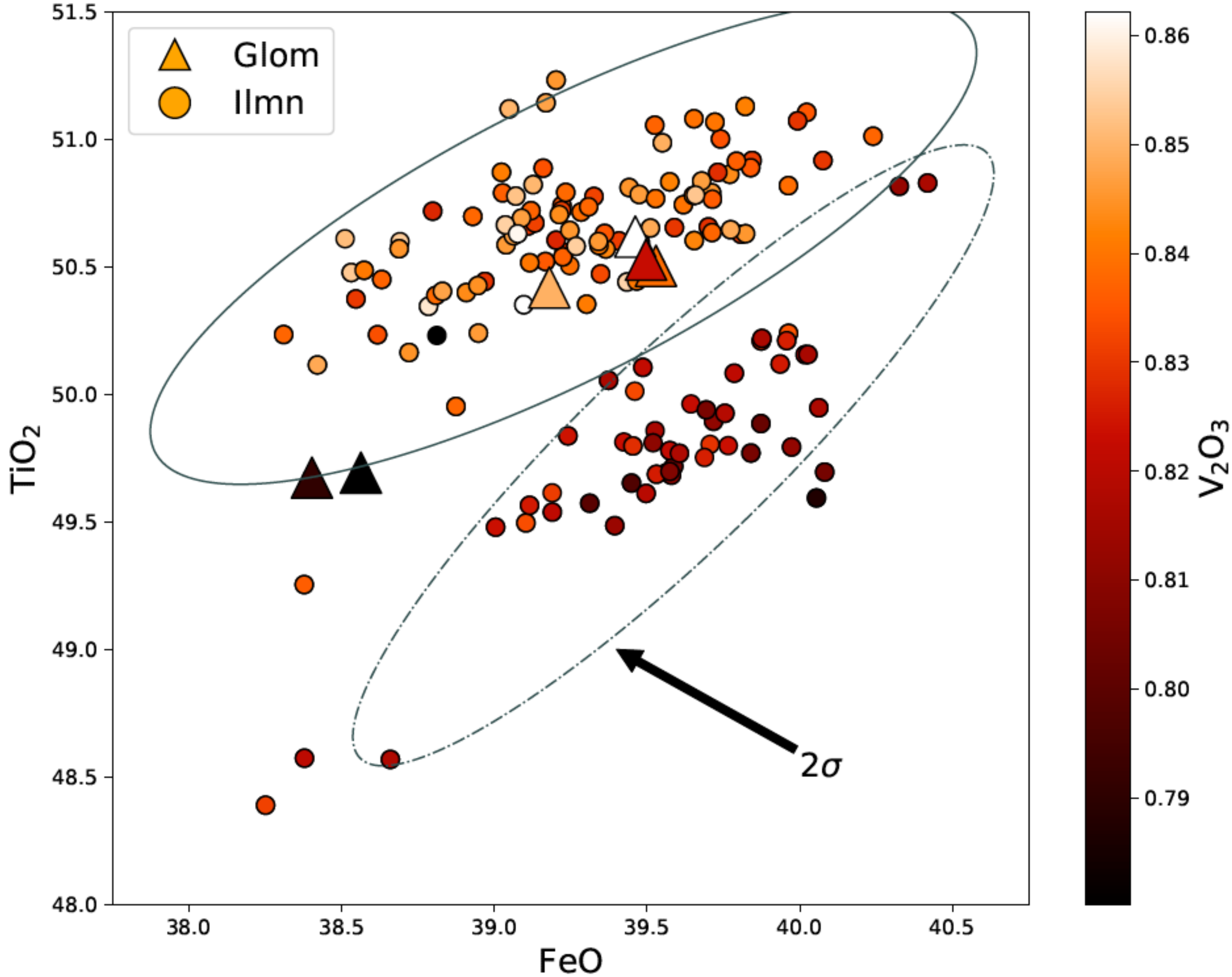
