The role of contamination in the tightrope of Gran Canaria felsic magma differentiation

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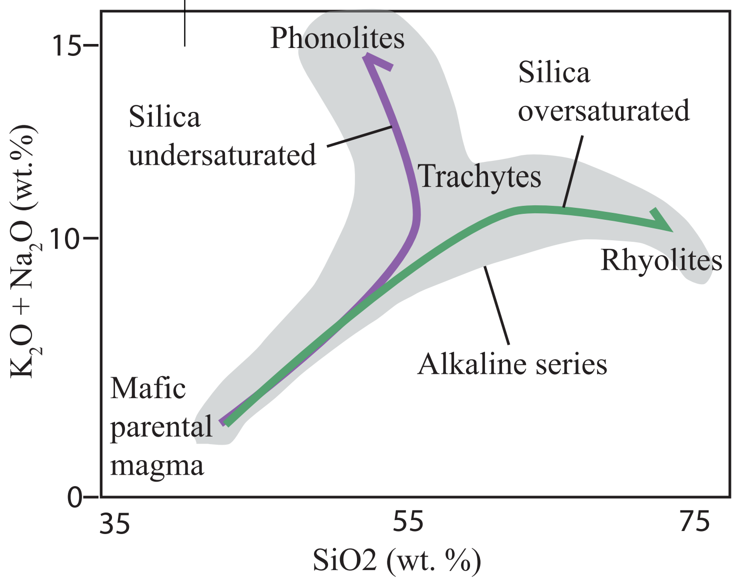
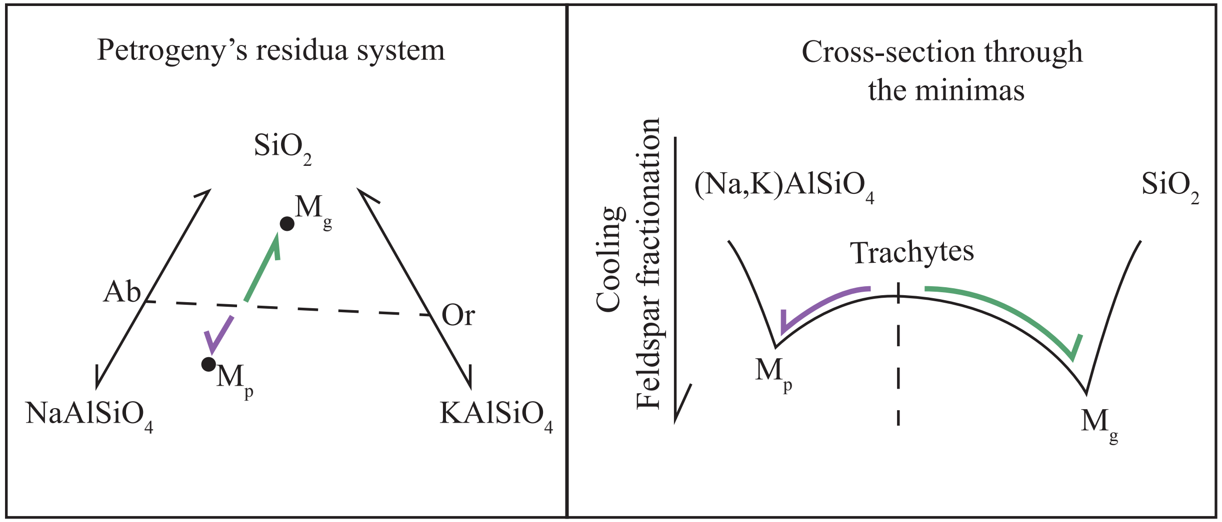
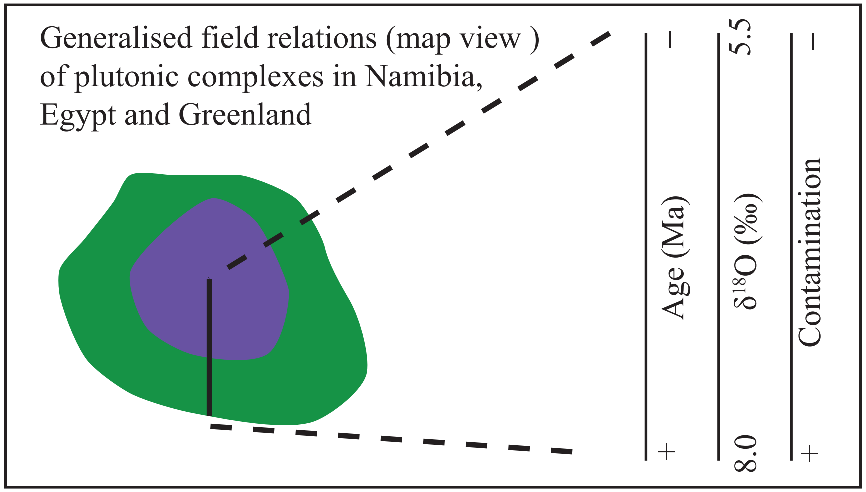
Alkaline Magmas



