Geochemistry of Gabbroic Xenoliths in the Graciosa Island Vulcão Central Unit (Azores, Portugal)

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INTRODUCTION.

The Graciosa Island belongs to the Central Group of the Azores archipelago, between 39º and 39º06' N latitudes and 27º56' and 28º05' W longitudes. It is located within the Azorean microplate, a topographic high near the Mid Atlantic Ridge (MAR), bordered by the Eurasian, African and American plates (*Fig. 1a*).

The island is formed by volcanic rocks that range from basaltic to trachytic terms. Gaspar (1996) recognized three major volcanic complexes (*Fig. 1b*), in order of decreasing age: the Serra das Fontes Volcanic Complex (SFVC), the Serra Branca Volcanic Complex (SBVC) and the Vitória-Vulcão Central Volcanic Complex. The latter comprises two contemporaneous units: the Vitória basaltic Unit (VU) and the Vulcão Central Unit (VCU).

Gabbroic xenoliths have been only found in the Vitória-Vulcão Central Volcanic Complex, both in the VU and the VCU. They are 5 to 30 cm long and show sub-rounded shapes and sharp contacts.

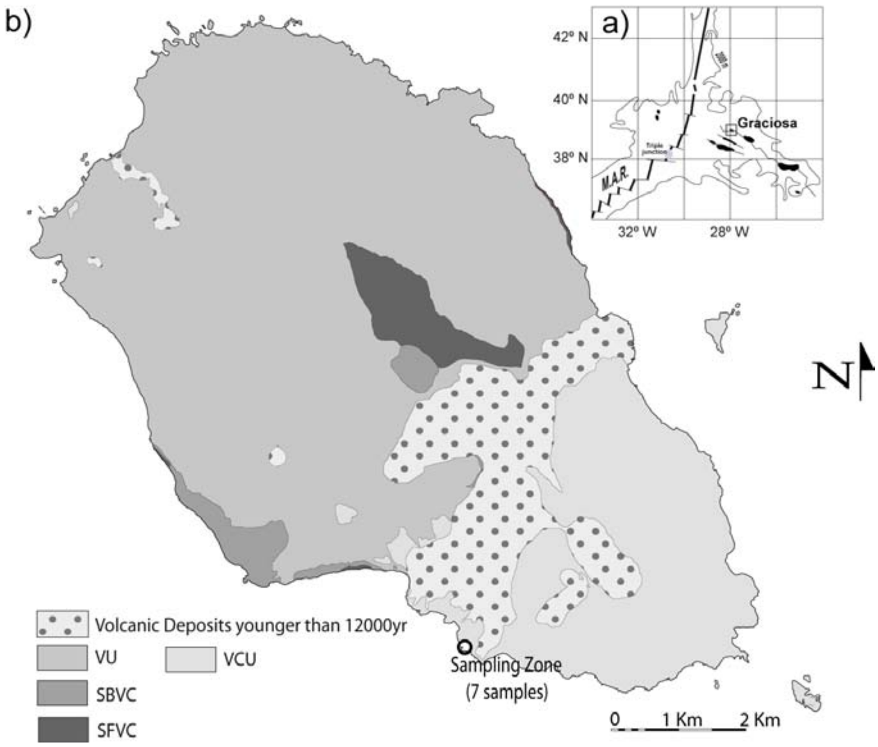

fig 1. a) Location of Graciosa Island within the Azores Archipelago; modified from França et al. (2006) (M.A.R.: Middle Atlantic Ridge). b) Volcanological map of Graciosa Island (modified from Gaspar, 1996).

Petrography and mineral chemistry of the Graciosa gabbros were the focus of preliminary studies (Larrea et al., 2010 in press; Larrea et al., 2010 in this volume). In this work we present the first whole rock geochemical analyses, which correspond to xenoliths from the VCU, and compare them with previously published compositions for their host basalts.

MATERIALS AND METHODS.

Gabbroic xenoliths in the VCU are composed of different proportions of olivine, clinopyroxene, amphibole, plagioclase, Fe-Ti oxides and apatite. According to their petrography and mineralogical composition they can be subdivided in five groups (Larrea et al., 2010 in this volume): (1) alkaline leucogabbros, (2) amphibolic alkaline gabbros, (3) alkaline gabbros bearing pyroxene and amphibole, (4) transitional gabbros and (5) subalkaline gabbros.

Seven xenoliths were analysed from a basaltic lava flow within the VCU (*Fig. 1b*). They belong to groups 1 to 4.

Sample preparation was carried out in the University of Zaragoza. Whole rock major and trace elements concentrations were determined by ICP-MS, (further details on technical method can be found on García de Madinabeitia et al., 2008) in the Ibercron laboratory (University of the Basque Country).

GEOCHEMISTRY OF THE XENOLITHS.

