Trace elements and noble gases (He, Ne, Ar) isotopic study of Fuerteventura carbonatites: implications for their mantle source

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Carbonatites are very rare in oceanic environments and in the Atlantic Ocean they can be only found at Fuerteventura (Canary Islands) and Cape Verde islands (De Ignacio et al., 2006). Fuerteventura is located on a transitional, oceanic to continental, crust (Moho depth ≈ 20 km), due to the proximity to the African Plate (Arevalo et al., 2013). This island consists of Mesozoic sediments, basalts and trachytes, ultramafic to felsic intrusives and carbonatitic dike swarms. Ca-carbonatites (*sövite*) and their related alkaline-silicate rocks crop out along the western coast of Fuerteventura.

The field relationship between the carbonatites and other volcanic rocks suggests that the carbonatites represent the latest intrusive event of the alkaline-carbonatitic complex (age 25 Ma), although they are almost contemporary with other related alkaline-silicate rocks (Muñoz et al., 2005). More primitive rocks are represented by clinopyroxenites from a mafic-ultra mafic complex (Mezquez), remnants of magma chambers that have fuelled Miocene magmatism. Noble gases (He, Ne, Ar) isotopic study was performed by crushing calcite and clinopyroxene from carbonatites (Ajuy, Punta de la Nao); clinopyroxene (augites) separates from clinopyroxenites were also analysed.

This research shows new measurements of trace elements and, for the first time, noble gases data in fluid inclusions of carbonatitic complex minerals from Punta de la Nao (Fuerteventura).

I LOCATION AND SAMPLING

Fig.1: Fuerteventura in its geographic contest and sampling coordinates.

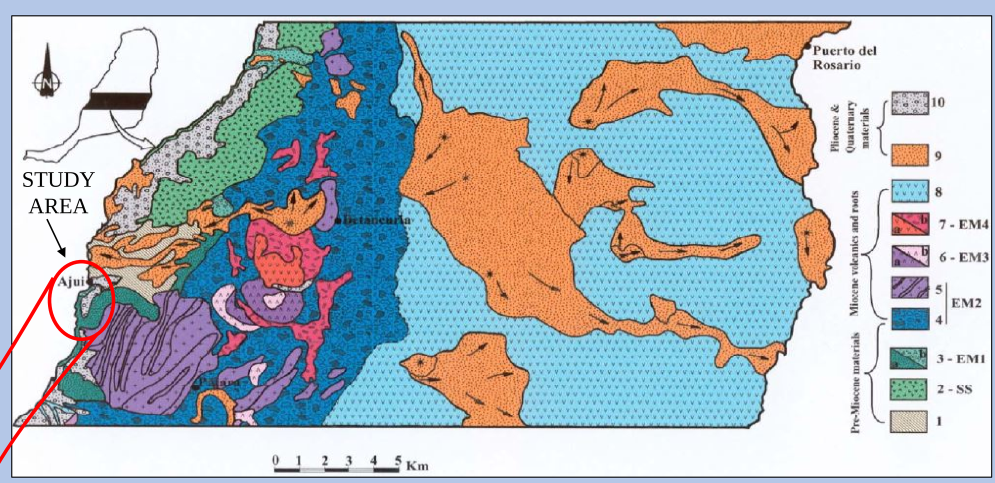

Fig.2: Geological map of the central sector of island with the study area. 1=Mesozoic sediments; 2=submarine series; 3a=subvolcanic-plutonic rocks; 3b=extrusive materials; 4=transitional volcanics; 5=mafic and ultramafic plutonics; 6=V.R.P complex; 6a=gabbros; 6b=syenites; 7=Betancuria edifice; 7a=basalts; 7b=syenites and trachytes; 8=shield volcanics; 9=Pliocene and Quaternary volcanics; 10=Quaternary sediments (Muñoz M. et al, 2003).