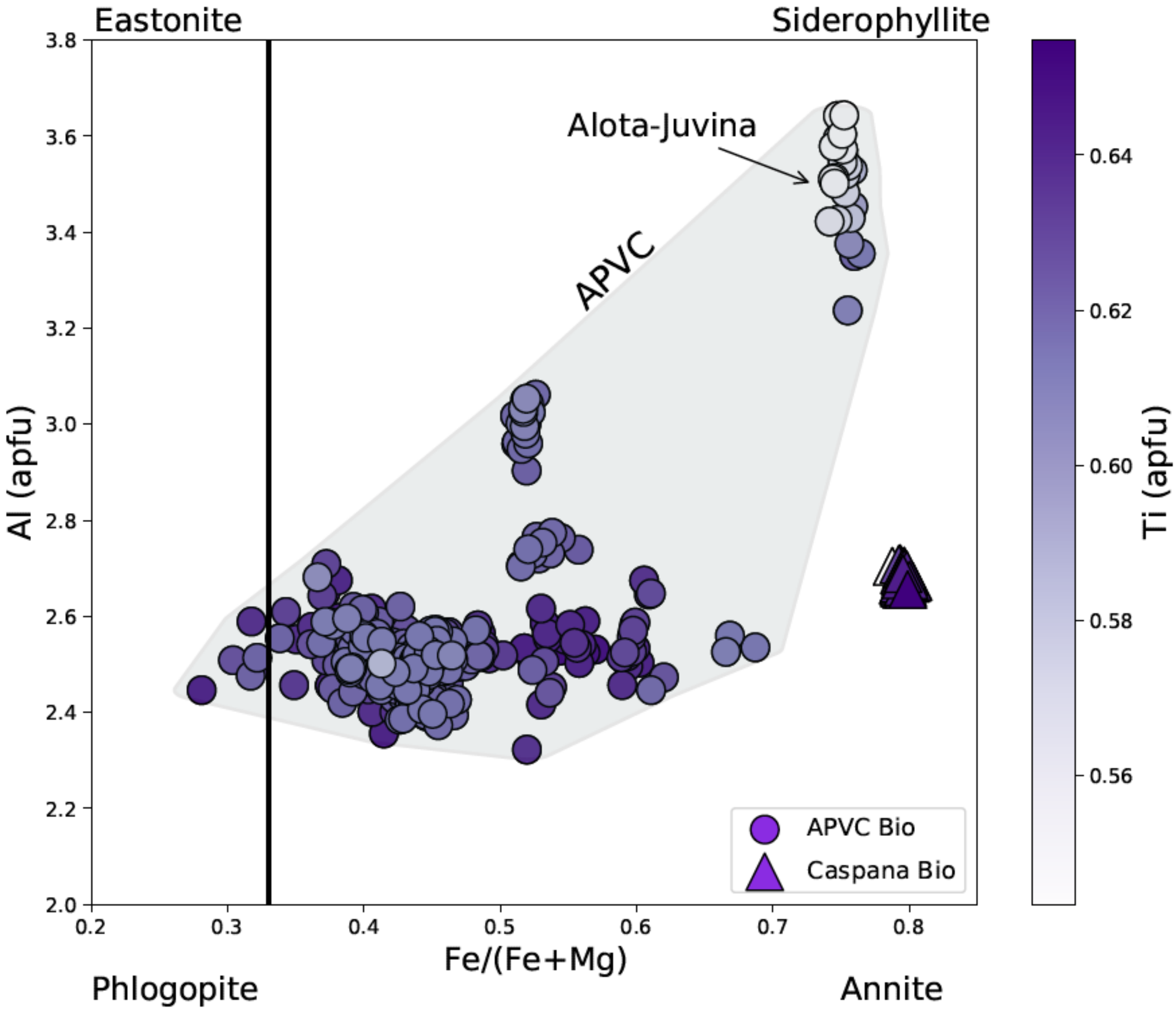
