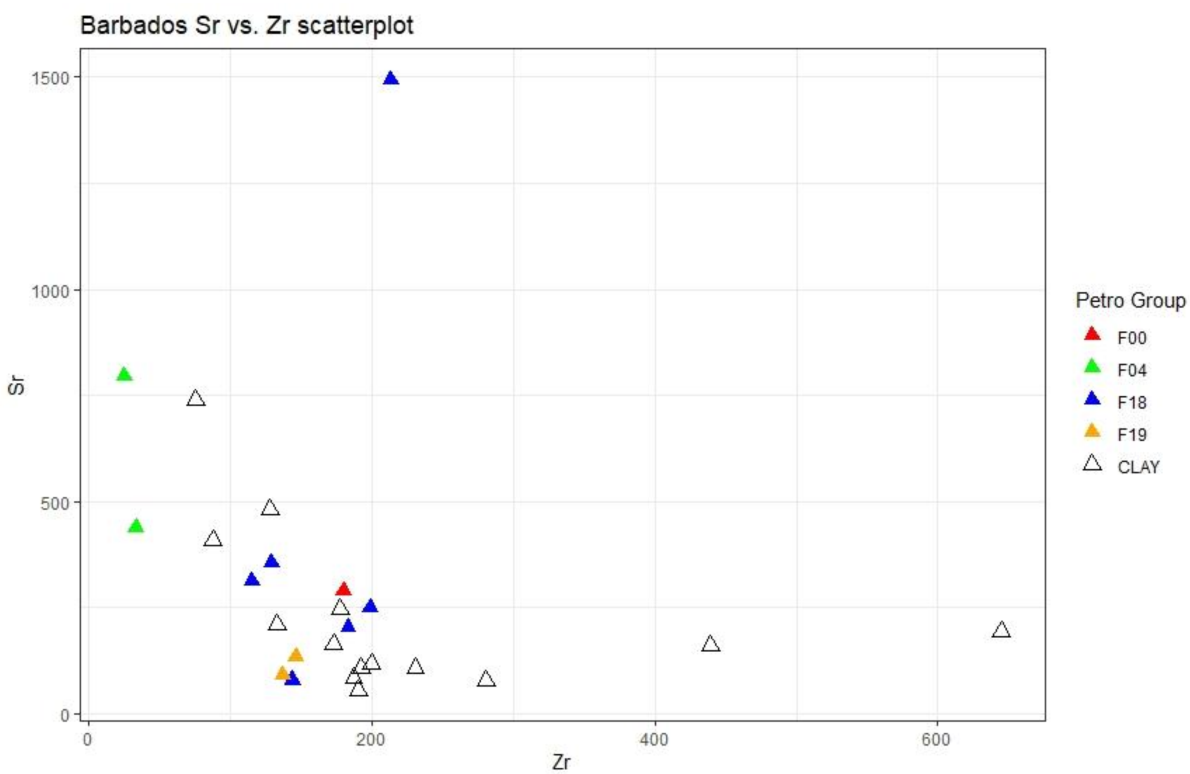

Fig. 77. Barbados Sr vs. Zr scatterplot. Both elements shown in ppm. Except for CB14BN286, there is a strong overlap between the ceramic samples and the clays, making local production likely.

Windward Islands

The chemical data for the Windward Islands display a lot of overlap, but clustering is nevertheless visible (fig. 78-82).

Visibility of the plots is further improved when the dataset is separated into F06 and F09, F10, F11 and F14 and F26. F25 is not incorporated into the chemical analyses because it was clear from the petrographic and typological analysis that this is European colonial trade ware. F00 (outliers) does not contain enough samples to make more conclusive remarks. F03 (*caraipé*) and F23 (volcanic with fine opaque grains) are to be discussed in 5.2.5 since F03 bridges the divide between pre-colonial and colonial and between the Trinidad and Windward interaction spheres and F23 bridges the Windward/Leeward divide (both pre-colonial).

F06 (granodiorite) and F09 (mafic volcanic with hornblende) (fig. 83-84)

F06 is only encountered on St. Vincent and shows a good compositional match with St. Vincent clays. Its mineral inclusion content is also consistent with local geology. Therefore, a local origin is highly likely.

All ceramics found on Grenada are F09 and there is a very large variation in the composition of Grenadian clay. This is logical given the highly diverse nature of the clays on the island, often occurring in close proximity to each other (cfr. supra). However, since all clay and ceramic samples from Grenada display an elevated Sr and Zr content and the ceramics contain hornblende, both typical characteristics for the basalts of the island (Scott et al. 2018, Devine 1995, Stamper et al. 2014), a local production for the F09 GRE samples seems likely. Scott et al. (2018) came to a similar conclusion for the hornblende-tempered Cayo ceramics she investigated with pXRF.

Because the number of samples and available contextual information about clays and ceramics permitted this, a case study was additionally executed on the F09 Grenada material to explore whether additional meaningful information could be gathered. When for example the criteria “distance to site” and “accessibility by water” are taken into account, an interesting pattern emerges (fig. 84). The former criterion is based on Arnold’s (1985, p.50) theorem that local clay is hardly ever sourced from more than a day’s march or approx. 7 km from the site in question, and the latter on the fact that clay sourcing trips, if not highly localised, may also have been undertaken by canoe travel along the coast and rivers.
Except two samples for both clay groups, clays gathered less than 8 km from the northern sites on Grenada (La Poterie and Pearls) and less than 8 km from the southern sites of Grenada (Caliviny Island and Westerhall) chemically cluster together. When the match between ceramic and clay chemistry is considered, only two ceramic samples (CB17AS023 and -025 from La Poterie) fall within the cluster of the southern clays. All other F09 ceramic samples from Grenada cluster together and match well with the cluster of the northern clays. The inland southern clay samples show the poorest match with the ceramics under consideration and therefore come out as the least likely clay sources. Further differentiation according to “accessibility by water” does not really show.

The time factor appears to be of little relevance yet again, as evidenced by the complete lack of differentiation in the chemical data according to time period. Instead, a large continuity in clay procurement across time is perceived. All arguments outlined above point towards the northern sources as the most likely candidates.

Apart from samples from Grenada, there is also a minority of St. Vincent ceramics belonging to F09. All but three of these samples plot together with F09 Grenada samples, so these were probably also produced from the same or similar Grenadian sources. Whether the clay was then transported to St. Vincent to be made into the finished product there or the finished pots were transported from Grenada to St. Vincent, is uncertain. The criterion of abundance and the fact that the rest of the Vincentian ceramics are relatively well-defined and provenanced groups with clearly Vincentian raw materials would favour the latter hypothesis, but the former possibility cannot be definitively ruled out.

F10 (mafic volcanic with quartz), F11 (mafic volc. without quartz) and F14 (plagioclase and clinopyroxene Windward) (fig. 85)

F10 major elements cluster together for St. Lucia and St. Vincent ceramics. There is a slightly better match with St. Lucia clay. In the trace elements, all F10 St. Vincent ceramics plot together with St. Lucia ceramics (all groups), but the match with St. Lucia clay is poorer than for the major elements. Therefore, it can be concluded from our data that F10 does not come from St. Vincent, but it is hard to ascertain whether it is from St. Lucia or some other source(s).

For the major elements, most F11 St. Vincent material plots close to other St. Vincent ceramics and clays but displays some outliers. F11 only contains two samples from St. Lucia. One is compositionally similar to other St. Lucia material, the other is a distant outlier for all major elements. All F11 ceramics have a similar trace element composition to St. Vincent clays. Therefore, F11 appears to be local to St. Vincent.

For both major and trace elements, all F14 ceramics from St. Vincent clearly cluster together with St. Vincent clays, whereas all F14 ceramics from St. Lucia clearly do not cluster together with St. Vincent clays. The match with St. Lucia clays is hardly better, however. There could be several reasons for this. Either the F14 St. Lucia ceramics are from St. Lucia, but the right clay source has not been sampled or the F14 St. Lucia material has an unknown other source. The choice is made to keep them in the same F-group because petrographically there is no distinction between the St. Vincent and St. Lucia material.

Since the inclusions present in all three petrographic groups can be encountered on both islands, the geological map does not provide additional provenance suggestions.

F26 (micaschist/quartzite with igneous) (fig. 86)

F26 consists of only three samples, found exclusively on Argyle, St. Vincent. However, the tempering material consists of – for the island – atypical metamorphic inclusions such as weathered schist. Within F26, CB15BN181 has a much higher Sr and a lower Zr value than CA17PD005 and -006, which plot very closely together. F26 does not exhibit a good match with St. Vincent clays. On fig. 5-F7, F26 is plotted together with F12 and Trinidad clay because this is the only other known metamorphic fabric in this study. However, the chemical signature of F26 does not match with those signatures either. Since no metamorphic outcrops are known on St. Vincent, these samples were probably imported from an unknown other source.