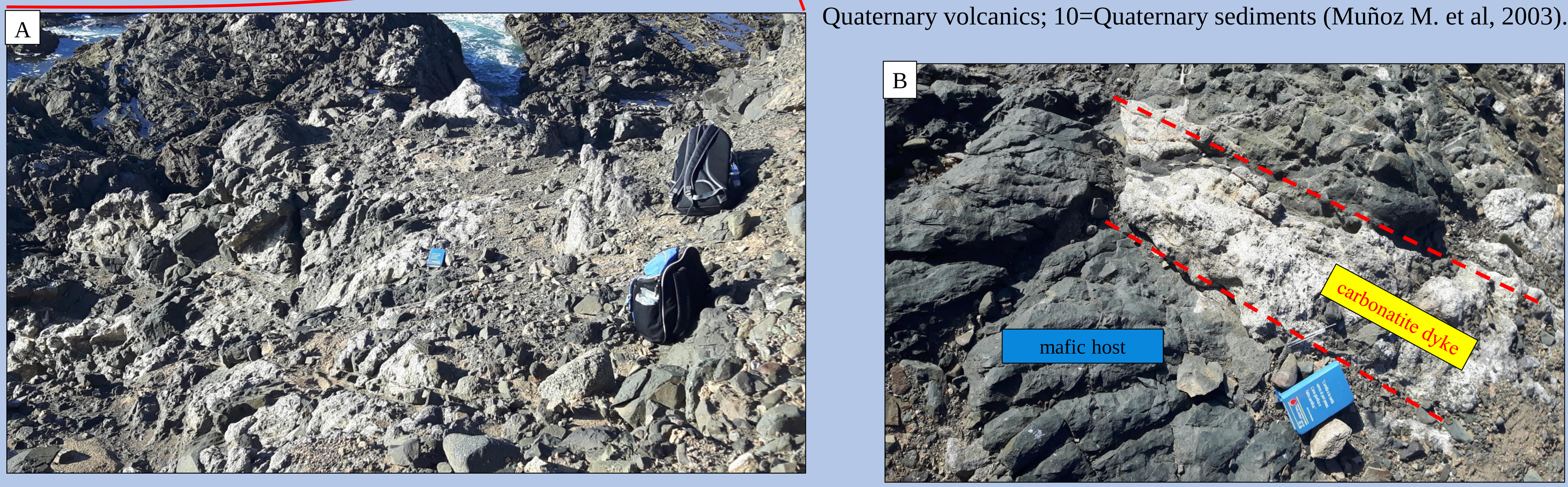

Fig. 3: Field aspects of the study carbonatite complex (A). Carbonatite dyke within mafic host (B).

II PETROGRAPHY

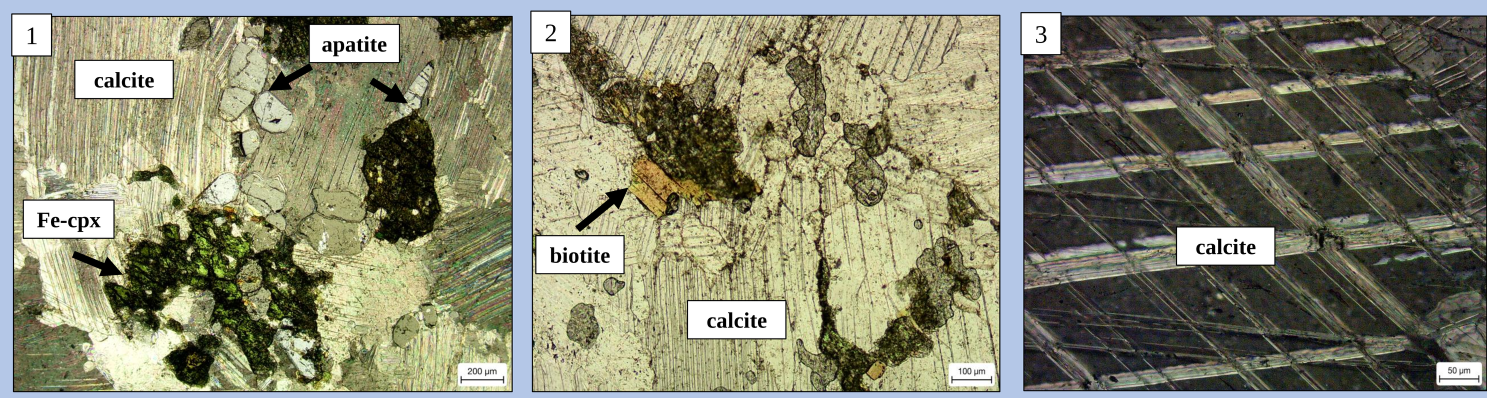

Fig. 4: Typical carbonatite mineral assemblage (1 – 2) and detail on different grain size of calcite (3).

