Peridotite xenoliths, olivine-pyroxene megacrysts and cumulates of the Bandama Volcanic Complex (Gran Sanarla, Spain): genesis in the oceanic lithosphere

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Geologic information on the deeper parts of the oceanic lithosphere is difficult to obtain directly. Mantle and crustal xenoliths carried to the surface by basaltic melts represent one very important source of such information. Thus, our research is based on the study of 18 samples of peridotite xenoliths and olivine-pyroxene phenocrysts, megacrysts and cumulates from pyroclastic deposits of Bandama volcanic complex (Gran Canaria), and 2 samples of lava flows associated to this complex. We have combined data from the volcanological study and the electron microprobe and microthermomertric analysis of minerals, and melt and fluid inclusions, and the bulk-rock analysis of these samples to define some characteristics of magmatism which gave rise to the Bandama volcanoes.

Gran Canaria island is at the centre of the Canary Archipielago. Geophysical data indicate the occurrence of an oceanic-type basement underneath the island modified by massive intrusions with a Moho depth of 13 kms (Fig. 1). Magmatic activity of this island began in the Miocene with an episode of submarine volcanism and their subaerial volcanism have been divided over three main episodes: Old Cycle (Miocene, 14.5-8.5 Ma), Roque Nublo Cycle (Pliocene, 5.5-2.7 Ma) and Recent Cycle (Plio-Quaternary, 2.9-Present).

The quaternary volcanic complex of Bandama is some 10 Kms to the southwest of the city of Las Palmas de Gran Canaria and is made up of a volcanic caldera (La Caldera de Bandama) and a strombolian cone (El Pico de Bandama). Bandama eruption began in the area of La Caldera with a strombolian episode which produced deposits of fall and a basanite lava flow. Later, the magma in the counduit mixed periodically with groundwater, producing both phreatomagmatic eruptions with base surge deposits and strombolian eruptions with fall deposits. Although the volcanism episodes were to continue in the area around La Caldera, most of these manifestations were centred around the NW area of the fisure, producing the strombolian cone known as the Pico Bandama, abundant deposits of fall in the surrounding areas and an intracanyon flow. The genesis of La Caldera is posterior to El Pico and was produced as a result of the last effusive-explosive eruptions and the eventual collapse of the volcanic cone located to the SE of the fissure. Around the wall of La Caldera, the materials to be found from the floor to the roof, are the following: a) phonolites and conglomerates of Miocene age; b) ignimbrites from the Roque Nublo Cycle and c) pyroclast deposits and a lava flow of the Bandama volcanic complex.

Lava flows of Bandama have thick below 5 m. and these show basanite composition (SiO_2 41.8% and sum of the alkalis 3.8%) and porphyritic texture with phenocrysts and microcrysts of olivine, pyroxene and oxide (spinel and ilmenite) with sizes under 2 cm. Micro~robe analysis of these minerals reveal olivine Fo_{70-89} (Ni/Ca ratio: 0.3-2.2) and clinopyroxene Wo_{40-52}, En_{27-54}. Spinel appear as subordinate minerals and as inclusions in phenocrysts and have Cr2O3 content between 36.4 and 40.2%. These analysis show variations of composition between the cores and rims of some phenocrysts and reveal different crystal generations.

Phreatomagmatic eruptions form base surge and explosive breccia rich in lithics (such as phonolites, tephrites and alkaline basalts) deposits with spectacular volcanic-sedimentary structures (imbricated channels, sand waves, bomb impacts, etc.). However, the strombolian volcanism is characterized by the presence of fall deposits, containing peridotite xenoliths and olivine-pyroxene megacrysts and cumulates with sizes under 7 cms. Microprobe analysis of these minerals show:

- phenoscrysts and megacrysts of olivine Fo_{77-89} (Ni/Ca: 0.5-2.2 and spinel with Cr_2O_3: 34-36.3%), clinopyroxene Wo_{34-52}, En_{33-51} (spinel with Cr_2O_3: 20.8-23.4%) and kaersutite (destabilized to fassaite – Wo_{54-57}, En_{31-34}--, rhönite, olivine and subsaturated melt).

- Olivine-clinopyroxene cumulates (dunite, werhlite, clinopyroxenite with olivine, clinopyroxenite) with olivine Fo_{80-87} (Ni/Ca: 0.6-2.1 and spinels with Cr_2O_3: 14-31.2%) and clinopyroxene Wo_{39-51}, En_{36-55} (spinels with Cr_2O_3: 10-16.1 %) .

- Peridotite xenoliths (dunite and Iherzolite) with olivine Fo_{83-89} (Ni/Ca: 1-20 and spinels with Cr_2O_3: 13.2-32.8%), orthopyroxene Fo_{84-85} (spinels with Cr_2O_3: 31.3%) and clinopyroxene Wo_{40-44}, En_{48-50}.

Melt inclusion study in olivine from fall deposits and lava flows show SiO_2 content: 35-44%, sum of alkalis: 4.1 -7% and high values of S and Cl (<5,500 and <980 ppm, respectively). The melt inclusion compositions are different from the lava whole rock and the intersticial melt. The melting temperatures (Tm) of melt inclusions range between 1,060 and 1,260°C.