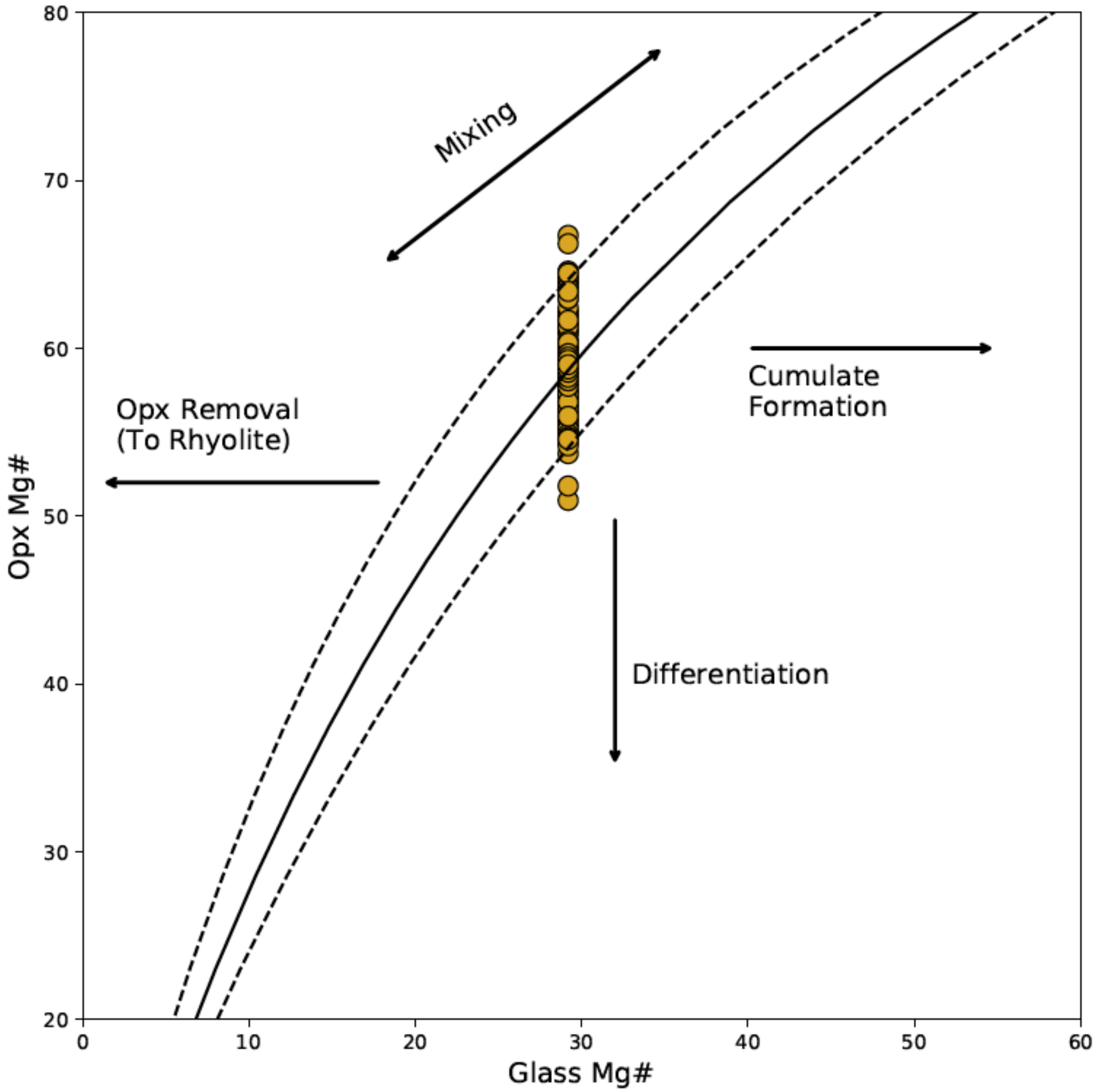