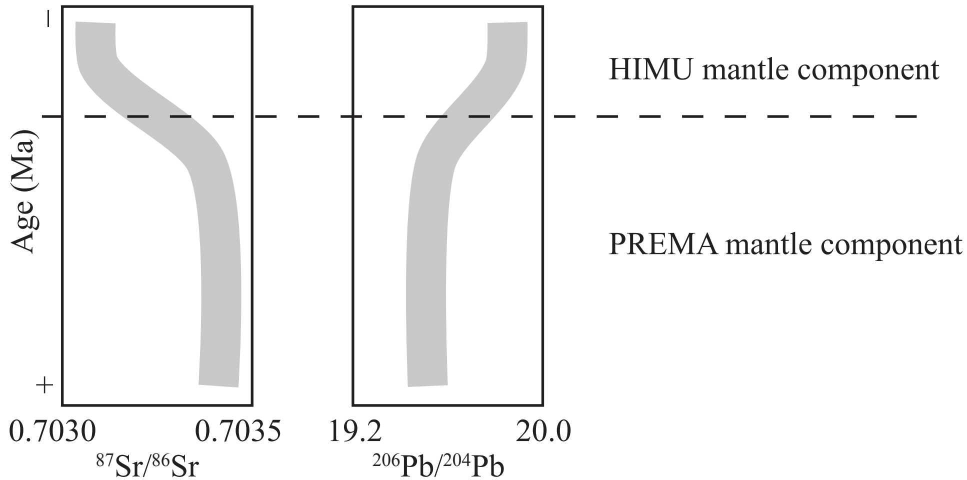
A. Two potential liquid lines of descent (LLD) controlled by fractional crystallisation (FC). (modified after Conceicao et al., 2007)



B. Thermal barrier hinders the relation of both LLD by FC (Ab-Albite, Or-Orthoclase, M_g-granite minima, M_p-phonolite minima) (modified after Tuttle & Bowen, 1958; Wolff, 2017)

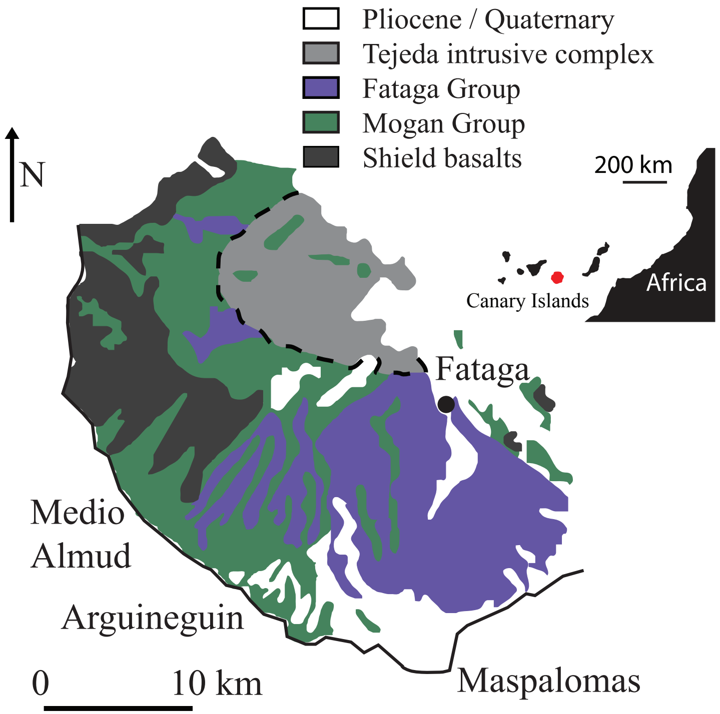


C. Crustal contamination of a silica undersaturated system potentially explains how to cross the thermal barrier (e.g. Harris, 1999; Riishuus, 2008: Decrée et al., 2019)