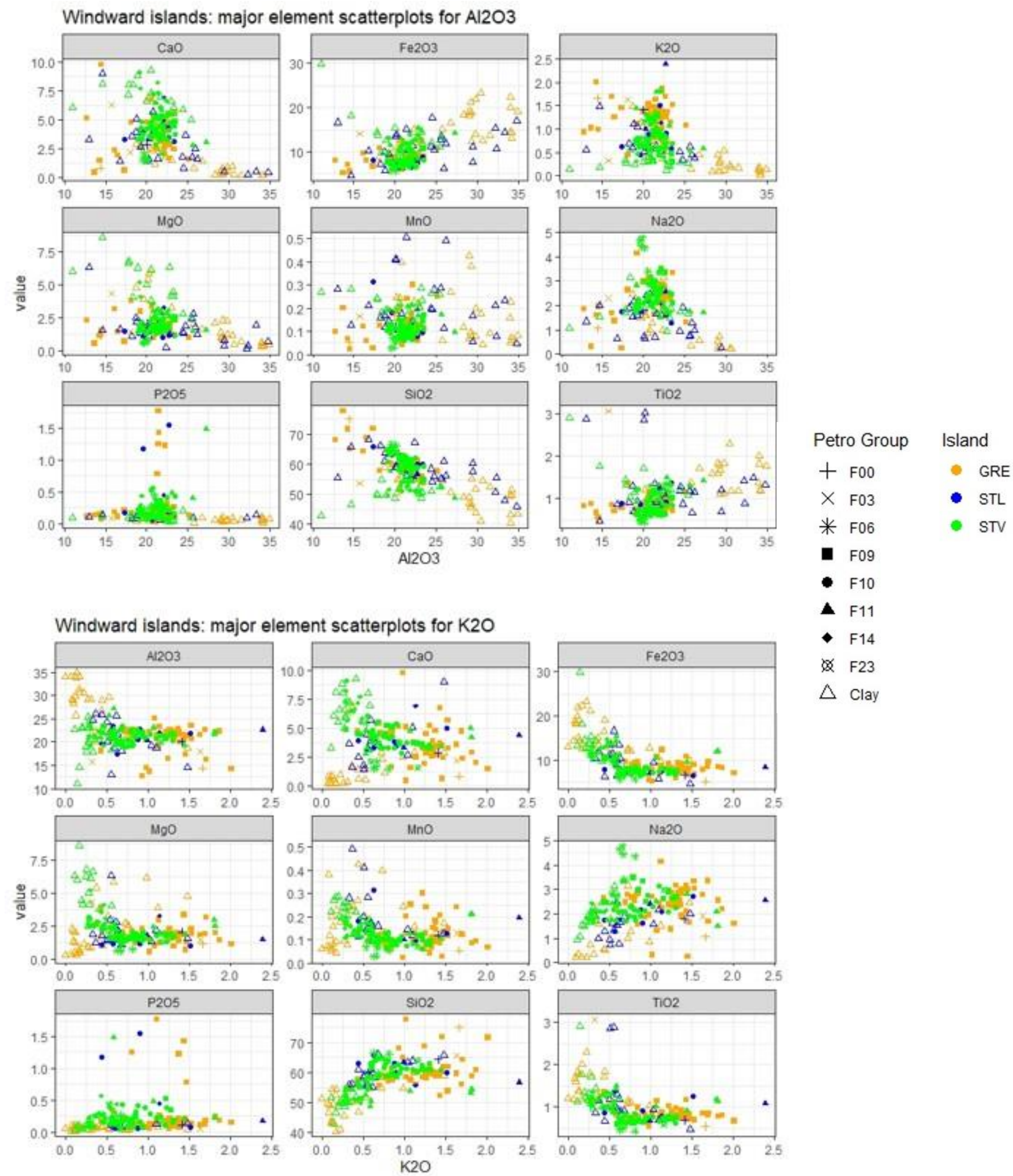

Fig. 78. Windward Islands major elements facet plot. Major oxides shown in wt%. On this general plot, many overlapping fields are visible.

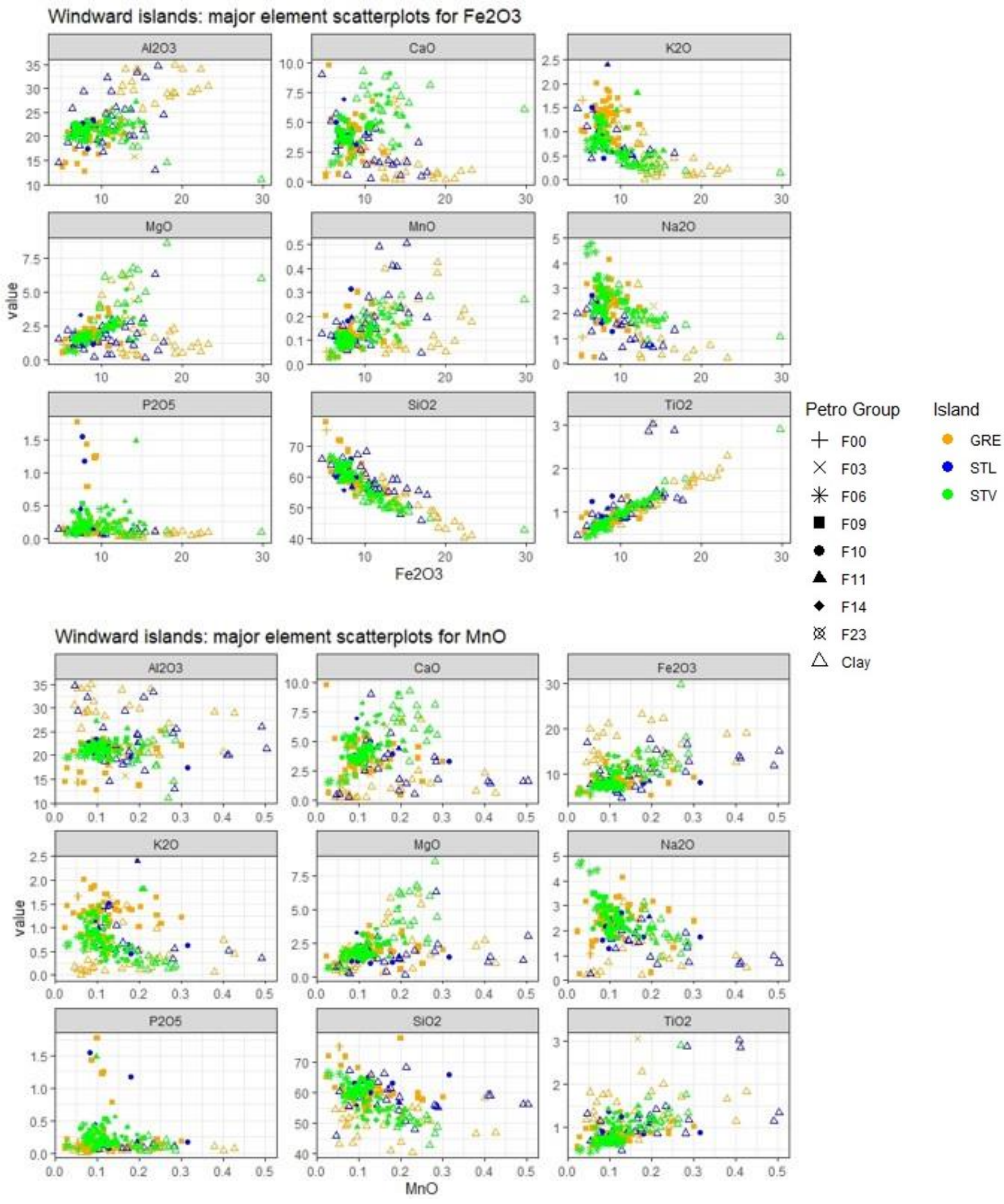

Fig. 79. Windward Islands major elements facet plot (continued). Major oxides shown in wt%. On this general plot, many overlapping fields are visible.

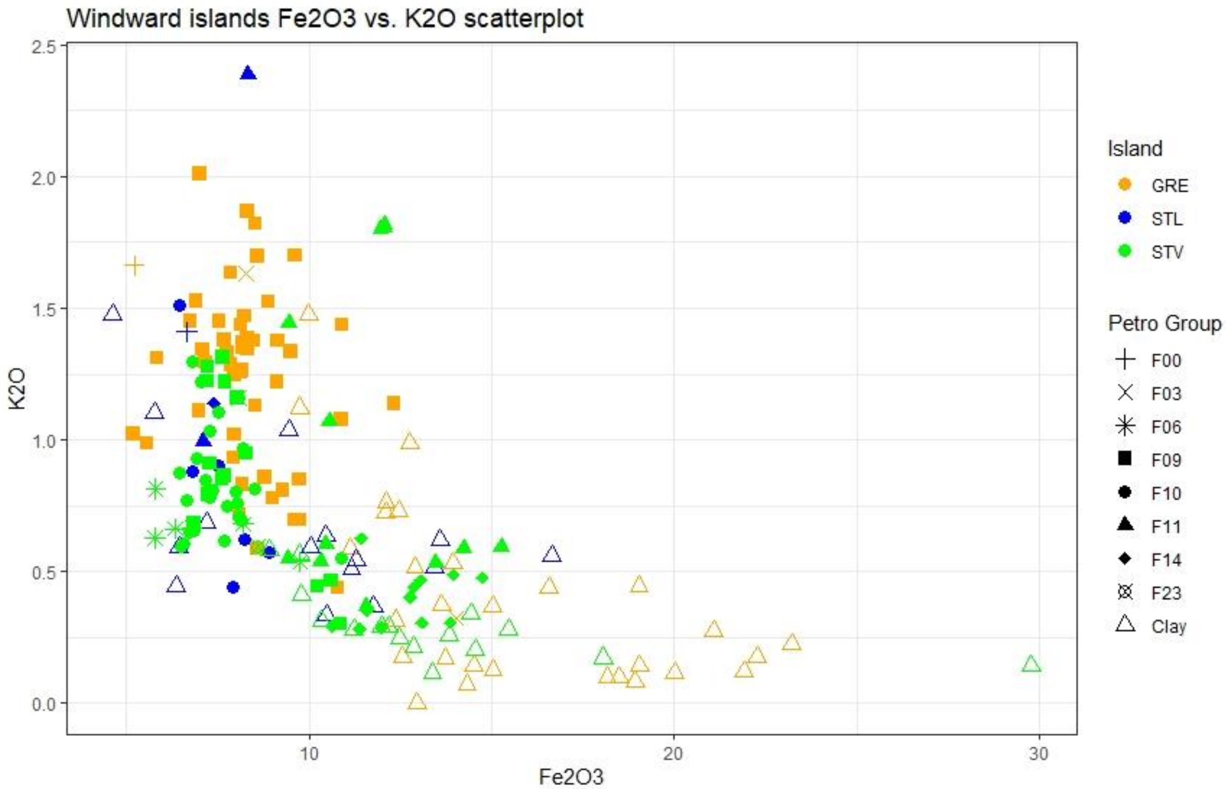

Fig. 80. Windward islands Fe_2O_3 vs. K_2O scatterplot. Major oxides shown in wt%. Many overlapping fields are visible.