Supplementary Figure S1: Ilmenite compositions from the andesite. X-axis is recalculated ferrous iron content. The ellipse shows a 2SD confidence of data in the low Ti and high Ti group in TiO2-FeO space. V is clearly correlated with an increase in Ti. Glomerocrysts are triangles. All other data are phenocrysts, microphenocrysts, and inclusions in other minerals.

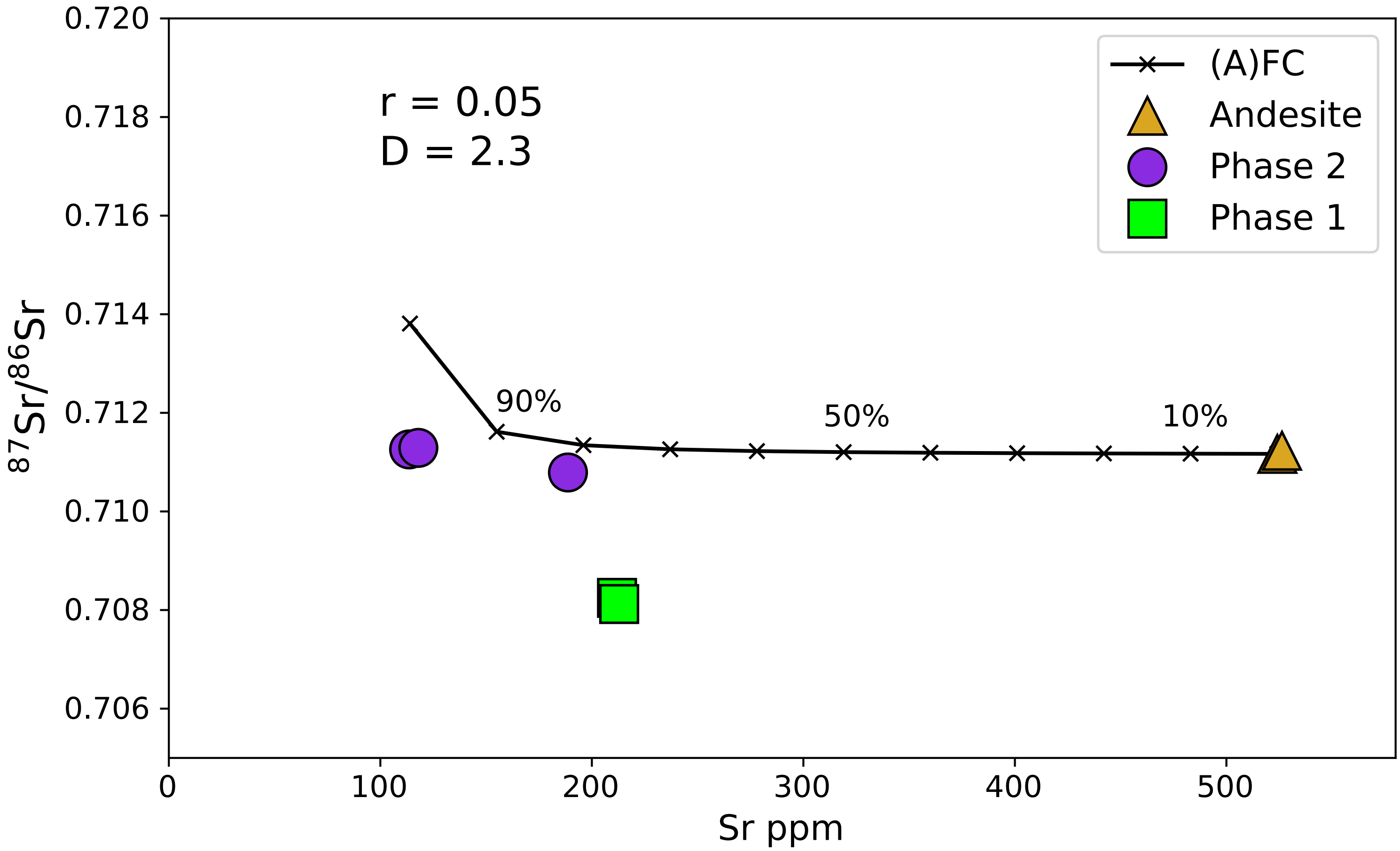
Lewis, C.T., de Silva, S.L., and Burns, D.H., 2022, Rhyolitic melt production in the midst of a continental arc flare-up—The heterogeneous Caspana ignimbrite of the Altiplano-Puna volcanic complex of the Central Andes Geosphere, v. 18, httpsdoi.org10.1130GES02462.1.