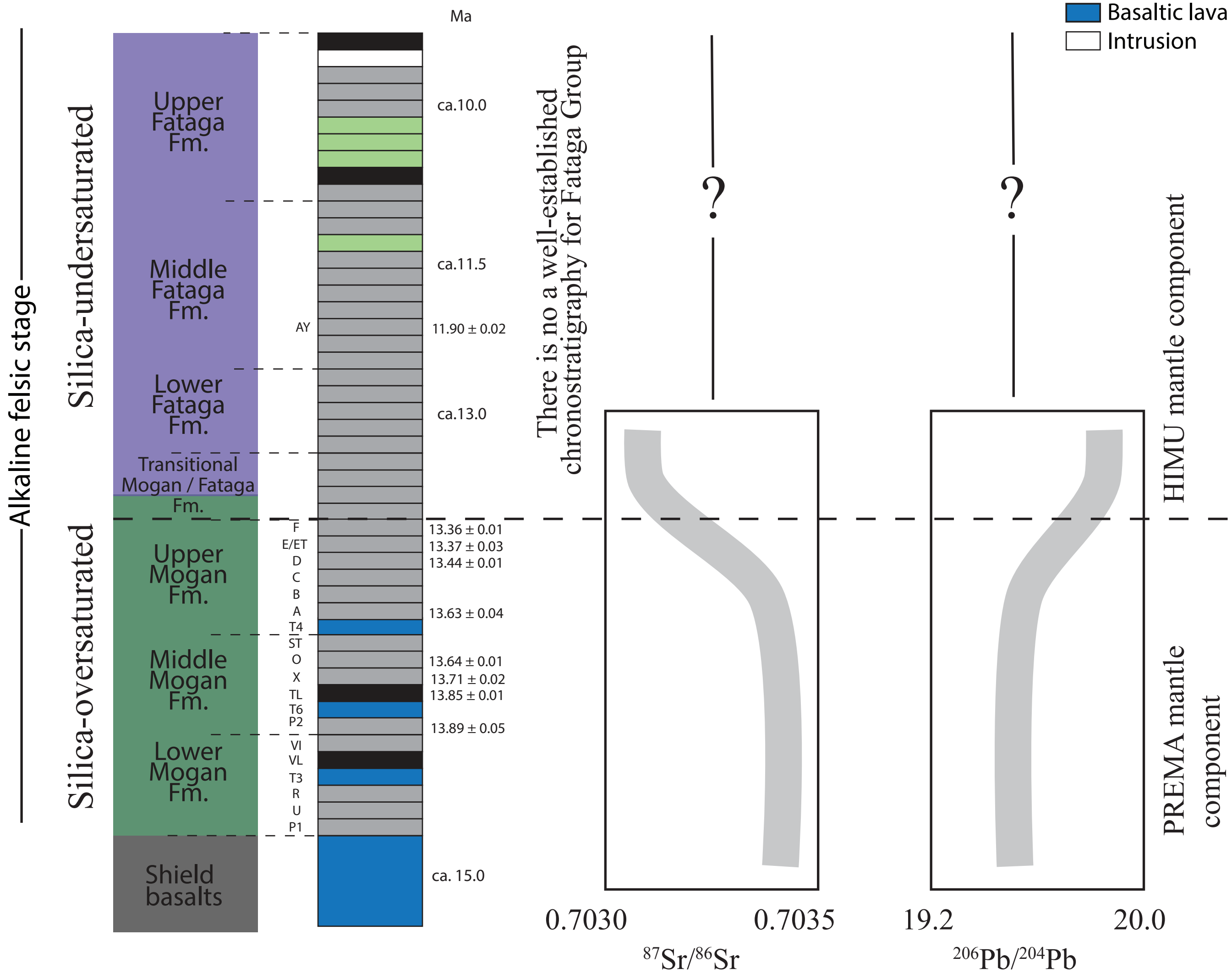


D. Identifying contamination is important because isotopic changes in alkaline centers have been linked to changes in mantle source (e.g. Gran Canaria, modified after Cousens et al, 1990)

Gran Canaria Volcanism



A. Gran Canaria is an oceanic intraplate volcanic island. Volcanism is divided into: 1) shield stage; 2) alkaline felsic stage; 3) rejuvenation stage (modified after Cousens et al., 1990; Troll & Carracedo, 2016)