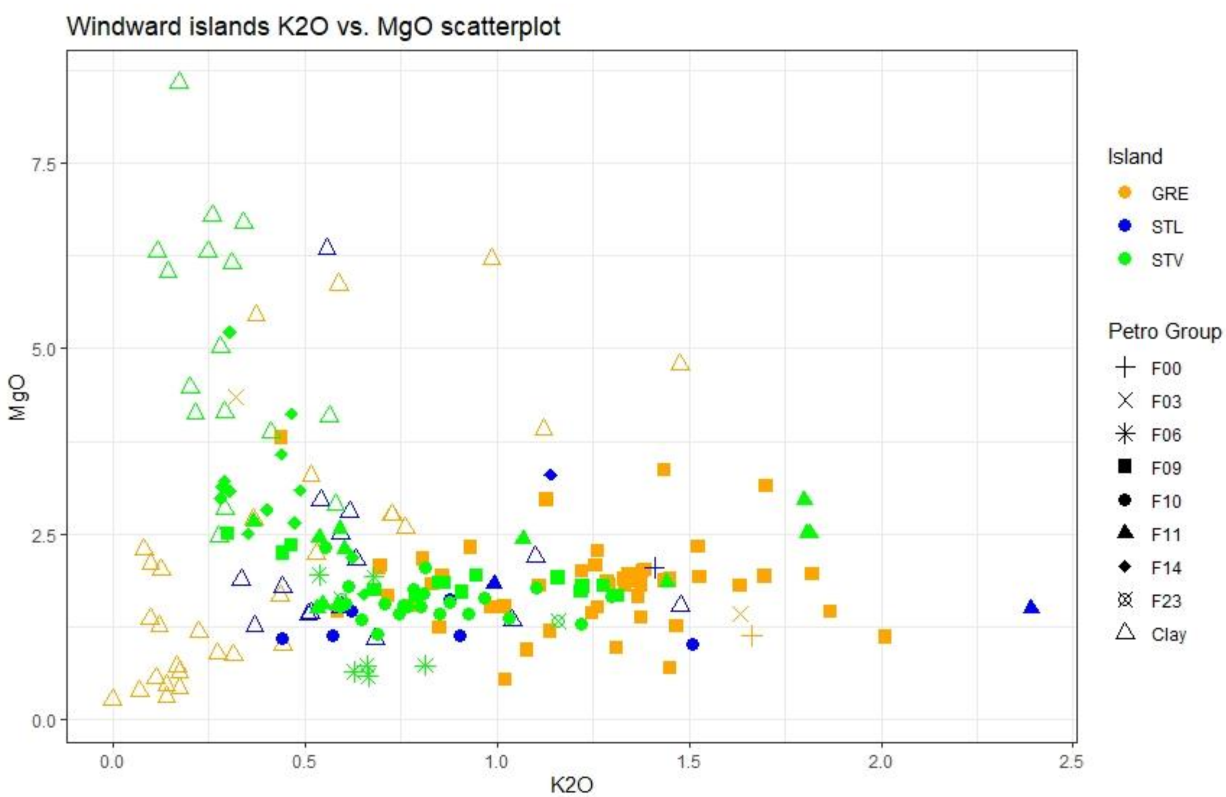

Fig. 81. Windward islands MgO vs. K_2O scatterplot. Major oxides shown in wt%. Many overlapping fields are visible.

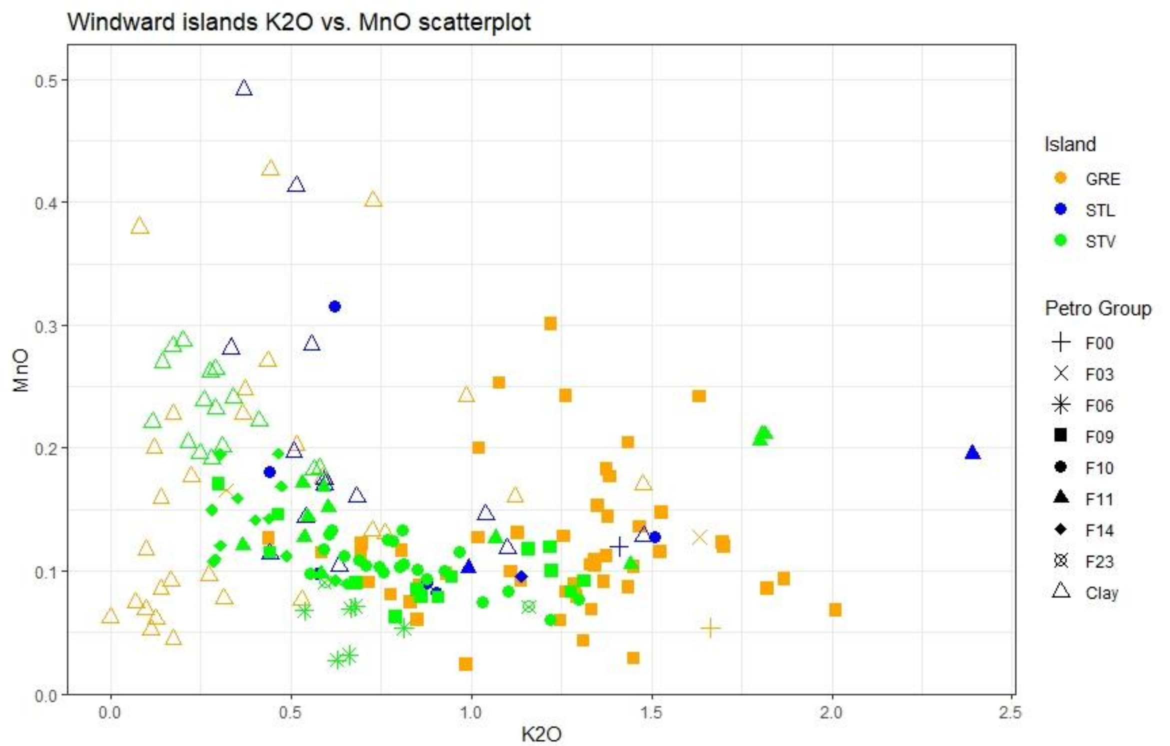

Fig. 82. Windward islands MnO vs. K_2O scatterplot. Major oxides shown in wt%. Many overlapping fields are visible.

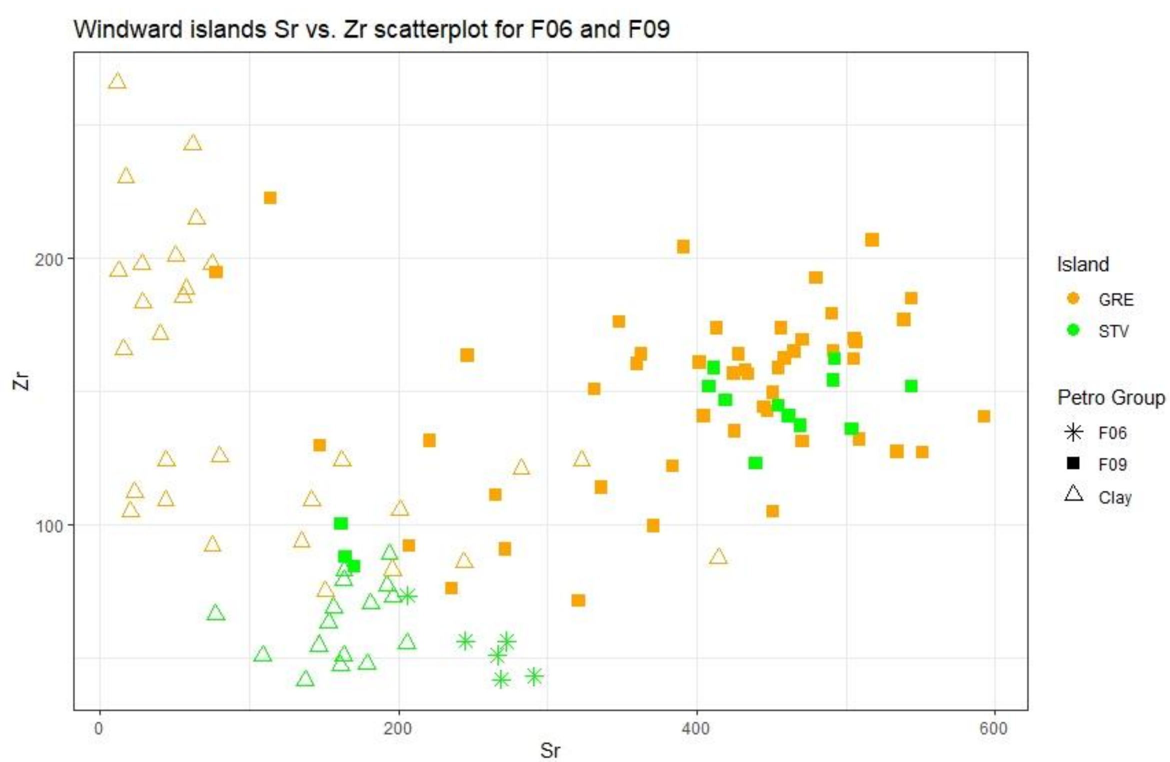

Fig. 83. F06 and F09 Sr vs. Zr (ppm) scatterplot. Grenadian clays are higher in Zr and some are higher in Sr, in accordance with the high-Sr basalts found on the island. There is a clear separation between F06 (green stars) which was exclusively encountered on St. Vincent and matches well with Vincentian clays and all F09 material (orange and green rectangles).