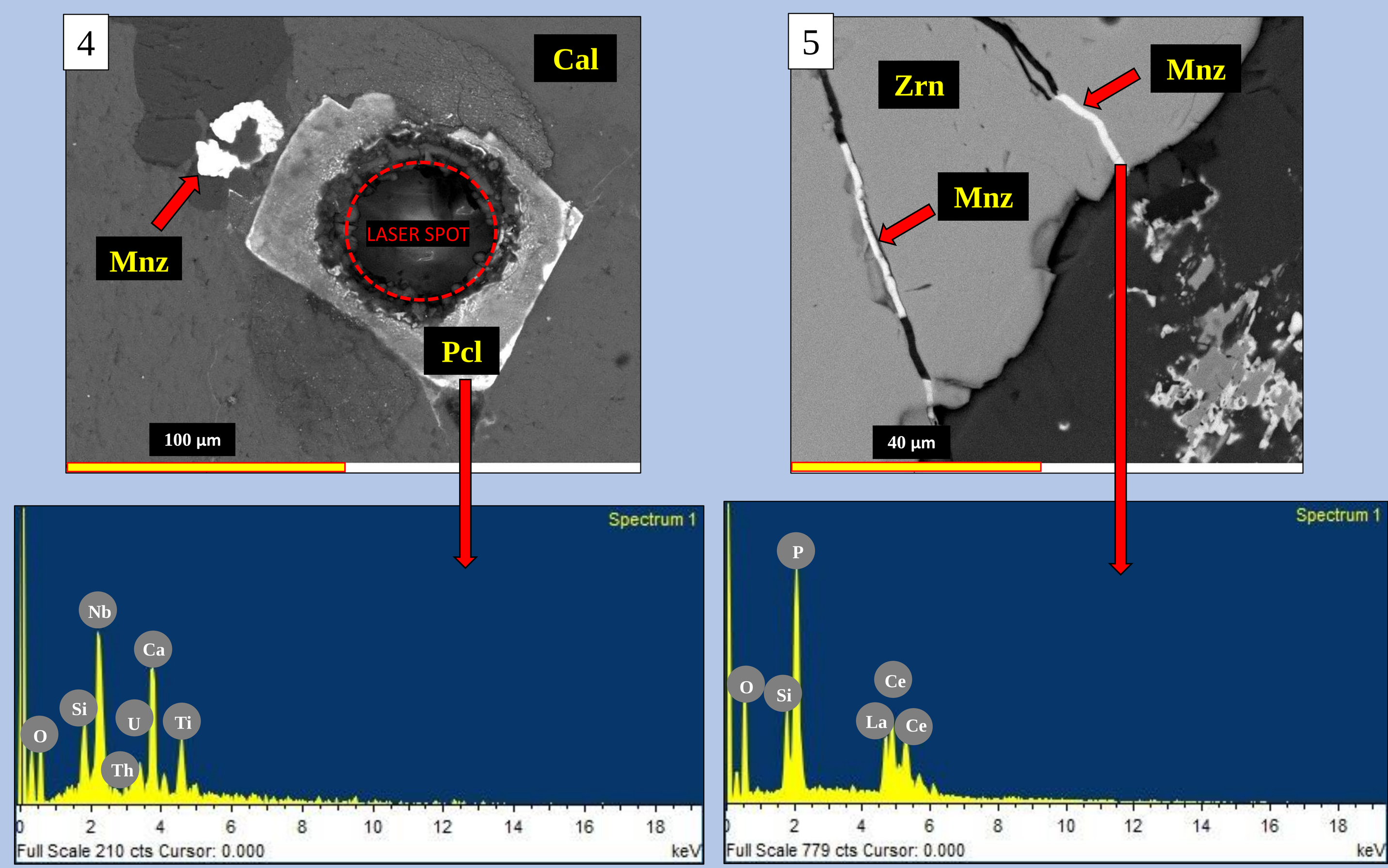

Fig. 5: SEM-BSE images of some accessory minerals: monazite and pyrochlore (4) and monazite-filled microfractures enriched in LREE, in zircon phenocryst (5). Cal = calcite; Mnz = monazite; Pcl = pyrochlore; Zrn = zircon.

