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Small-scale mantle heterogeneity on the source of the Gran Canaria (Canary Islands) Pliocene–Quaternary magmas

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ABSTRACT

New chemical and Sr–Nd–Pb isotopic data of the Plio-Quaternary mafic lavas of Gran Canaria are used to investigate their mantle source composition. The most prominent aspects of the new dataset are the slight isotopic differences between the Plio-Quaternary (Post-Roque Nublo Group) and the older Pliocene (Roque Nublo Group) mafic parental magmas, which reflect small-scale mantle heterogeneities. Melting of two mantle materials, one isotopically more depleted and similar to the Depleted Mantle (DM) and the other with more radiogenic Pb-isotope ratios comparable to a mantle with high U/Pb ratio (HIMU), accounts for the isotopic and trace element composition of the Pliocene–Quaternary magmas of Gran Canaria. Geochemical variations show that the Pliocene–Quaternary mantle source is compositionally and lithologically heterogeneous and supports the presence of a silica-deficient pyroxenite mantle component. The contribution of the pyroxenite component in the generation of the Roque Nublo and Post-Roque Nublo magmas is estimated to be in the range from 50 to 70%. Trace element ratios support mixing between the two mantle components (pyroxenite veins in a peridotite matrix) which obscure the original chemical and isotopic composition of these two end-members.

1. Introduction

Although the presence of small-to-large scale mantle heterogeneities (high U/Pb ratio, HIMU; enriched mantle 1, EM1; enriched mantle 2, EM2; depleted mantle, DMM) in Ocean Island Basalts (OIB) is widely accepted, the origin of these compositional and isotopic variations is still a topic of debate. Although many workers believe that trace element and isotope variations in OIB are related to the recycling of ancient oceanic crust (Hofmann and White, 1982; Hofmann, 1997) associated with crustal or pelagic sediment assimilation (Weaver, 1991; Chauvel et al., 1992), this idea is not universally accepted. Some authors suggest that OIB compositional variations can be explained by metasomatism of the lithospheric mantle (e.g., Halliday et al., 1995; Niu and O'Hara, 2003; Donnelly et al., 2004; Pilet et al., 2005).

The classical model to interpret compositional and isotopic variations in OIB (and the origin of pristine basic basalts) is related to different degrees of partial melting of a peridotite source (e.g. McKenzie and O'Nions, 1991), and is supported by high pressure experimental data and the presence of olivine-rich melts (e.g., Keshav et al., 2004). However, the role of eclogite/pyroxenite in the OIB petrogenesis has also been considered (e.g., Allègre and Turcotte, 1986; Hirschmann and Stolper, 1996; Eiler et al., 2000; Sobolev et al., 2005). Experimental studies and geochemical/petrological modelling suggest that pyroxenitic material is a potential source component of basaltic magmatism (Lustrino, 2005). Hirschmann et al. (2003) and Kogiso et al. (2003) postulated that alkaline melts including nephelinites, basanites and alkali basalts are linked to an enriched source, whereas less alkaline basaltic melts (i.e., tholeiites) are correlated to high degrees of partial melting of a shallow peridotite source. Recently, it has also been suggested that many OIB lavas, such as tholeiites from Hawaii, are derived from a hybridized pyroxenitic source resulting from a reaction between eclogitic melts and associated peridotite (Sobolev et al., 2005, 2007).

Although the OIB from the Canarian Archipelago has been the focus of numerous studies related to mantle component characterization (e.g., Cousens et al., 1990; Hoernle et al., 1991; Hoernle and Schmincke, 1993a,b; Marcantonio et al., 1995; Thirwall et al., 1997;

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Sigmarsson et al., 1998; Widom et al., 1999; Simonsen et al., 2000; Demeny et al., 2004), melting of a pyroxenite mantle component has only been suggested for the shield stage magmas of central and western islands (e.g., Hoernle, 1998; Gurenko et al., 2006, 2008, 2009, 2010), and the rejuvenation stage magmas of the easternmost island, Lanzarote (Sigmarsson et al., 1998).