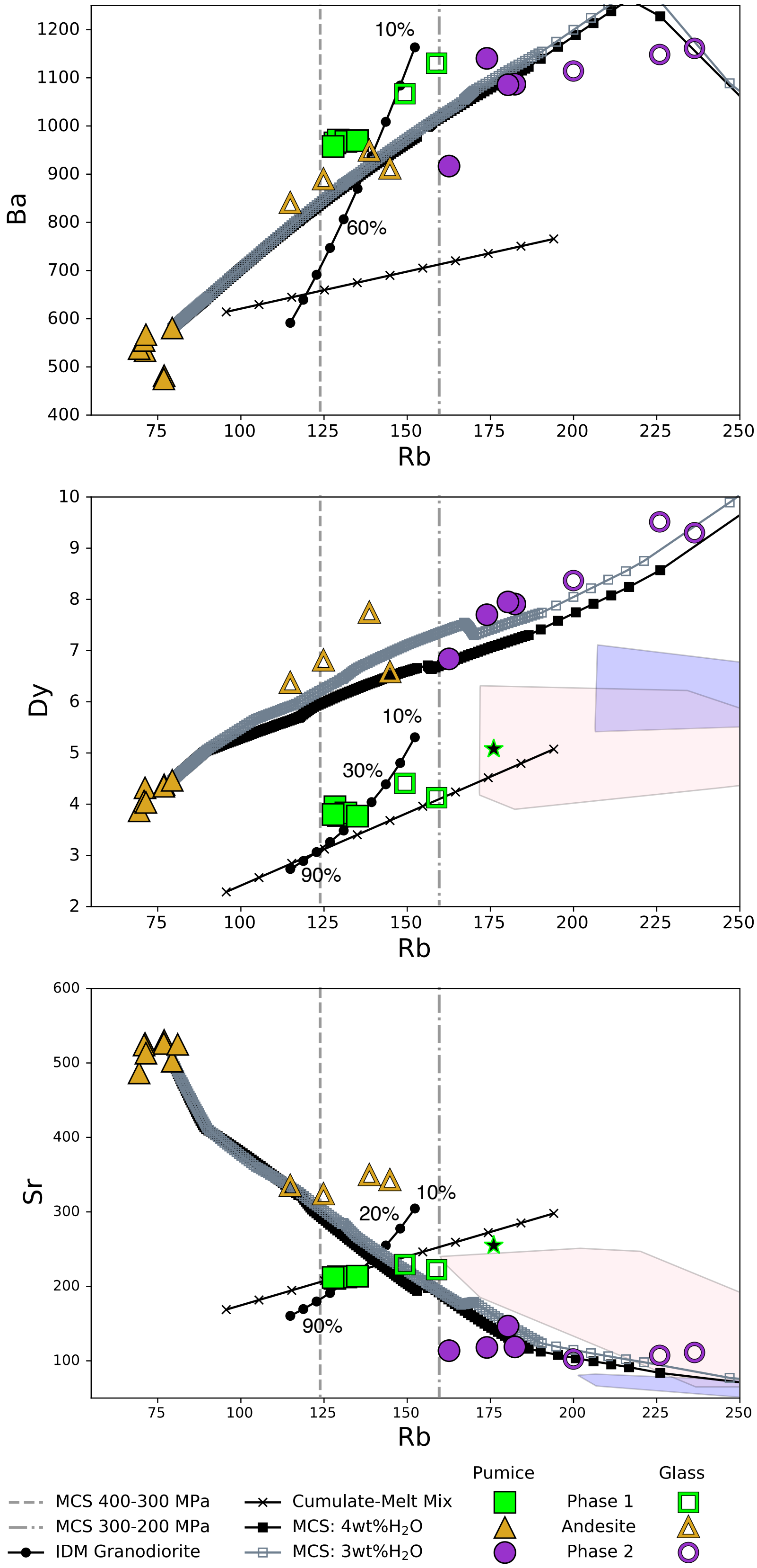
Supplementary Figure S2: Biotite from phase 2 (triangles) and the APVC (gray field, circles) shown using the classification of Deer et al. (1992). All data recalculated assuming 22 oxygens and all Fe as ferrous. Like the Ti-magnetite found in phase 2, biotite from the Caspana also is anomalously high in TiO_2 relative to other APVC ignimbrite and has substantially high Fe#. The Alota-Juvina rhyolites that have characteristics similar to phase 2 (Figure 5) crystallized high Fe biotite as well; unlike other APVC rhyolites with lower Fe indices.