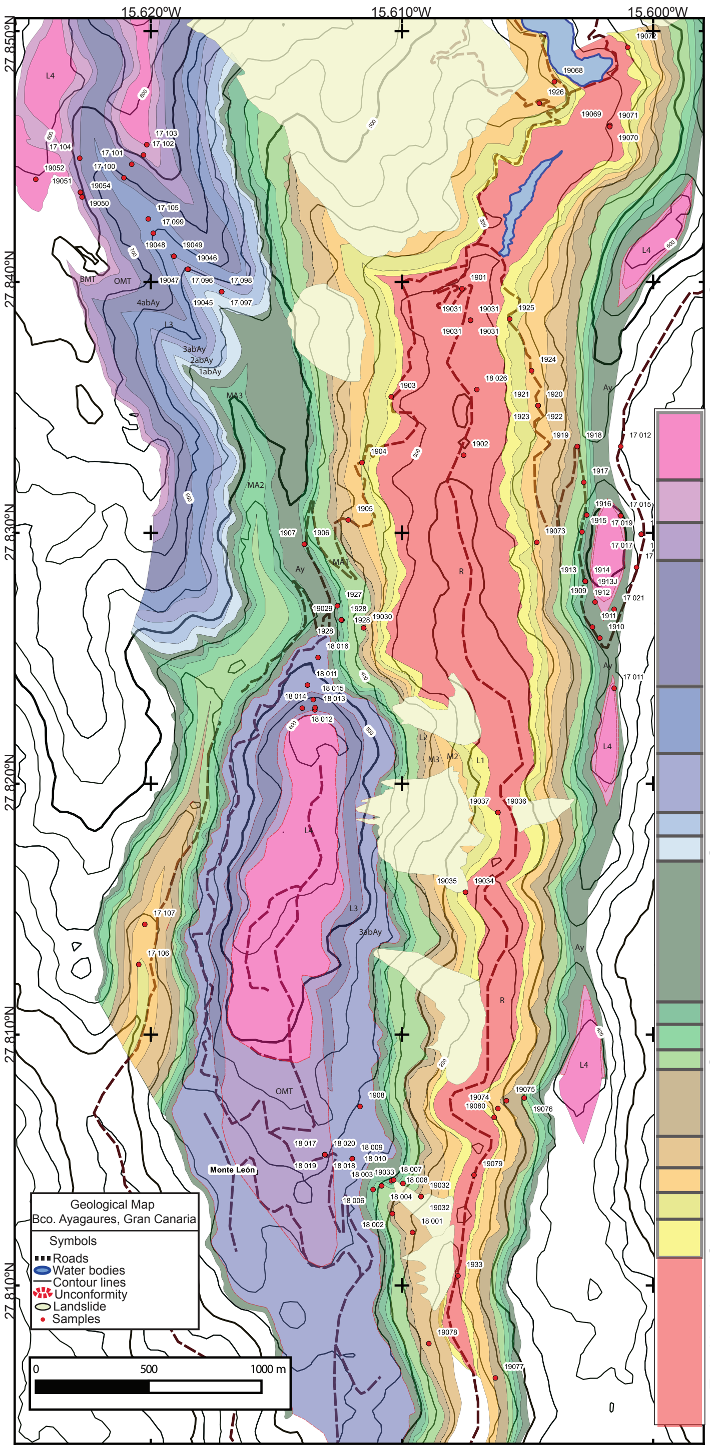


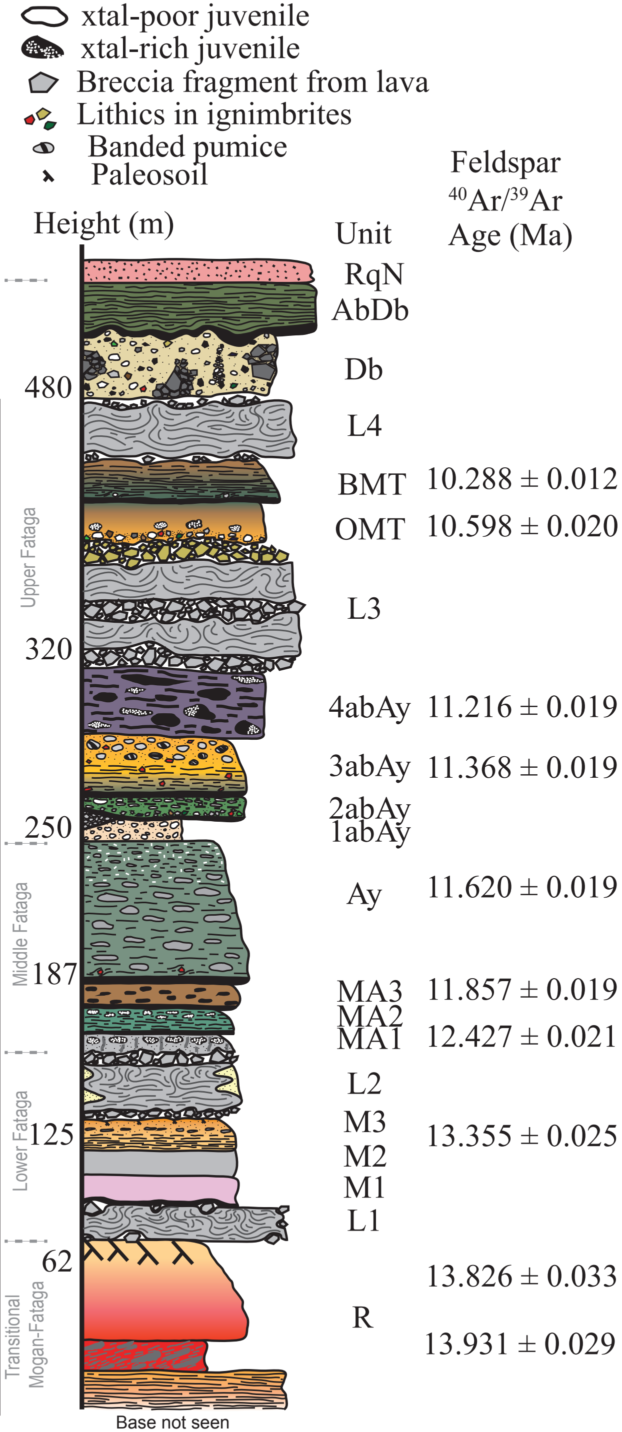
Research questions

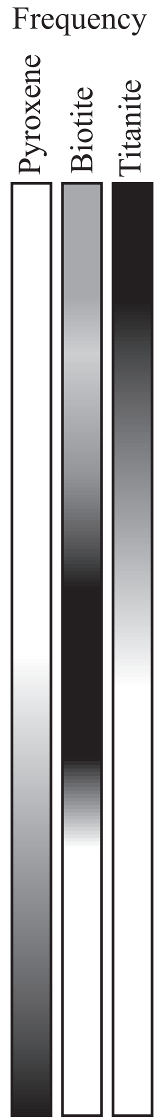
1. Are the LLDs in the alkaline felsic stage of Gran Canaria akin tothose in alkaline plutonic complexes showing changes in crustal contamination?
2. if there is crustal contamination, which lithologies are involved and to which extent?

B. Studies based on radiogenic isotopes (Sr,Pb) in the Mogan Group and Lower Fataga formation suggest that the changes in isotopes are due to changes in the mantle source (Cousens et al., 1990). The outputs of any isotopic study rely upon chronostratigraphy, but this is not the case for the silica-undersaturated volcanics in Gran Canaria. Furthermore, all this studies extrapolate the results of the lower Fataga formation to the whole Group. (stratigraphic column modified after Van den Bogaard & Schmincke, 1998: radiogenic logs modified after Cousens et al., 1990)

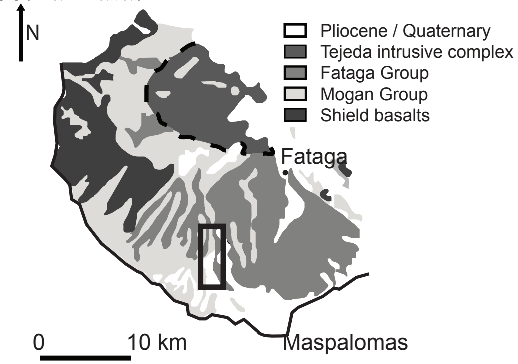
(Cortes-Calderon et al., in prep)







We carried out sampling, mapping and logging in Bco. la Data.