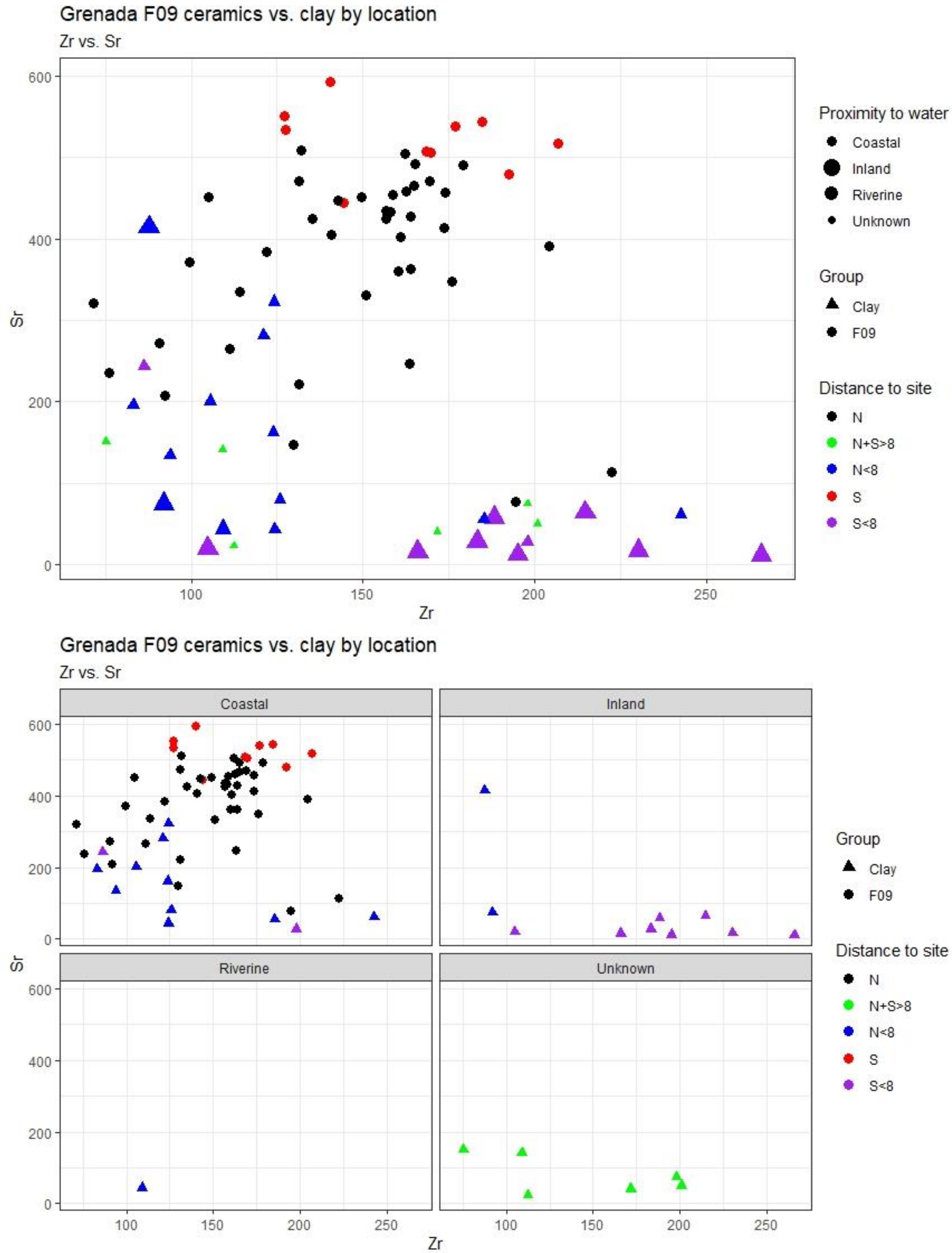

Fig. 84. Grenada clay sources vs. Grenada F09 ceramics with location vs. water and distance to site taken into account. S = Westerhall Site (Late Ceramic Age) and Caliviny Island (All Ceramic Age), N = Pearls (Early Ceramic Age) and La Poterie (Late Ceramic Age and Early Colonial). N+S>8 means the clay samples were sourced more than 8 km from the respective sites and x<8 less than 8 km. A preference for northern coastal clays is visible.

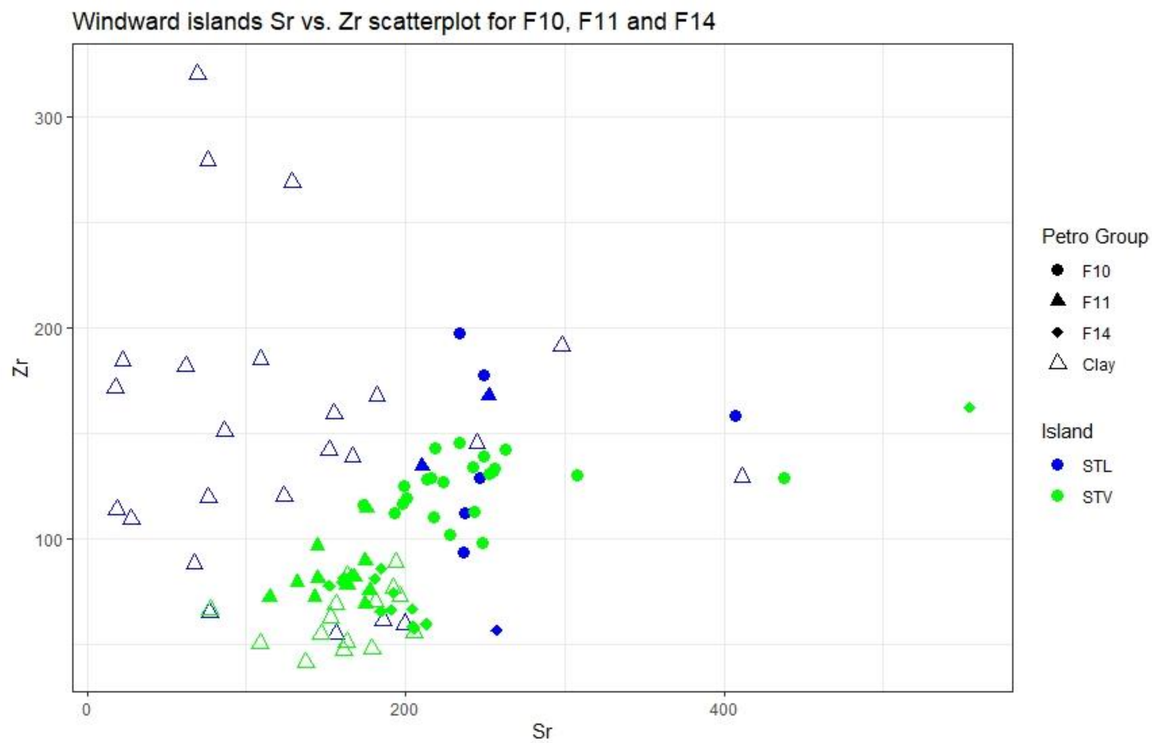

Fig. 85. F10, F11 and F14 Sr vs. Zr (ppm) scatterplot. Notice the good and tight fit of F14 St. Vincent ceramics (green diamonds), with St. Vincent clays (green hollow triangles) and the clustering of St. Vincent F10 ceramics (green dots) with all St. Lucia material (blue).

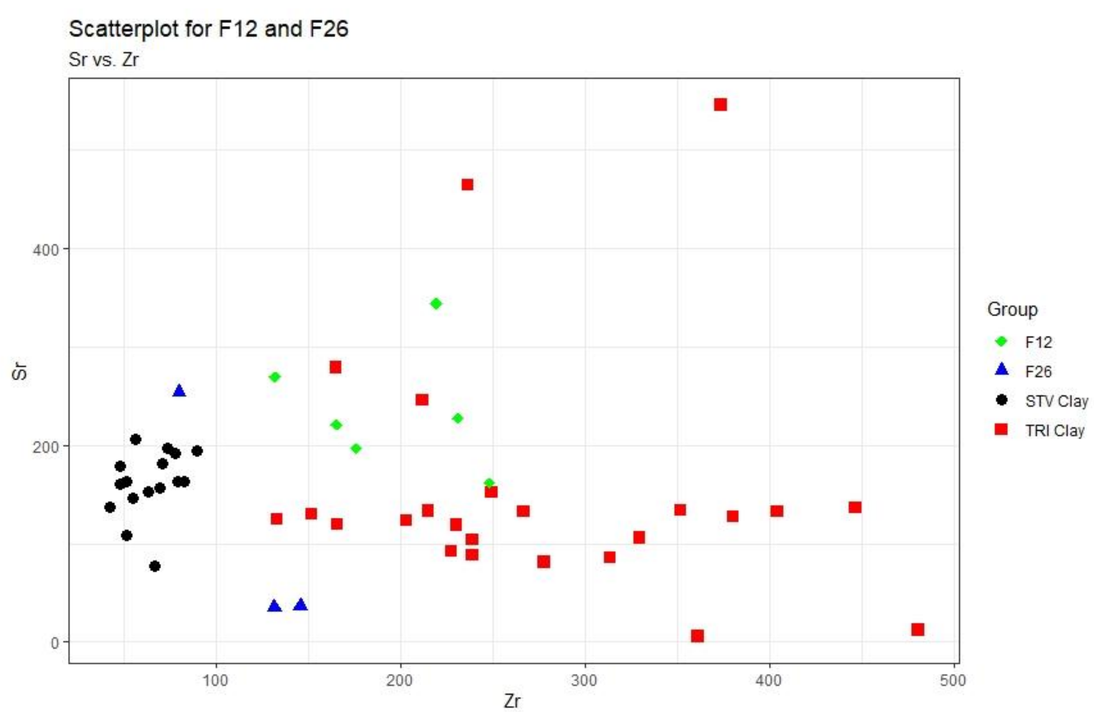

Fig. 86. F26 vs. F12 Sr and Zr (ppm) scatterplot. F26 ceramics (blue triangles) do not show a convincing match with either St. Vincent or Trinidad clays.

Leeward Islands

Figures 87-94 show the results of the chemical analyses of the Leeward Island samples.

St. Martin ceramics and clays are heterogeneous with a lot of overlap with the other groups/islands. F17 (Quartz and Granite) is exclusively encountered on St. Martin, so these ceramics are probably local to the more felsic igneous parts of the island. The F05 and F24 samples encountered on St. Martin were probably imported from one of the Volcanic Caribbee Islands because they are chemically much more consistent with the other samples of those groups than with F17 and St. Martin clay compositions and this would also be more logical given the geological substrate and the nature of the inclusions.

F08 (heterogeneous clay matrix and few inclusions) was found exclusively on Guadeloupe. Moreover, chemically there is a good match between these ceramics and Guadeloupe clay sources and they occupy a fairly distinct region in the plots. This renders a local production of F08 on Guadeloupe likely. Figure 93 zooms in on this F08 group, because from the soil information, we found that GUA-08 and GUA-09 were probably the most easily workable clays and GUA-01 to GUA-09, GUA-11 and the site of Morel itself were all clays from the limestone part of the island (Grande-Terre). Especially the Sr values are indeed lower in the volcanic clay samples, which is to be expected because of the association between Sr and lime. This makes these volcanic clay samples less likely provenance candidates. Further differentiation within the Grande-Terre sources is difficult.

St. Eustatius and Saba material (F01, F05, F15, F24) is impossible to separate chemically for trace elements. There is a better match with Saba clays than with St. Eustatius clays for trace elements but only two St. Eustatius clay samples are available, so the number of samples is too limited for definitive conclusions. For Fe_2O_3 vs. K_2O, however, there does seem to be a separation between Saba clays and ceramics on the one hand, and St. Eustatius clays and ceramics on the other.

St. Kitts (F05, F13, F15, F24) ceramics occupy a fairly homogeneous region of the plots so they might be local, but unfortunately no clay data is available for further verification. F13 ceramics were encountered exclusively on St. Kitts. All inclusion types are consistent with the geological substrate of St. Kitts.