Here, we present a new dataset of whole rock major and trace element compositions as well as Sr–Nd–Pb isotope ratios of mafic lavas from the Plio-Quaternary volcanic activity of Gran Canaria. We discuss the role of silica-deficient pyroxenite and CO_2-rich peridotite on the generation of pristine basic melts during the rejuvenation stage of the island. We also assess the relative proportions of mantle end-

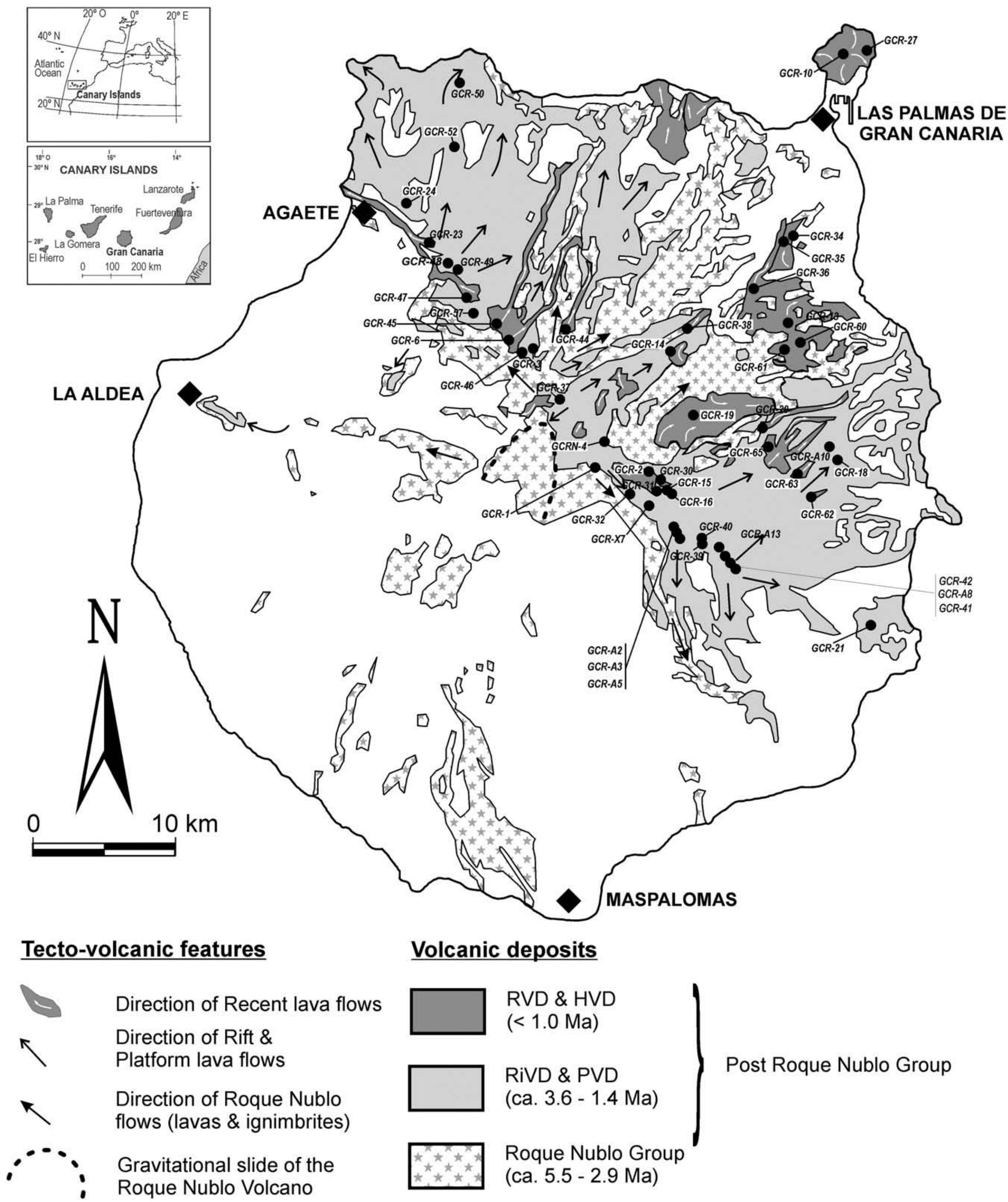

Fig. 1. Simplified map of Gran Canaria with the distribution of the Plio-Quaternary volcanic vents. It is noted that the Post-Roque Nublo volcanism is mainly located at the north-eastern part of the island. Sampled lava locations refer to the volcanic vents from which they were erupted.