Our general stratigratigraphy consists of 21 members (lava flows and tuffs), which span ca. 3Myr. The main mineral phase in these deposits is alkali feldspar. Deposits often show crystal-poor juveniles at the bottom and crystal-rich at the top of each member. Mafic minerals represents less than 20% of the crystallising phases (biotite, pyroxene, Fe-Ti oxides, titanite).

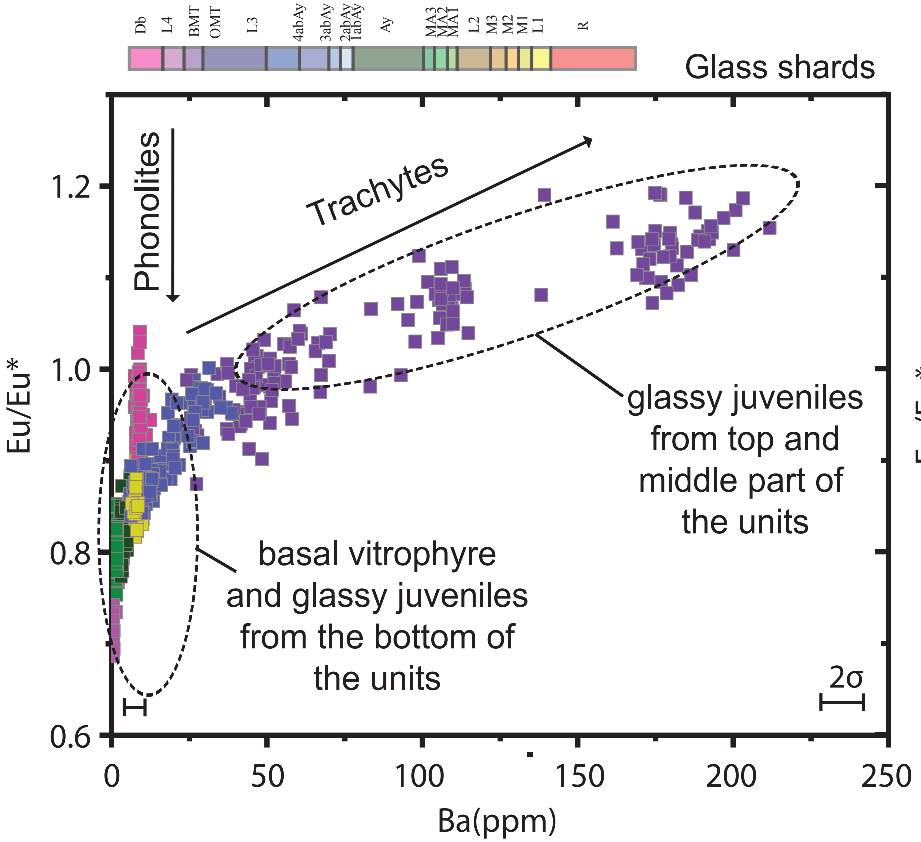
Mineral and glass chemistry by EPMA, LA-ICP-MS

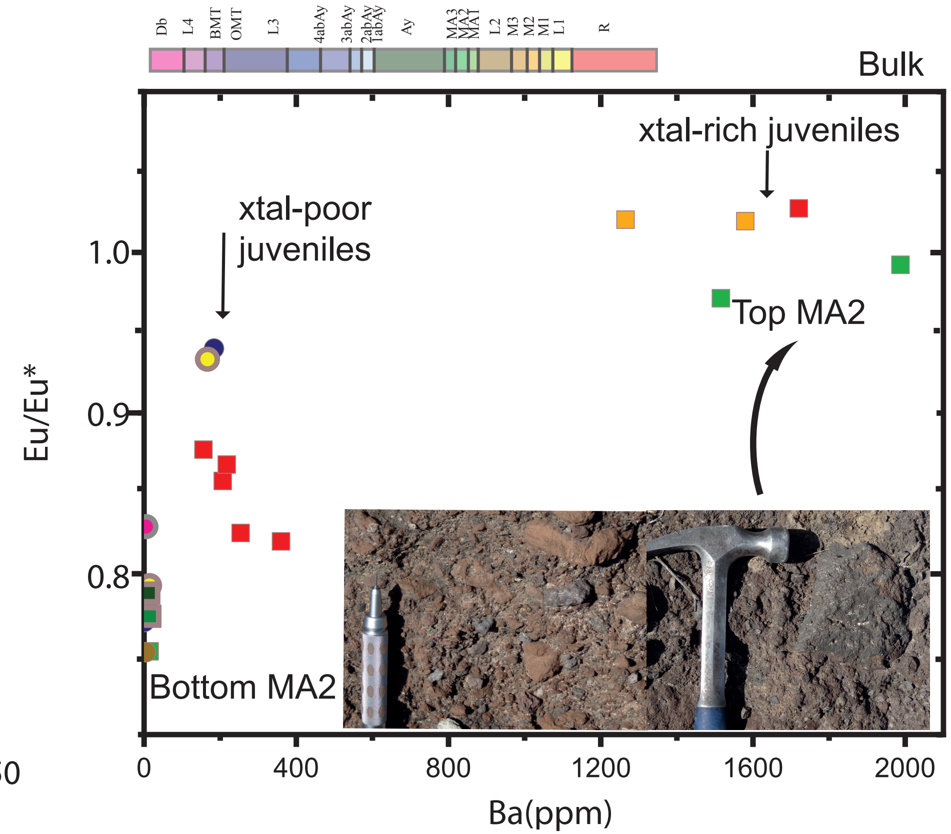
Bulk chemistry of juvenile clasts by XRF, LA-ICP-MS