Antigua ceramics (F01, F22) occupy a fairly distinct region of the Sr vs. Zr plot and have good match with some of the Antigua clay samples. Major element composition is inconclusive. Based on the trace element composition, a local production is the most likely scenario for at least F01. F23 is a shared group with St. Vincent material, so will be discussed further in the part dedicated to groups bridging a divide. In accordance with the gathered soil and geological information, a comparison was also made with clay sources of the same geological substrate (fig. 94). Indeed, the best match appears to exist with the marl clays and the trap clays. The fit with the clays from different geological substrates (conglomerate and chert) is poorer. Because of the very tight clustering, it is impossible to say whether the Doigs ceramics correspond better with ANT-17, ANT-09 and ANT-10 (trap) and the ceramics from the other sites with ANT-19, ANT-14, ANT-13 and ANT-21 (marl).

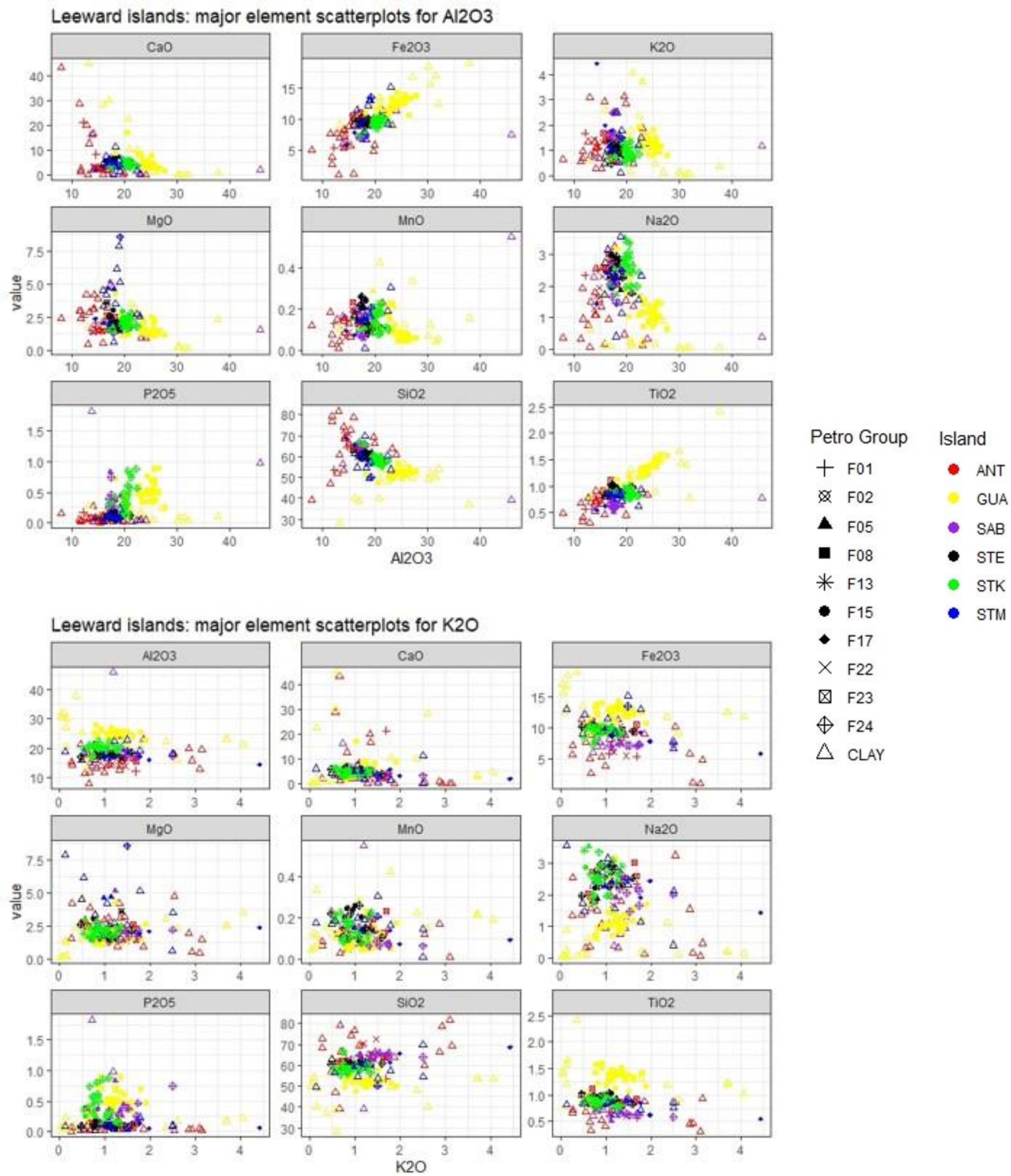

Fig. 87. Leeward Islands major elements facet plot. Major oxides shown in wt%. On this general plot, many overlapping fields are visible.

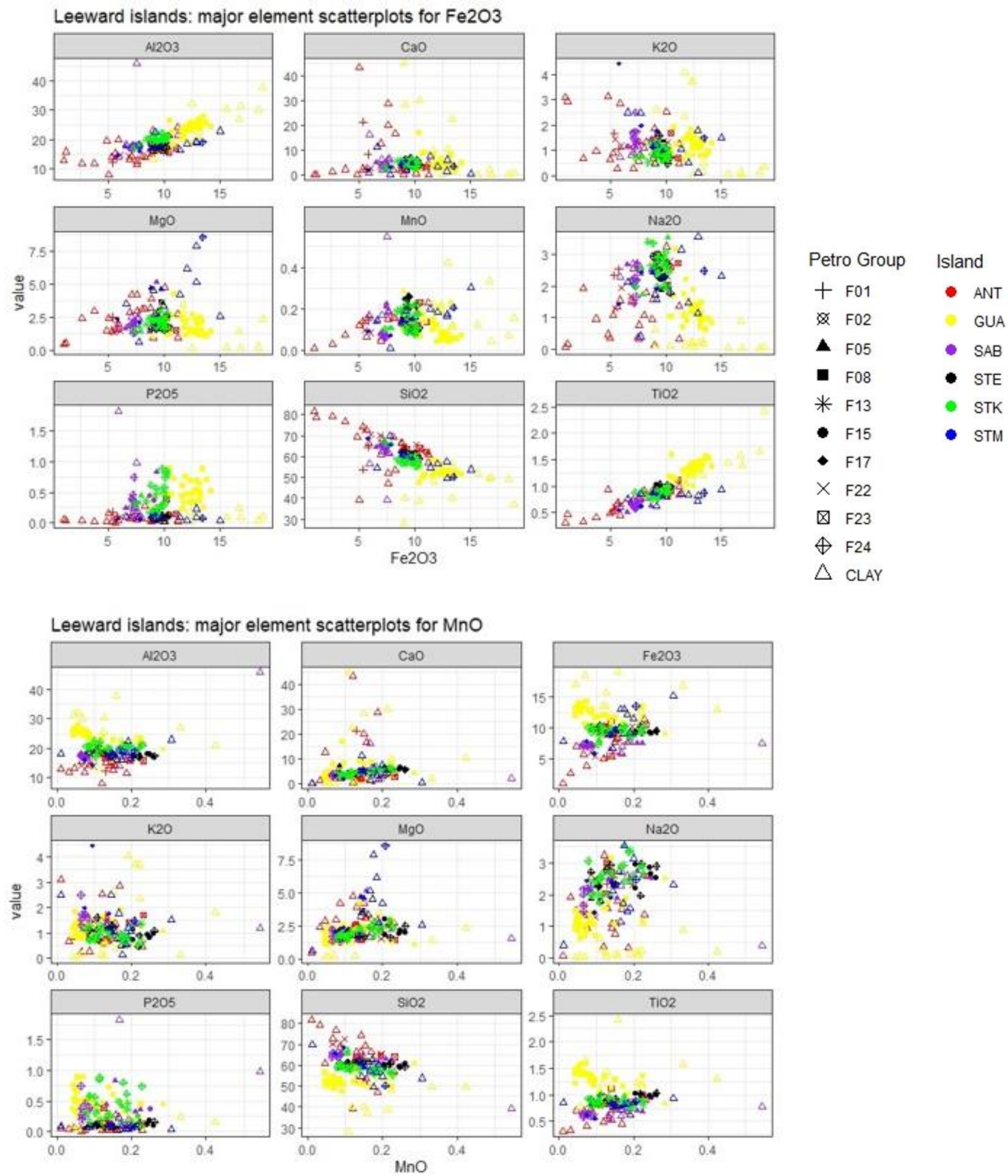

Fig. 88. Leeward Islands major elements facet plot (continued). Major oxides shown in wt%. On this general plot, many overlapping fields are visible.

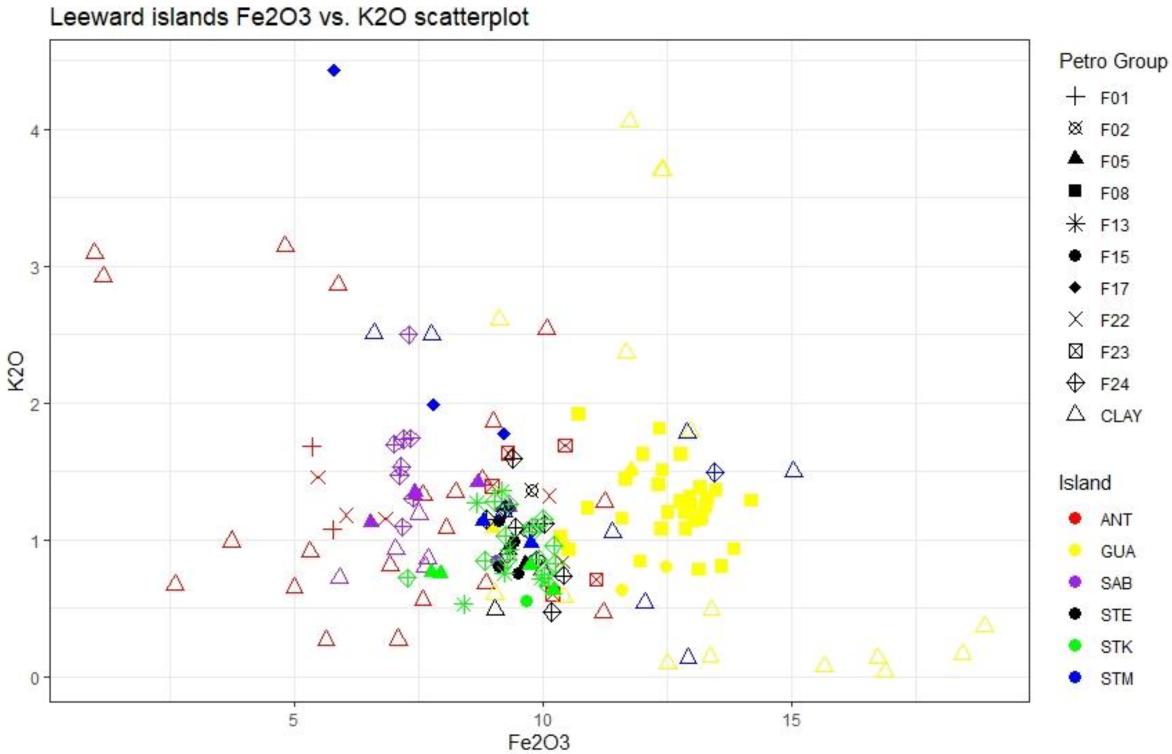

Fig. 89. Leeward islands Fe_2O_3 vs. K_2O scatterplot. Major oxides shown in wt%. Many overlapping fields are visible, but with generally a seemingly stronger correlation between colour (= island) than petrographic group (= symbol).