Microthermometric study of melt and fluid inclusions in olivine and clynopyroxe shows pure, or almost pure, CO_2 trapped in the gas bubble. These carbonic fluids reveal a wide range of Th of CO_2 (-39 to 31 °C) in liquid, indicating minimun depths of mineral formations (at Tm: 1200°C) between 12-18 Km for olivine-pyroxene megacrysts, 4.5-27 Km for olivine-pyroxenes cummulates, 10.5-25 km for peridotite xenoliths, and 7.5-33 Km for olivine phenocrysts of lava flows (Fig. 1).

The minerals which make up the megacrysts, cumulates and xenoliths of Bandama reveal reaction rims with the lava which are reequilibrated with the magma. These minerals display textural, mineralogical, microthermometric and chemical composite characteristics from the ratio to minerals of the lava flow and thus we can conclude that those minerals were originated under different conditions.

From the aforementioned data, we can conclude that the magma which gave rise to the Bandama volcanic complex ascended from upper mantle to the surface (-33 km to 0.5 km), trapping peridotite xenoliths, olivine-pyroxene megacrysts and cumulates of different origins from the upper mantle and the oceanic crust (-27 to -4.5 km) (Fig. 1).

Gran Canaria Island

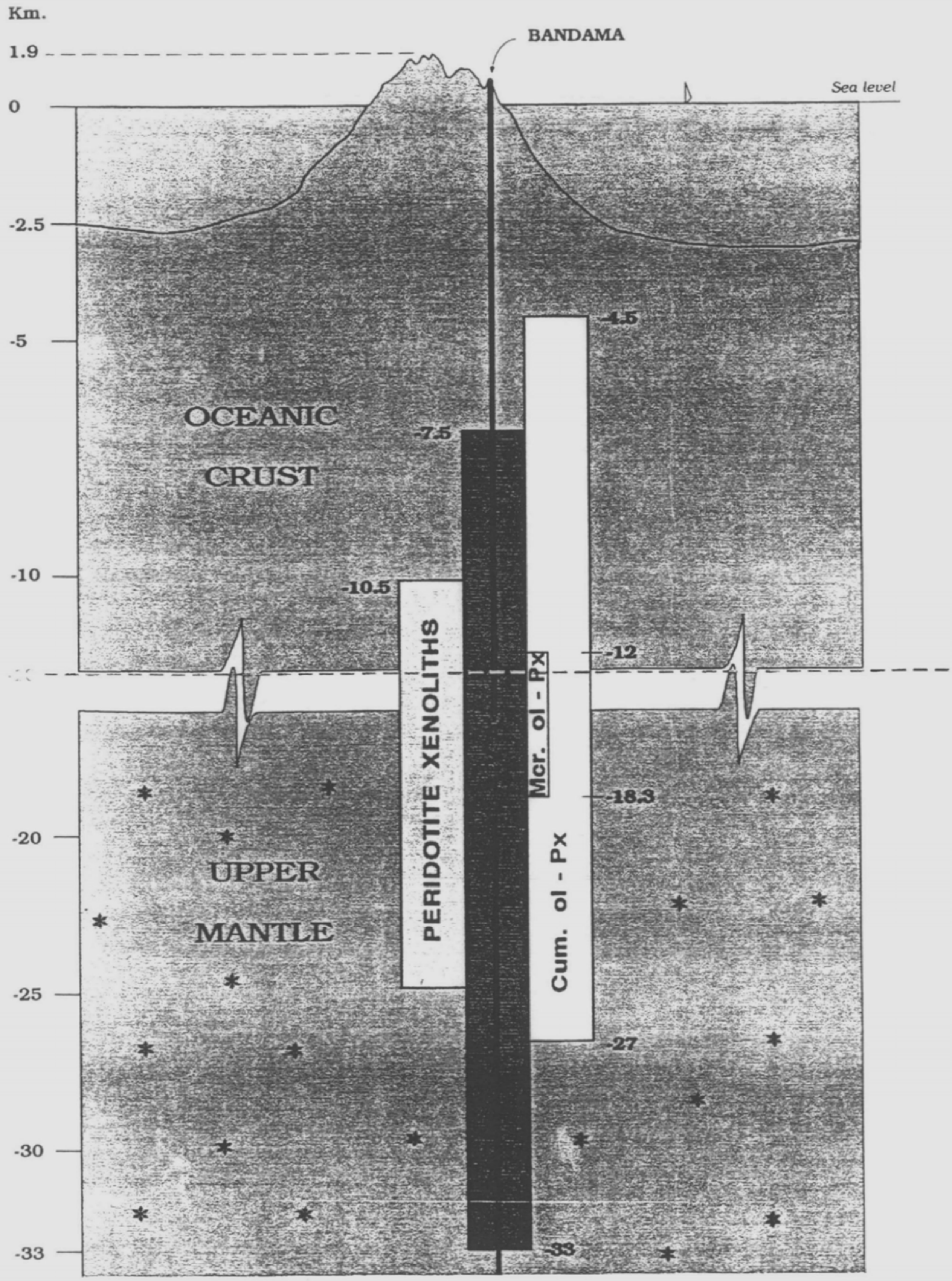

Figure 1. Interpretative scheme of depth calculated by CO_2-rich fluid inclusions trapped in olivine and pyroxene from lava flows, peridotite xenoliths and megacrysts of Bandama.