Oxygen isotopes in feldspar, biotite and pyroxene by laserfluorination

Eruption ages by high-precision single crystal $^{40}Ar/^{39}Ar$ in feldspars

Crustal contamination: Petrological cannibalism

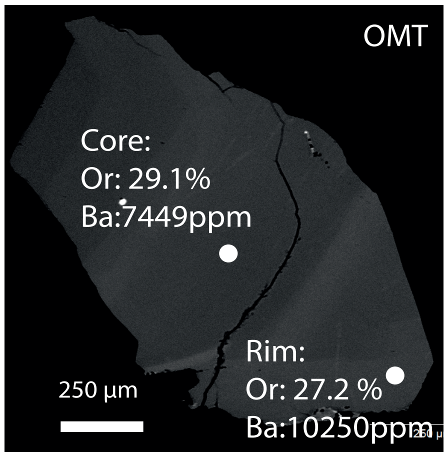


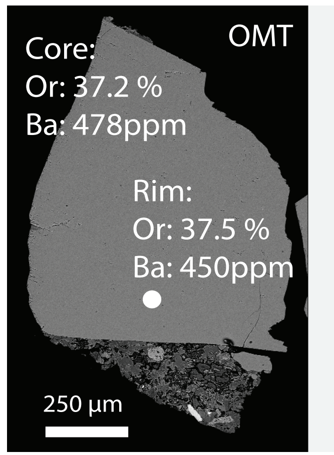


Two alkali-feldspar compositions are found throughout the volcanic sequence. Anorthoclases show strong chemical zonation in Ba and Or (orthoclase) content (rims richer than cores). Sanidines are unzoned and with lower Ba content than anorthoclases. Or content in sanidines increase towards younger deposits as well as the frequency

Cumulate signatures (feldspar accumulation) in juvenile clast are characterised by an increase in Eu/Eu* and Ba.

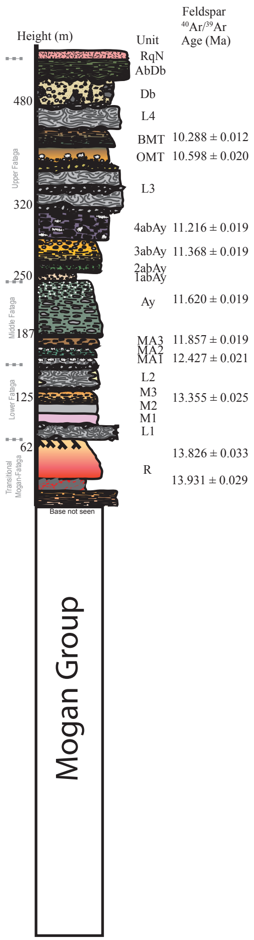
Remelting of cumulutes during rejuvenation can be traced in glasses with positive Eu anomalies and increase in Ba.