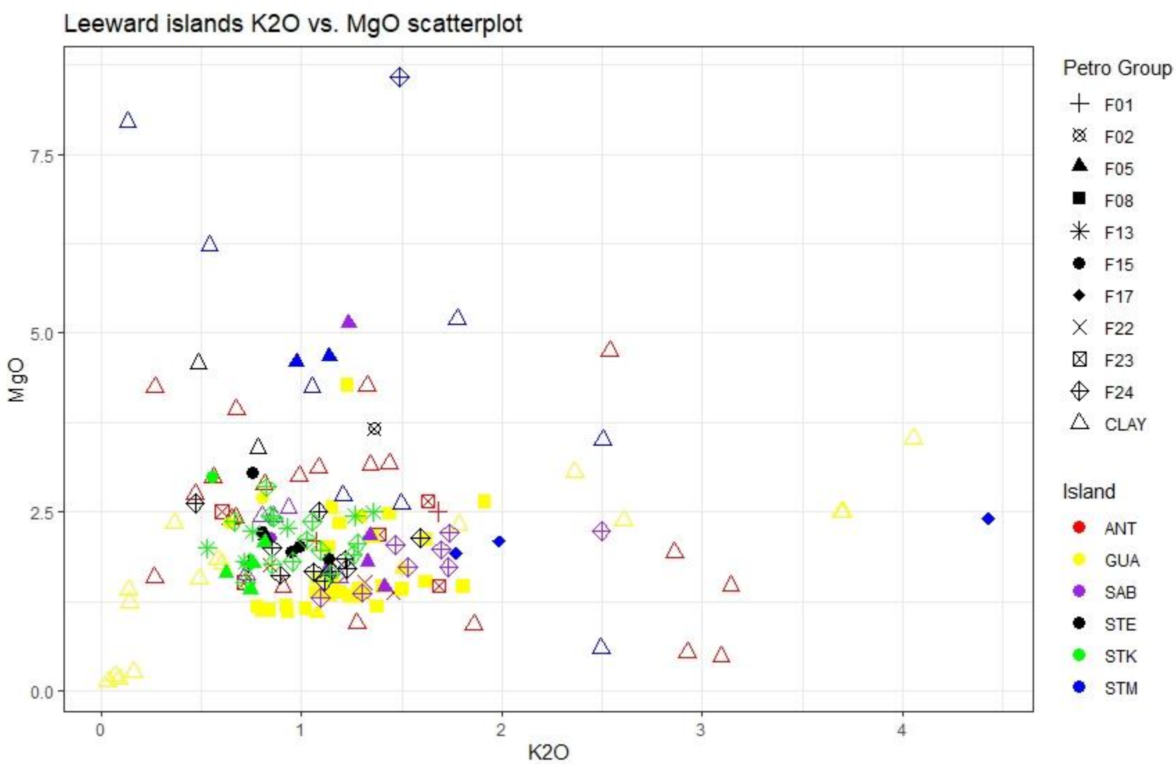

Fig. 90. Leeward islands MgO vs. K_2O scatterplot. Major oxides shown in wt%. Many overlapping fields are visible.

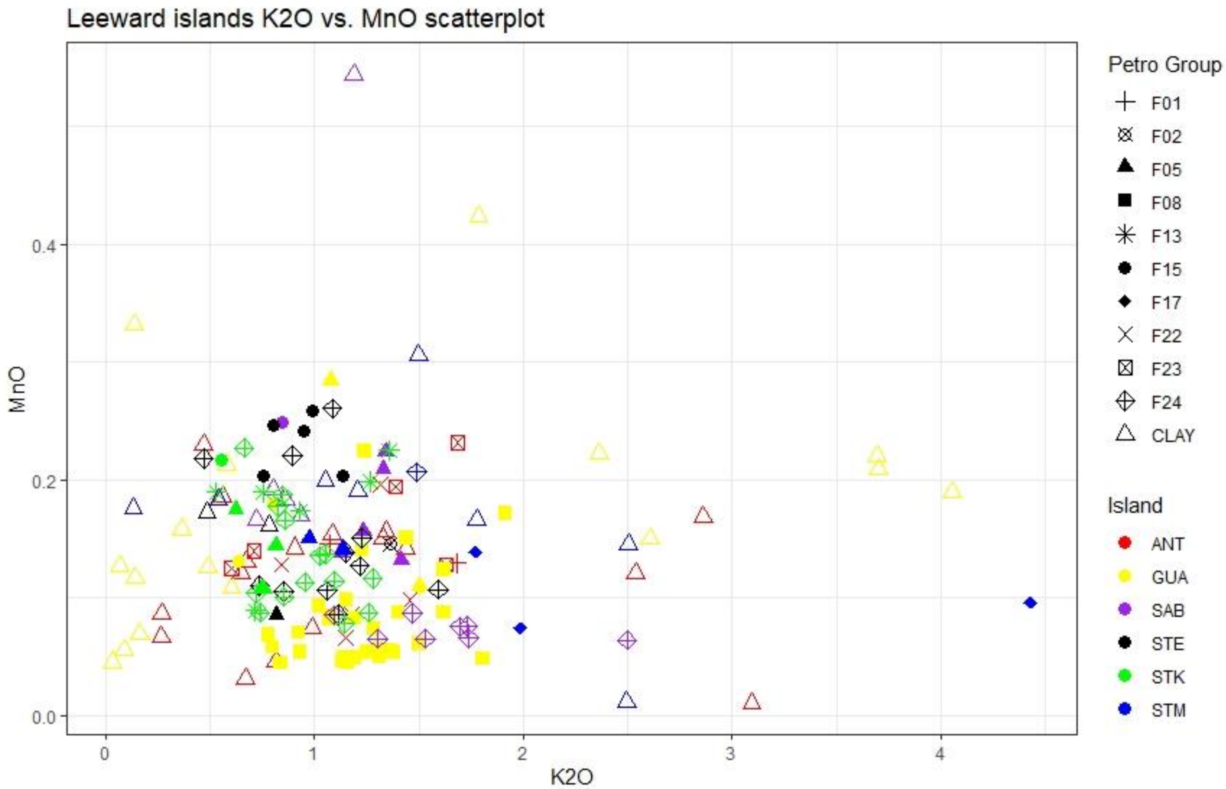

Fig. 91. Leeward islands MnO vs. K_2O scatterplot. Major oxides shown in wt%. Many overlapping fields are visible.

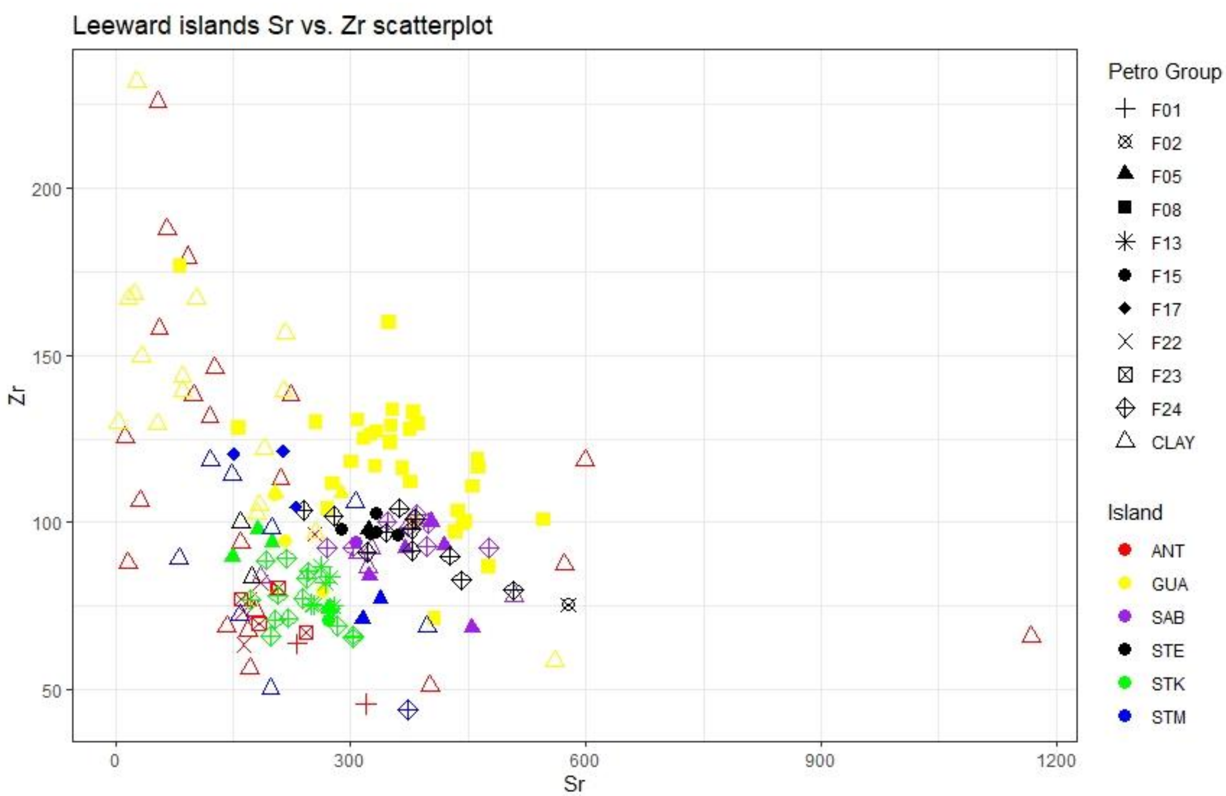

Fig. 92. Leeward islands Sr vs. Zr (ppm) scatterplot. Many overlapping fields are visible, but with generally a seemingly stronger correlation between colour (= island) than symbol (= petrographic group).