III TRACE ELEMENTS AND REE (LA-ICP-MS)

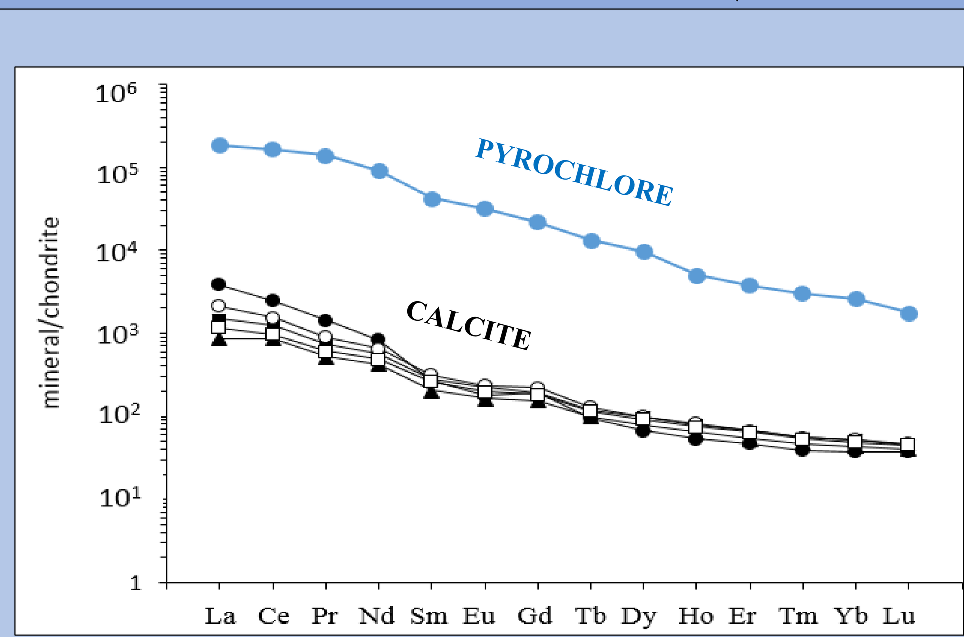

Fig. 6: REE patterns in pyrochlore and calcite.

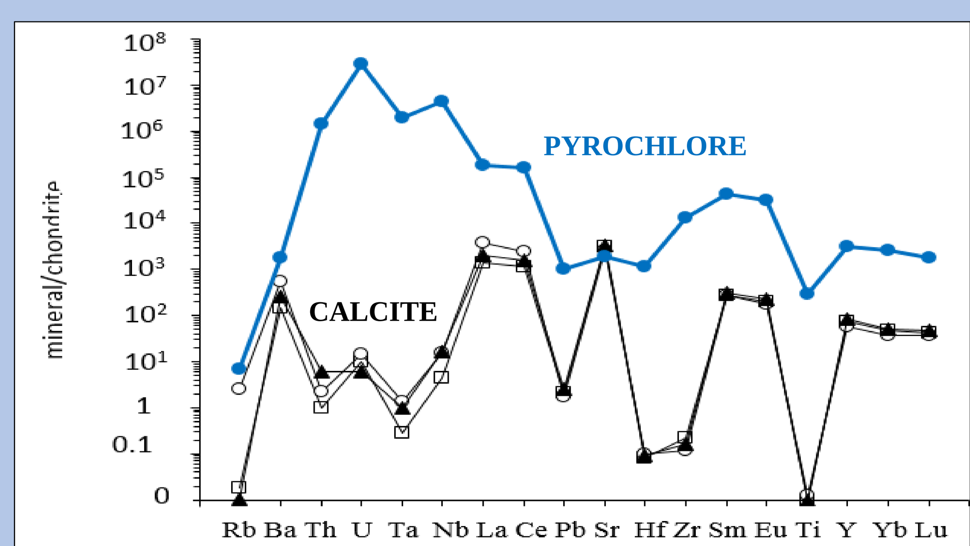

Fig. 7: Spider diagram for trace elements and REE in pyrochlore and calcite.