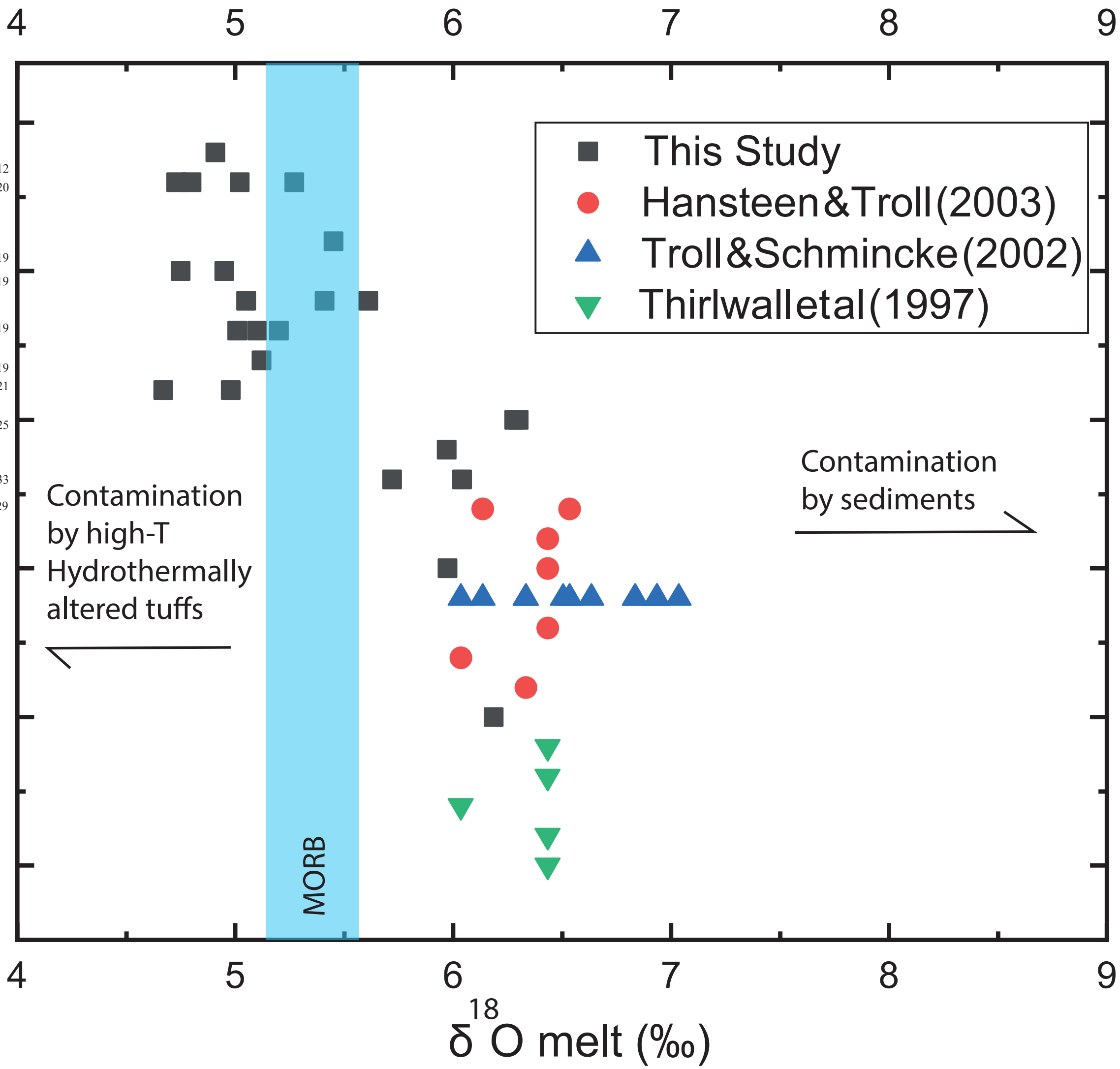




(Cortes-Calderon et al., in prep)

Crustal contamination: Assimilation of sediments and hydrothermally altered crust