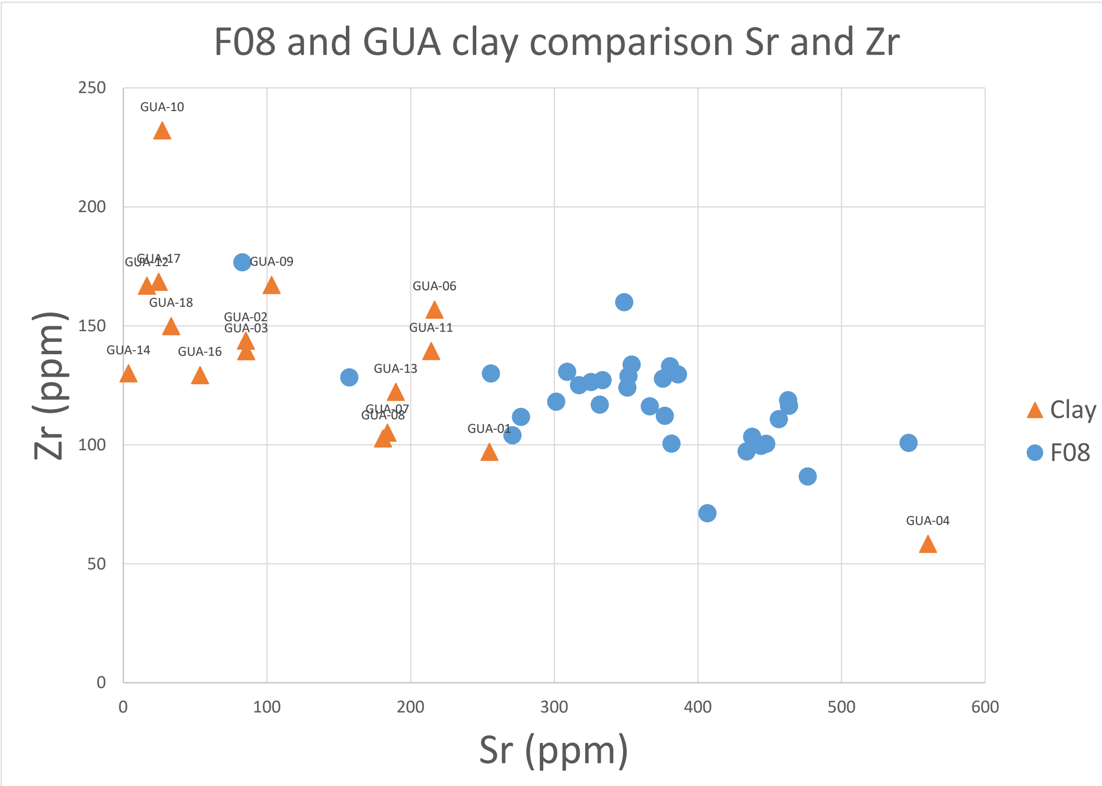

Fig. 93. Guadeloupe Sr vs. Zr (ppm) scatterplot. There is a good match with local clays, especially the clays from Grande-Terre.

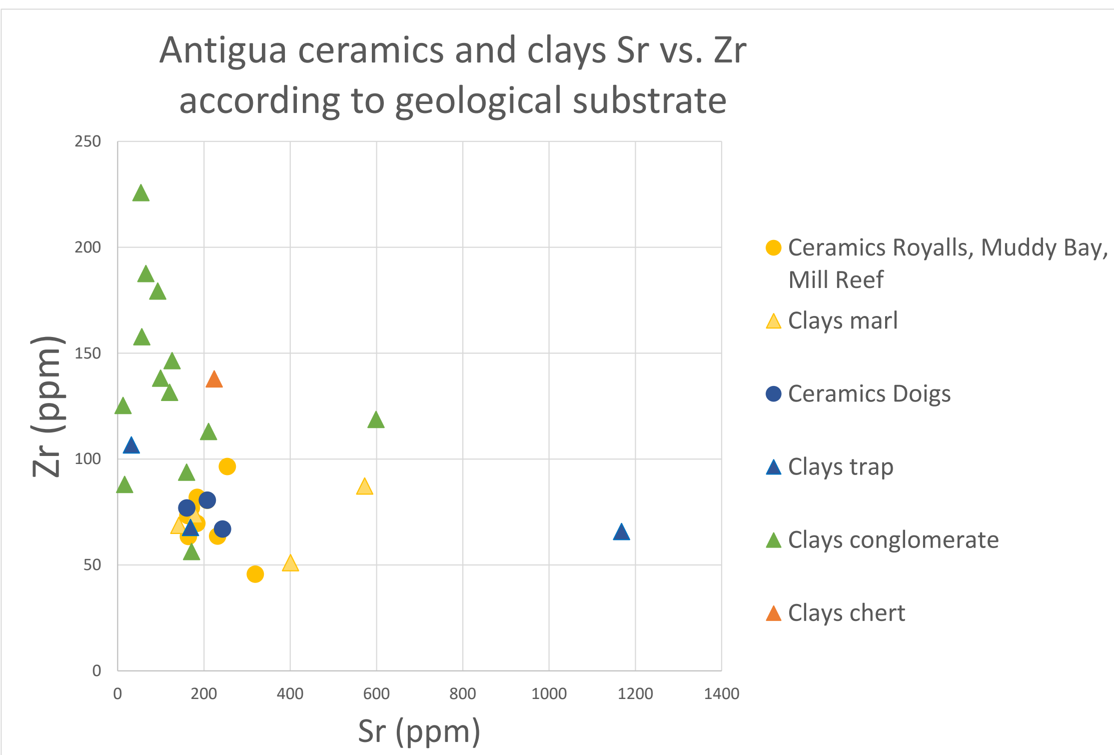

Fig. 94. Antigua Sr vs. Zr (ppm) scatterplot. There is a good match with local clays, especially with the marl and trap clays.

Groups across a divide

As mentioned earlier in this chapter, there are three petrographic groups (F03 *caraipé*, F23 Volcanic with Fine Opaque Grains and F27 Porous Volcanic) which do not comply with the otherwise constantly recurring "divide" between the defined regions. Figures 95-97 show the Sr vs. Zr plots for these groups. For F03 nor F27 it can be confidently ascertained whether they have a source on both islands where they were found, on one of the islands where they were found, or are from an unknown third source. F27 (porous volcanic) samples from Barbados also displayed very low non-normalised totals (86.1% and 73.8%) for the oxide data. Although chemically the distinction between the St. Vincent and Antigua samples from F23 is also impossible to make, the typical appearance of the andesite inclusions does favour an Antiguan provenance hypothesis.

Despite a limited amount of samples which is too restricted to make definitive claims, the pattern of F03 does merit some closer attention since the Grenada F03 sample plots closer to the Grenada clay and the Trinidad F03 sample to the Trinidad clay. This is interesting since the tempering material, *caraipé*, does not occur naturally on Grenada. Further discussion of the possible implications of this, is reserved for the next chapter since it cannot rely on this dataset alone.

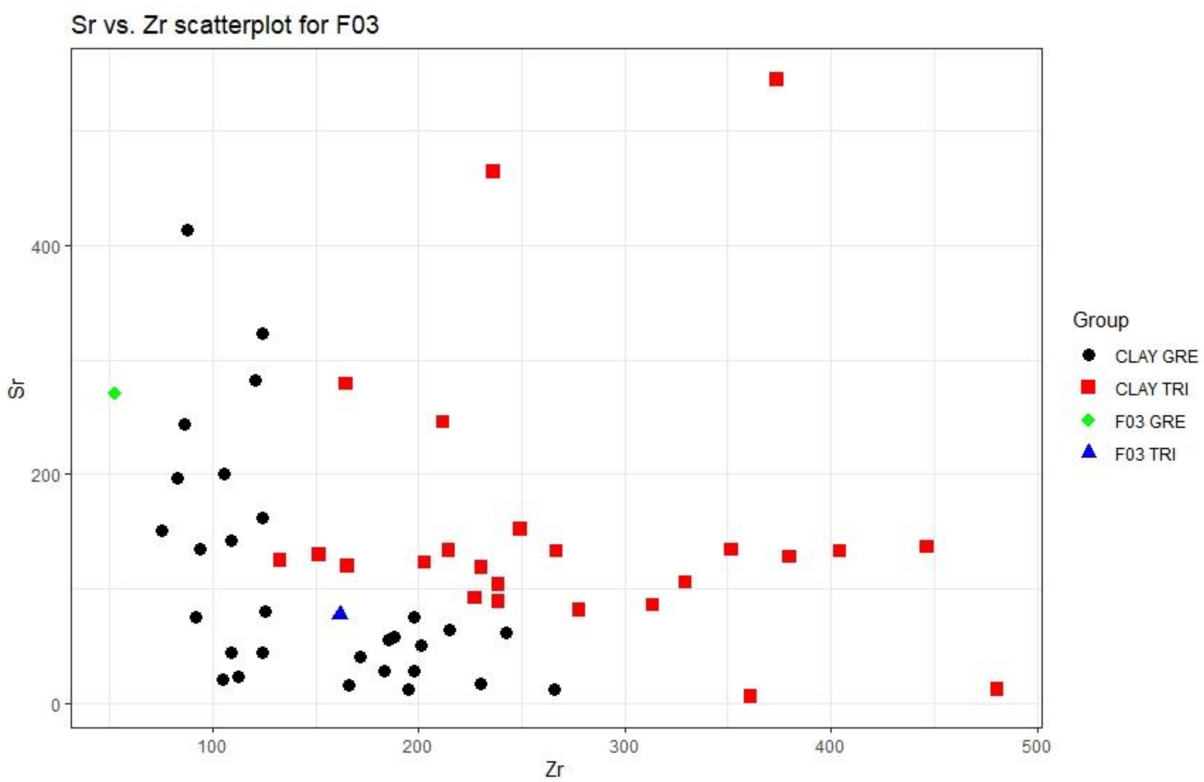

Fig. 95. F03 Sr vs. Zr scatterplot in ppm.