The xenoliths are classified as gabbros according to their modal compositions; they present low SiO_2 (41.8-47.3%) and variable MgO (10.5-3.4%) values. According to their geochemical affinity, the seven analyzed xenoliths can be divided in two major types, which agree with petrographical and mineral compositional data (Larrea et al., 2010 in press; Larrea et al., 2010 in this volume): alkaline (6 samples, corresponding to the aforementioned groups 1, 2 and 3) and transitional (1

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sample, group 4). SiO_2 reaches its highest values for the transitional group. Alkaline gabbros show maximum Na_2O+K_2O (3.0-4.1%), TiO_2 (2.4-5.1%), P_2O_5 (0.3-4.6%), Nb/Y (0.9-1.1) and Ta (1.2-2.9ppm) contents. Their normalized REE patterns (*fig.* 2) show the highest slopes (La/Lu_N = 5.2-11.9). In contrast, the transitional gabbro presents 2.6% Na_2O+K_2O, 1.1% TiO_2, 0.04% P_2O_5, 0.6 Nb/Y, 0.7ppm Ta and 4.2 La/Lu_N values.

The normalized REE patterns of the alkaline-type xenoliths present rather parallel enriched patterns (*Fig.* 2), although slight differences can be recognized among the different alkaline groups (1, 2 and 3). In any case, alkaline compositions seem to be genetically related and more enriched than E-MORB. In contrast, the transitional composition displays lower REE values, resembling a T-MORB pattern for the LREE (*Fig. 2*).

The VCU basalts hosting the studied xenoliths display an alkaline affinity (Almeida, 2001) and their REE patterns agree with those of the alkaline xenoliths (*Fig.* 2). Therefore, the magmas generating the alkaline-type xenoliths and the basalts may be related.

The relationships among highly incompatible elements (e.g. La, Ce, Th) in VCU basalts and gabbros (Fig. 3) suggest they are related by a fractional crystallization process. Hence, the original magma generating both the VCU basalts and gabbros might be the same.

Regarding the transitional gabbro, it can be included in the same fractional crystallization process (Fig. 3). Therefore, although with a slightly different geochemical affinity, its origin is likely to be close to the origin of the alkaline xenoliths.

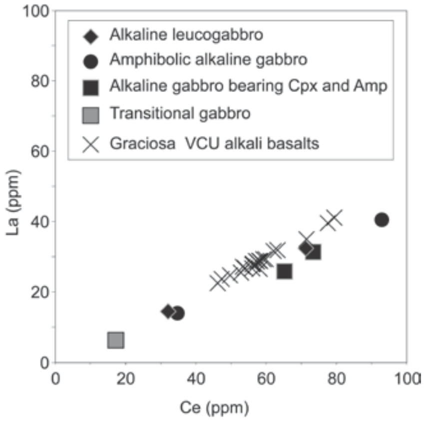

fig 3. *La vs Ce plot of the xenoliths and lavas from the VCU host basalts.*

CONSIDERATIONS.

The geochemical study of the Graciosa island Vulcão Central Unit (VCU) gabbroic enclaves yields the following conclusions:

- According to their geochemical affinity, two major types can be recognized: alkaline (includes groups 1, 2 and 3 from Larrea et al., 2010 in this volume) and transitional (group 4).
- Whole rock analyses agree with the subdivision according to petrographical and mineral compositional criteria of the alkaline-type xenoliths.
- Alkaline gabbros appear to be genetically related among them, and also to the alkali basalts of the VCU which host them.
- The transitional gabbro presents a slightly different geochemical trend, towards a subalkaline composition. However, its origin is likely to be linked to that of the alkaline-type xenoliths.

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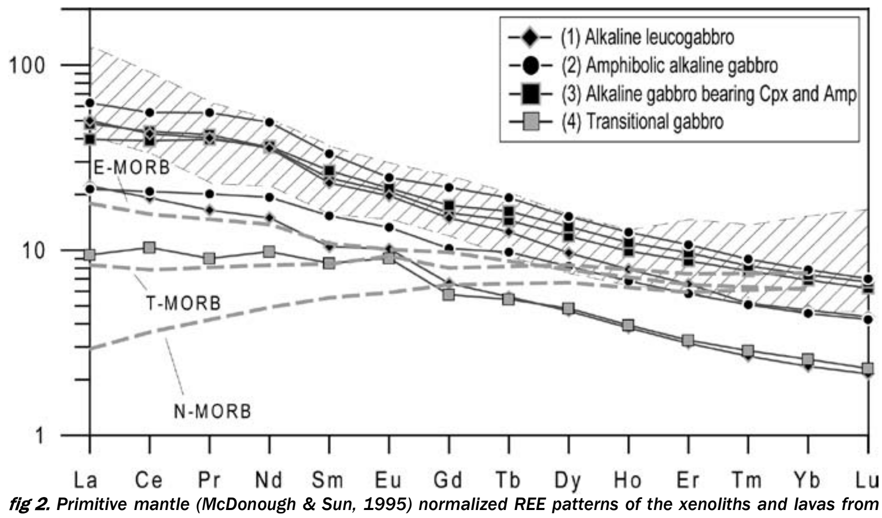

fig 2. *Primitive mantle (McDonough & Sun, 1995) normalized REE patterns of the xenoliths and lavas from the VCU. T-MORB, E-MORB and N-MORB primitive mantle normalized REE compositions are also plotted (Klein, 2003).*