IV NOBLE GASES (He, Ne, Ar)

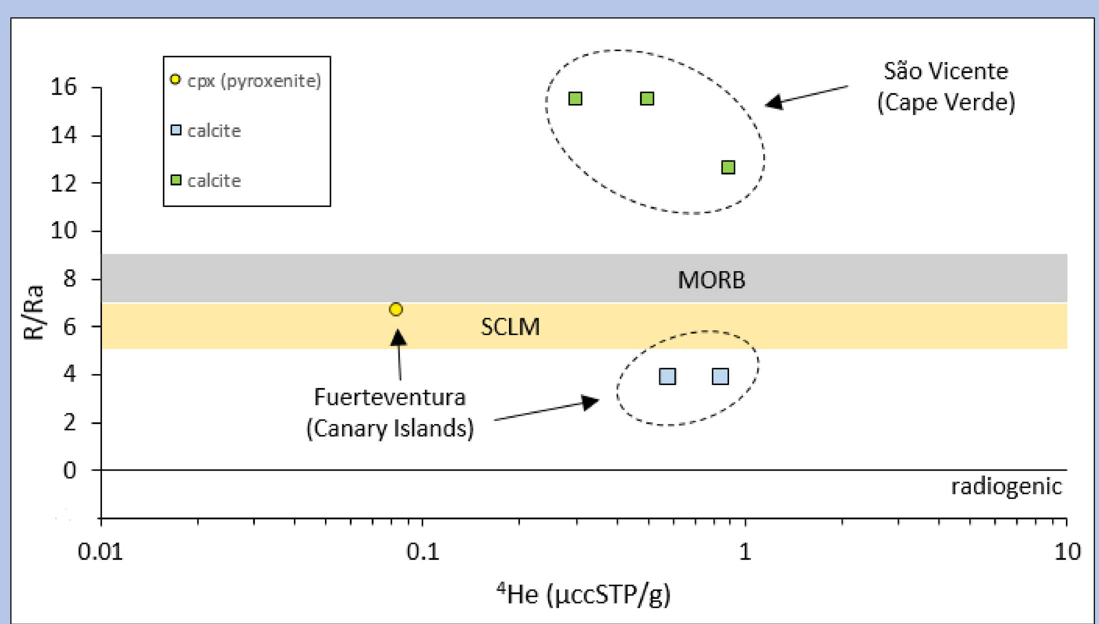

Fig. 8: R/Ra ratios vs ^{4}He concentration obtained by crushing calcite in Fuerteventura carbonatites and clinopyroxene in pyroxenites. Data from Cape Verde carbonatites are also plotted for comparison (Mata et al., 2010).

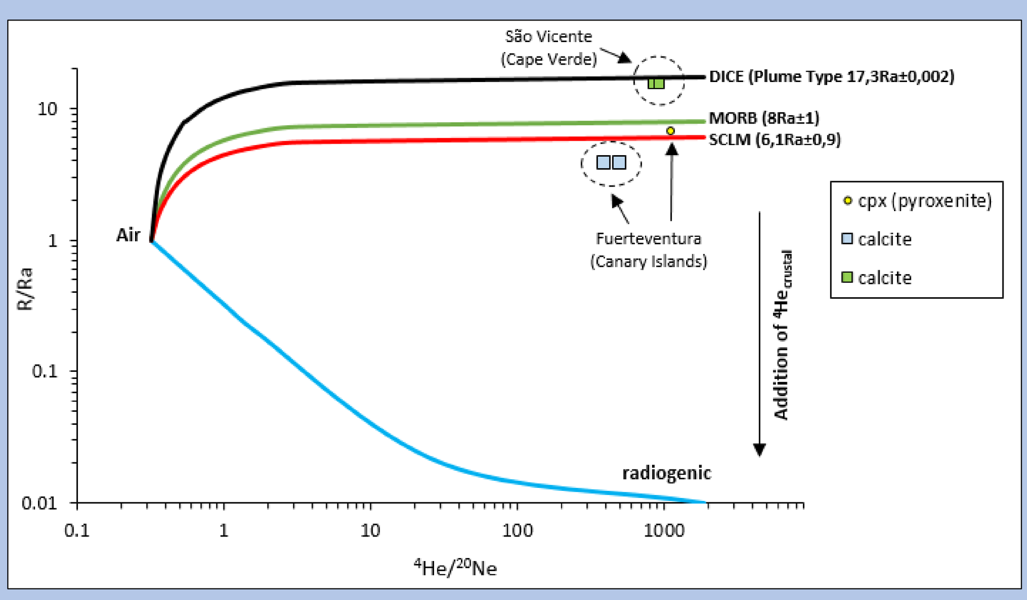

Fig. 9: R/Ra ratios vs ^{4}He/^{20}Ne. Data from Cape Verde carbonatites are also plotted for comparison (Mata et al., 2010).