Supplementary Figure S3: Opx Mg# vs. Mg# of rhyodacitic glass on a cation basis (after Rhodes et al., 1979). Glass is average of all analyses and have a range of Mg# 24-35, a similar range to the pumice (Figure 12) with a 1SD of 2.5 from two samples. The sample that contains the lower Mg# is somewhat distinct from the other as noted here and seen clearly in Figure 12.



Supplementary Figure S4: 87Sr/86Sr vs Sr concentration of pumices with isotopic evolution model of DePaolo (1981). Model shows that the Phase 2 rhyolite can be derived from the andesite by near closed system fractionation on the basis of isoptic constraints using local basement (Sierra de Moreno) as a possible upper crustal contaminant. Trend requires DSr >1, consistent with upper crustal processes. Phase 1 lies off-trend. Model details can be found in Supplementary Table S8



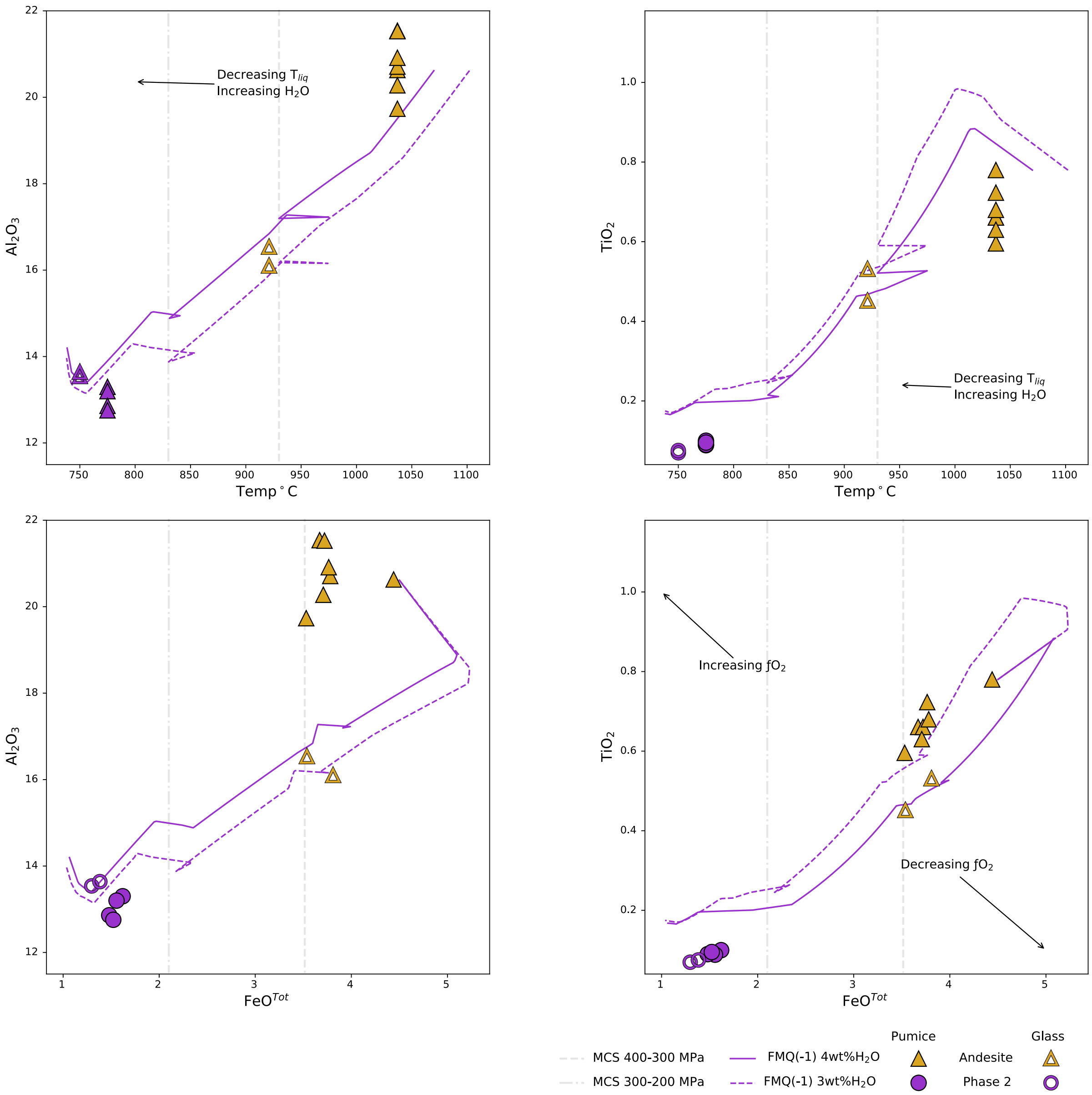
Supplementary Figure S5: Supplement to Figure 11 in the text. Graphs showing additional MCS models, IDM melting models of granodiorite, and a mixing line between cumulate and resident melt (seee text for details). Gray vertical lines show where the MCS models were restarted at a new pressure. The observed assemblage is dominant in the r-MELTS backed models with some caveats described in the text and in this supplementary file.