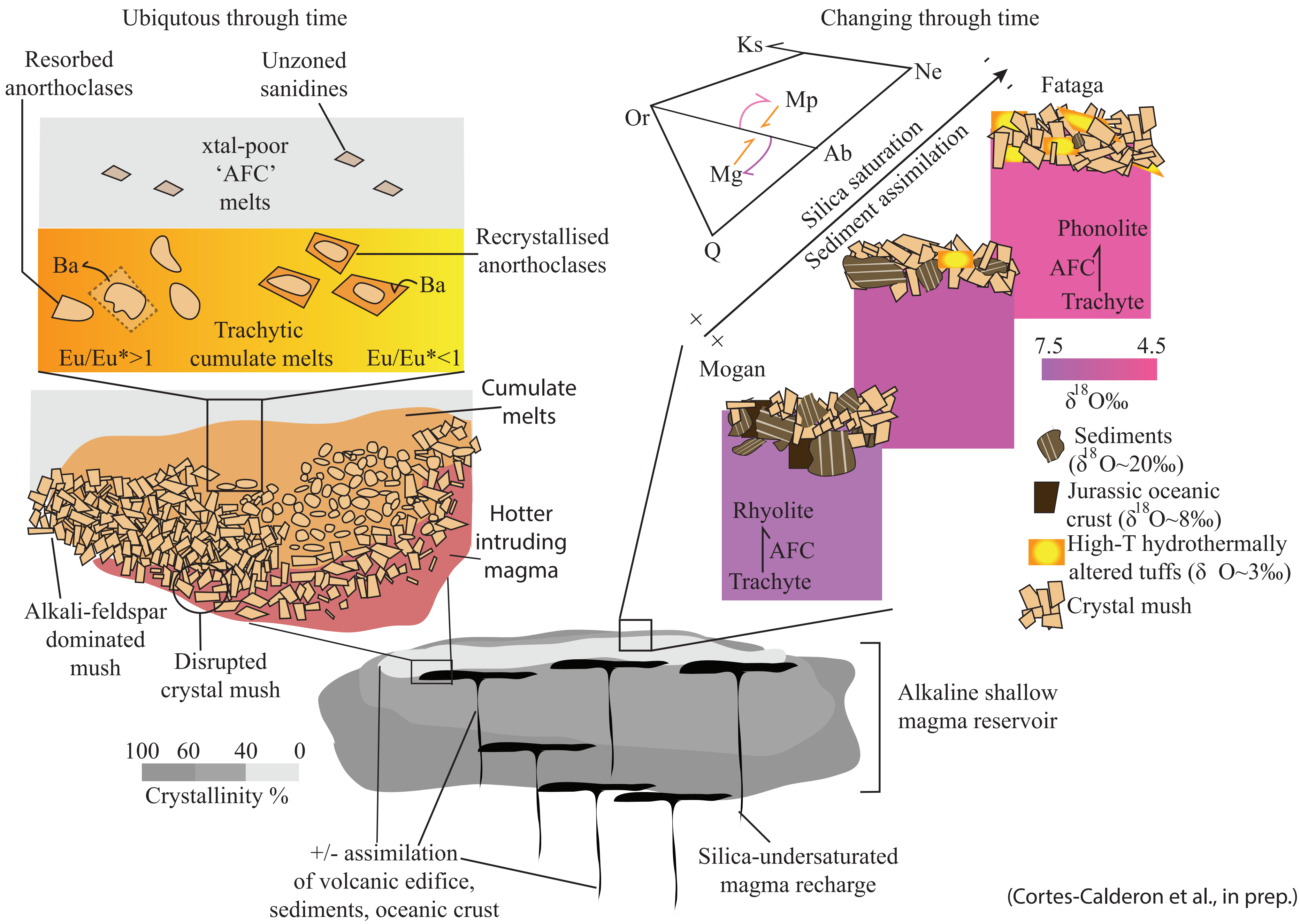


Assimilation of crustal lithologies is hindered by heat budgets in magma reservoirs.

Sedimentary xenoliths in Gran Canaria show a fabric affected by melting (Hansteen & Troll, 2003).
The good point of melting sediments is that helps to shift composition towards silica-oversaturated field and that Oxygen isotope values are that high (ca. +15) that only small amounts of partial melting is needed (ca. 8%)

The formation and colapse of calderas triggers fault systems where water can interact and alter lithologies. Emplacement of Fataga batches in Mogan intracaldera deposits will trigger high-T hydrothermal alteration ($\delta^{18}O$ ca. 3.0). These altered lithologies contain enough fractures and water that facilitate melting

Petrological model for the Miocene felsic stage



(Cortes-Calderon et al., in prep.)

References

Conceicao, Herbet & Rosa, Maria & Oberli, Felix & Rios, Debora. (2007). Idade U-Pb do dique sienítico Anurí, sul da Bahia: magmatismo alcalino-potássico paleoproterozóico e sua implicação para a orogenia transamazônica no Cráton do São Francisco. Revista Brasileira de Geociências. 37. 61-69.

Cousens, B. L., Spera, F. J. & Tilton, G. R. (1990). Isotopic patterns in silicic ignimbrites and lava flows of the Mogan and lower Fataga formations, Gran Canaria, Canary Islands: Temporal changes in mantle source composition. Earth and Planetary Science Letters. 96. 319-335.

Gurenko, A. A., Chaussidon, M. & Schmincke, H. -U. (2001). Magma ascent and contamination beneath one intraplate volcano: evidence from S and O isotopes in glass inclusions and their host clinopyroxenes from Miocene shield basaltic hyaloclastites southwest of Gran Canaria (Canary Islands). Geochemica et Cosmochimica Acta. 65. 4359-4374.

Gurenko, A. A., Hoernle, K. A., Sobolev, A. V., Hauff, F. & Schmincke, H. -U. (2010). Source components of the Gran Canaria (Canary Islands) shield stage magmas: evidence from olivine compositions and Sr-Nd-Pb isotopes. Contributions to Mineralogy and Petrology. 159. 689-702.

Hansteen, T. H. & Troll, V. R. (2003). Oxygen isotope composition of xenoliths from the oceanic crust and volcanic edifice beneath Gran Canaria (Canary Islands): consequences for crustal contamination of ascending magmas. Chemical Geology. 193. 181-193.

Harris, C., Marsh, J. S. & Milner, S. C. (1999). Petrology of the Alkaline core of the Messum Igneous Complex, Namibia: Evidence for pograssively decreasing effect of crustal contamination. Journal of Petrology. 40.

Riishuus, M. S., Peate, D. W., Tegner, C., Wilson, J. R. & Brooks, C. K. (2008). Petrogenesis of cogenetic silica-oversaturated and -undersaturated syenites by periodic recharge in a crustally contaminated magma chamber: The kangerlussuaq Intrusion, East Greenland. 49. 493-522.

Thirlwall, M. F., Jenkins, C., Vroon, P. Z. & Mattey, D. P. (1997). Crustal interaction during construction of ocean islands: Pb-Sr-Nd-O isotope geochemistry of the shield basalts of Gran Canaria, Canary Islands. Chemical Geology. 135. 233-262.

Troll, V. & Carracedo, J.C. (2016). The geology of the Canary Islands. Elsevier

Troll, V. & Schmincke, H. -U. (2002). Magma mixing and crustal recycling recordered in ternary feldspar from compositional zoned peralkaline ignimbrite 'A'. Gran Canaria, Canary Islands. Journal of Petrology. 43. 243-270.

van den Bogaard, P. & Schmincke, H. -U. (1998). Chronostratigraphy of Gran Canaria. In: Weever, P. P. E., Schmincke, H. -U., Firth, J. V. & Duffield, W. A. (Eds.). Proceedings of the Ocean Drilling Program, Scientific Results. 157. 127-140.

Wolff, J. A. (2017). On the syenite-trachyte problem. Geological Society of America. 45. 1067-1070.