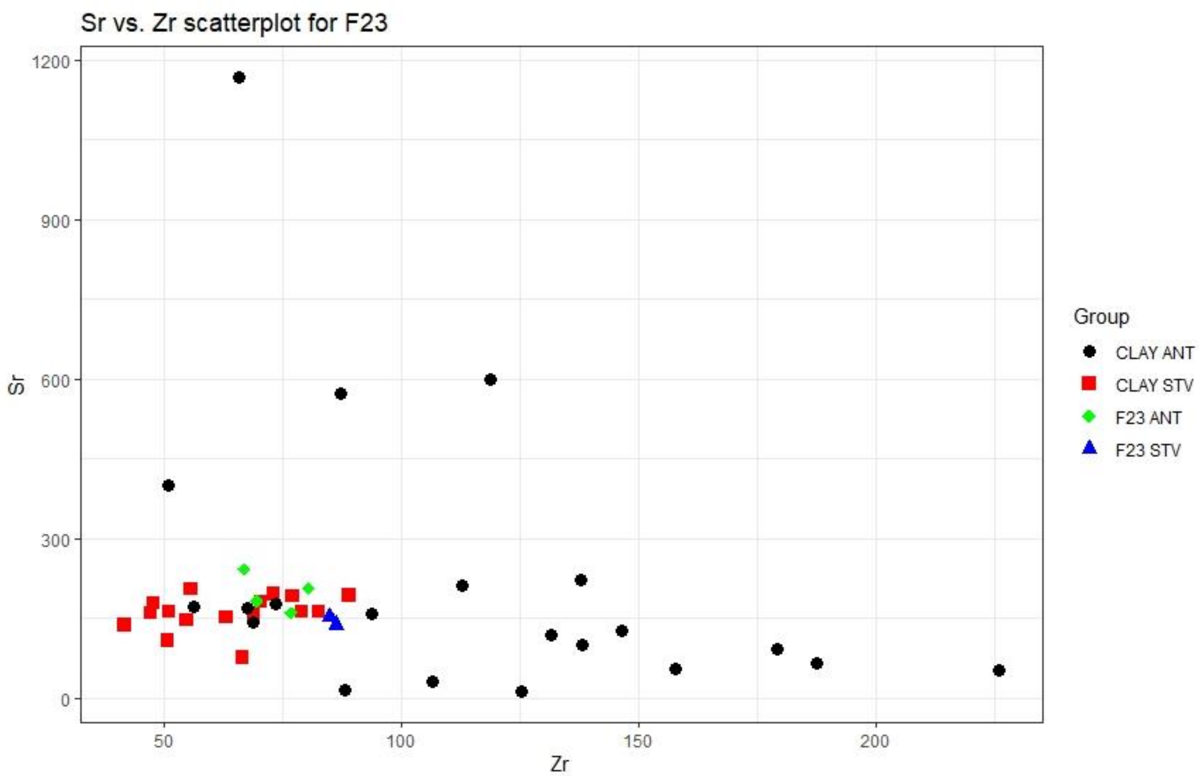

Fig. 96. F23 Sr vs. Zr scatterplot in ppm.

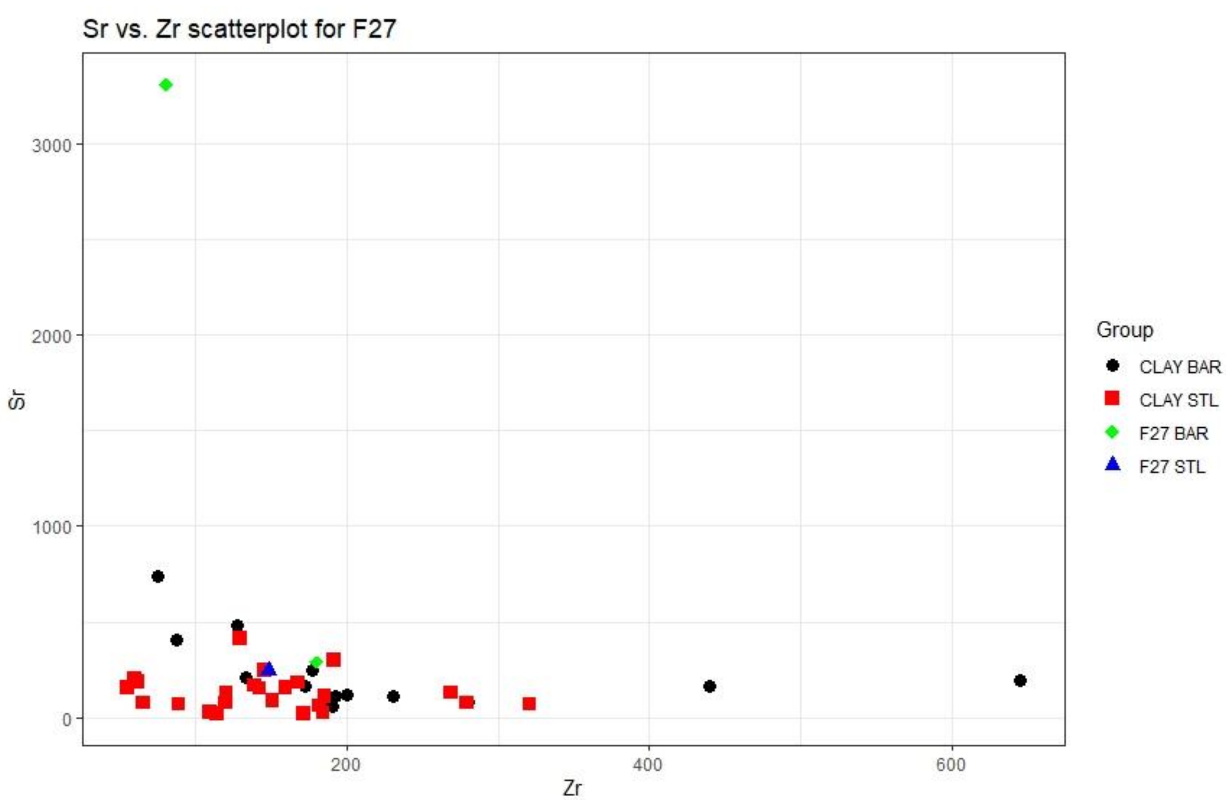

Fig. 97. F27 Sr vs. Zr scatterplot in ppm.

Cluster analysis

A cluster analysis was run on the ceramics in order to verify the petrographic and chemical information mostly obtained on a visual basis. The summary of the output of this analysis is shown in table 28. When applying such a technique on archaeological data, it should be borne in mind that we are dealing with bulk chemical data obtained from inherently heterogeneous materials. Heterogeneity within clay pockets, relative amounts and types of inclusions etc. can have a noticeable impact on chemical variability. Less than perfect matches are therefore to be expected. Nevertheless, the cluster analysis reveals that, overall, there is a good match with the results detailed earlier in this chapter. Four main patterns emerge when bearing in mind that the closer two clusters are to each other, the more statistical similarities they share (e.g. clusters 9 and 10 are much more similar than clusters 9 and 15).

Firstly, Cluster groups 2-6, 27 and to a lesser extent 8 consist of individual thin sections either stemming from the groups across a divide or of outliers or sections which were already difficult to assign from a chemical/petrographical perspective. These samples would be highly interesting to incorporate in a more detailed archaeologically oriented study outside the scope of the present research.

Secondly, nine of the statistically generated groups show a perfect correlation with a petrographic group. The following correlations emerged: 7 = F04, 11 = F06, 14+15 = F08, 16+18 = F09, 20 = F10, 26 = F26 and 27 = F27. Note that this does not necessarily hold true the other way around, e.g. there are some F09 samples in other clusters.

Thirdly, although the Barbados ceramics were clearly locally made, as established both petrographically and through a visual examination of our chemical data, the Barbados groups are more scattered in this statistical cluster analysis. This is probably due to their highly diverse nature of inclusions and clay types, restricted sample numbers and deviant values for one of the F18 samples (cfr. supra). The two thin sections of the F19 group of Barbados are to be found in clusters 2 and 8, while F04 makes up its own distinctive cluster (7). Cluster 1 is a “Mixed Barbados” cluster, with samples from F18 and F27.

Finally, from the remaining cluster groups, the same interaction cells as defined earlier emerge. Clusters 9+22+23 are a mix of Leeward groups, 10+17+19+21 a mix of Windward groups and cluster 12 consists solely of Trinidad material.

The only slightly ambiguous case is F15. The bulk of F15 is indeed categorised as “Mixed Leeward”, but two samples are assigned to one of the “Mixed Windward” clusters. This is not very surprising given the petrographic similarity between F15 (Leeward) and F14 (Windward). If anything, this result clearly demonstrates that apart from these two ambiguous samples, the chemical distinction between F14 and F15 is sufficiently large to define them as separate groups.

Cluster group	F-group	Cluster group	F-group	Cluster group	F-group	Cluster group	F-group
1	F00 (1)	4	F01 (1)	10	F06 (2)	17	F09 (24)
	F18 (4)		F08 (1)		F09 (3)		F10 (6)
	F27 (1)		F20 (2)		F10 (1)		F11 (1)
2	F00 (1)	5	F05 (3)		F11 (5)		F14 (1)
	F03 (2)		F08 (1)		F14 (5)	18	F09 (5)
	F05 (1)		F09 (4)		F15 (2)	19	F09 (1)
	F09 (2)	6	F03 (1)		F23 (1)		F11 (3)
	F12 (1)		F24 (1)		F26 (1)	20	F10 (18)
	F17 (2)	7	F04 (2)	11	F06 (4)	21	F11 (3)
	F19 (1)	8	F05 (3)	12	F07 (20)		F14 (8)
	F24 (6)		F10 (1)		F12 (3)	22	F13 (5)
3	F00 (1)		F17 (1)		F20 (1)		F15 (1)
	F01 (1)		F19 (1)		F21 (1)		F24 (3)
	F05 (3)		F22 (2)	13	F07 (1)	23	F15 (6)
	F09 (2)		F23 (3)		F09 (2)		F24 (3)
	F10 (2)	9	F05 (4)		F12 (2)	24	F18 (1)
	F11 (1)		F11 (1)		F16 (1)	25	F23 (1)
	F16 (1)		F13 (1)		F21 (2)	26	F26 (2)
	F18 (1)		F15 (1)	14	F08 (23)	27	F27 (1)
	F22 (3)		F24 (18)	15	F08 (6)		
	F24 (3)			16	F09 (20)		
	F27 (1)						

Table 28. Comparison between cluster analysis generated groups and petrographic groups. The single number is the cluster group, the F-code the petrographic group. The number in brackets is the amount of samples of the F-group which falls into the cluster group. Blue = Barbados, purple = Leeward, orange = Windward, green = Trinidad, white = outlier or across a divide. The closer two cluster numbers are to each other, the more statistical similarities they share (e.g. clusters 9 and 10 are much more similar than clusters 9 and 15).