Supplementary File - MCS and r-MELTS models

To deal with the 200MPa pressure change (Table 7) the model was run in three steps (following Heinonen et al. (2019)) between 400-200 MPa with a 100MPa change. Assuming that fO_2 remained more or less constant in the system (e.g Kress and Carmichael, 1991; Grocke et al., 2016), the Fe^{3+}/Fe^{tot} was reset to adhere to our estimated value of ΔFMQ-1 (Table 8) at each step. fO_2 was allowed to equilibrate with temperature change and thus crystallization during each run. The following sequence was followed:

1) Step 1 was done using major elements from one of the andesite samples
2) Step 2 was started using the major element composition that was present at the estimated temperature from the orthopyroxene-liquid (~930°C) in Step 1.
3) Step 3 began where composition was well into the dacite field at temperatures (830 °C) and compositions where the appropriate rhyolite-MELTS model (version 1.1) could be used to model fractionation to rhyolite.
4) For the purposes of keeping plots that compare LLD's in major element space coherent (see below) the beginning of the LLD at 300 and 200 MPa are removed and a full plot is shown below. This initial sequence, removed in Figure 13, is an artifact of resetting $Fe^{2+/}Fe^{tot}$ to keep the isobaric computer model in agreement with petrologic observations and our current understanding of oxygen fugacity (e.g., Kress and Carmichael, 1991).

To elaborate, the relationships of P-T-Fe^{3+}/Fe^{tot}-fO_2 is calibrated on thermodynamic and compressibility criteria as follows: Temperature ∝ 1/Fe^{3+}/Fe^{tot}, Pressure ∝ 1/Fe^{3+}/Fe^{tot}, and fO_2 ∝ Fe^{3+}/Fe^{tot}. So, taking the Fe_2O_3/FeO^{tot} output from a model of higher pressure and inputting it into a lower pressure isobaric model while keeping fO_2 constant causes an increase in the Fe^{3+}/Fe^{tot} that must be accounted for. At the start of each of these models the FeO content increases until magnetite, usually the first phase on the liquidus, saturates and begins to decrease Fe_2O_3/FeO^{tot} and FeO^{tot}. The crystallization of magnetite and the decrease in temperature cause the Fe_2O_3/FeO^{tot} in the MCS models to re-equilibrate back to the values that were present at the end of the preceding MCS model (below). Modal percentages of each of these models are given in Supplementary Table S1.