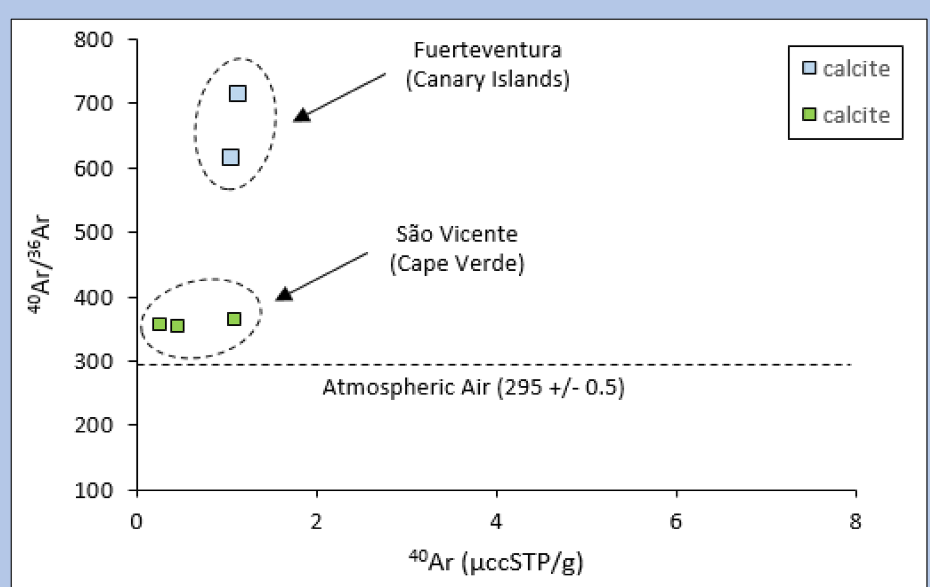

Fig. 10: ^{40}Ar/^{36}Ar ratios vs ^{40}Ar concentrations. The ^{40}Ar/^{36}Ar atmospheric air ratio is taken from Porcelli et al., 2002.

RESULTS AND CONCLUSIONS

- Pyrochlore is the main mineral repository of REEs (sum REE = 21.7 wt %), with very high LREE La_N = 71214 and Ce_N = 62803 with respect to HREE (Yb_N = 997, Lu_N = 695) and a slightly steeper pattern $(La/Yb)_N$ = 71 if compared to calcite $(La/Yb)_N$ = 58. Calcite phenocrysts REE patterns are highly enriched in all REEs (sum REE= 1186-2943 ppm); small negative Eu anomalies do also occur (Eu/Eu* = 0.77 - 0.94) and these are coupled with high Sr anomalies (Sr/Sr* = 28.3 - 58.7).
- Clinopyroxenes from clinopyroxenites reveal the presence of ^{3}He/^{4}He ratios ≈ 6.66 Ra (Ra is the He isotopic signature in atmosphere); clinopyroxenes analyses from carbonatites show low ^{3}He/^{4}He ratios (≈ 2.23 Ra), while calcites ^{3}He/^{4}He ratios are a little higher (≈ 3.87 Ra). ^{4}He/^{20}Ne ratios in clinopyroxenes from clinopyroxenites and carbonatites are respectively 1121 and 1583. Calcites values of ^{4}He/^{20}Ne ratios in carbonatites are > 400.
- The elevated ^{4}He/^{20}Ne ratios in the fluid inclusions of the Fuerteventura volcanic rocks suggest that these fluids are affected by low air contamination.
- ^{40}Ar/^{36}Ar ratios from calcites are higher than the atmospheric air value of 295 +/- 0.5, ranging from 614 to 713.
- Preliminary results show that ^{3}He/^{4}He ratios are slightly lower than typical MORB mantle values and they are in the range of the Sub Continental Lithospheric Mantle (SCLM, 6.1 Ra ± 0.9), suggesting that Fuerteventura carbonatitic magmas originated in a modified mantle, possibly by past subduction events that changed their pristine source-related ^{3}He/^{4}He ratios and their magmatic primary fingerprint.

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