Supplementary Figure S6 showing the LLDs of interest as adjunct to figure 12 in the text. The artifacts of the modelling process that are the result of adhering to well-known geologic processes (i.e., relatively constant fO_2) are shown here. The drastic changes in melt major element content at high degrees of crystallinity in r-MELTS models, which don't seem to be naturally observed in rhyolites (i.e., stark decreases in SiO_2 during crystallization, etc.) are also shown. See Figure 12, Table 9, S9, S10 for further details. Grey vertical lines are as on Figure 11 and 12.

The Caspana ignimbrite, crops out in the Toconce-Caspana area of N. Chile (de Silva, 1989; de Silva, 1991; Figure 1,2). The age of the eruption is bracketed stratigraphically between 4.09 and 4.54 Ma. It's source vent(s) is/are thought to be buried beneath the younger Toconce and Leon volcanoes. de Silva (1991) found that the ignimbrite was bimodal containing both andesitic and rhyolitic juvenile clasts, defining a large compositional gap. On the basis of reconnaissance bulk and mineral chemistry, an origin of the rhyolite by fractional crystallization of the andesite was proposed to have led to a small bimodal, zoned magma chamber.

We have resampled and reexamined the same exposures and sections introduced in de Silva (1991). The northern outcrops above the community of Toconce contain a rhyolitic plinian fallout of nearly aphyric pumice with occasional phenocrysts of feldspar in hand specimen (Section B - Figure 2). There is a fine ash on top of the fallout, that is in turn overlain by a distinct ~10 to 40cm flow unit that contains equally aphyric rhyolite. This sequence is collectively referred to as Phase 1. Above this lies several meters of massive ignimbrite that is referred to herein as Phase 2. Phase 2 also contains rhyolitic pumice. However, these are distinct from the pumice in Phase 1 as they have obviously higher, yet still very low crystallinity (~3-5%) and are substantially less fragile in hand-sample. Phenocrysts in pumice from Phase 2 include plagioclase and biotite, with occasional yellow-green olivine. The top of the section is eroded and has lava and colluvium from Volcan Toconce on top. Between this location and the community of Toconce, the ignimbrite fills deep narrow canyons carved into the underlying Toconce formation (5.56 – 6.65 Ma). Throughout this area a distinct orange hue dominates the ignimbrite.

To the south of Toconce, around Caspana and to the south and east, the Caspana Ignimbrite is capped by the extensive 4.09 Ma Puripicar ignimbrite. These outcrops contain a more complete section of dominantly Phase 2. The upper parts of the stratigraphy record the appearance of andesite pumice. At the distal flow front (Figure 2, Section A), a basal ash (equivalent to the basal Plinian in Section B) is overlain by a thin 5-10 cm reworked layer above which lies ~ 5 meters of massive ignimbrite. The center of the massive unit includes a crudely laminated facies that contains rhyolitic pumice with a higher crystal content of up to 5 volume %. Several pumice rafts attest to progressive aggradation of the deposit in several pulses. These rafts contain successively more andesitic clasts up-sequence. At the clast-rich flow front rhyolite and andesite pumice are largely mixed together with only hints of any internal stratigraphy (Figure 2).

The andesitic pumice in the Phase 2 ignimbrite has variable crystallinity from sample to sample that ranges from 20-45%. In hand-sample the pumice has plagioclase, orthopyroxene, and oxides readily identifiable. Andesite pumice textures vary from highly oxidized, lower crystallinity porphyritic pumices found in the upper flow unit to glomeroporphyritic, higher crystallinity black to gray pumices in the lower flow unit. These latter pumices can occur in the upper flow unit but not nearly as often and are more vesiculated than their counterparts, with round to oblate vesicles.

In the distal outcrops south of Caspana, a thick sequence of lake sediments occurs between the Caspana and the overlying Puripicar ignimbrite. Significant penetration of carbonate veins and coatings were seen in some of the distal outcrops. We were careful in our selection of pumice samples and treated them accordingly (see text).