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Relationship between the fractal dimension of the enclaves and the volumes of magmas in Montaña Reventada (Tenerife)

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The volcanic unit of Montaña Reventada is an example of magma mixing in Tenerife (Canary Islands, Spain). The eruptive process has been detonated by a basanite intruding into a phonolite magma chamber. This eruption started with a basanite followed by a phonolite. Montaña Reventada phonolite is characterized by the presence of mafic enclaves. These enclaves represent about the 2% of the outcrop and have been classified like basanites, phono-tephrite and tephri-phonolite. The enclaves have different morphologies, from rounded to complex fingers-like structures, and usually exhibit cuspate terminations.

This study aims to provide a new perspective on the 1100 AD Montaña Reventada eruption quantifying the textural heterogeneities related to the enclaves generated by the mixing process. The textural study was carried out using a fractal geometry approach, and its results were used to calculate some parameters related to magma chamber dynamics.

Photographs of 67 samples were taken normal to the surface of the enclaves with the aim of delineating the contact between the enclaves and the host rocks. The resulted pictures were processed with the NIH (National Institutes of Health) image analysis software to generate binary images in which enclaves and host rock were replaced by black and white pixels, respectively. The fractal dimension (D_{box}) has been computed by using the box-counting method in order to quantify the complexity of the enclaves morphology. Viscosity ratio (μ_R) between the phonolite and the enclaves has been calculated as follows:

$$\log(\mu_R) = 0.013e^{3.34D_{box}}$$

The viscosity of the enclaves has been calculated according to the $\mu_R$value with the higher frequency and to the calculated viscosity of the phonolite between 900˚ and 1200˚. We hypothesized that this value corresponds to the amount of mafic magma present in the system, while the other values represent different degrees of mingling and chemical diffusion. Viscosity of the basanite can be computed like:

$$\mu_{enclave} = (\%_{phonolite} * \mu_{phonolite}) + (\%_{basanite} * \mu_{basanite})$$

$$\mu_{basanite} = \frac{\mu_{enclaves} - (\%_{phonolite} * \mu_{phonolite})}{\%_{basanite}}$$

The minimum percentages which satisfy the relation are 69.5% of basanite and 30.5% of phonolite. Although the amount of mafic magma reaches the 69.5%, the presence of enclaves in the phonolite is just the ≈1% and the amount of basanite erupted before could correspond to the 15% of the phonolite (estimated from stratigraphic sections). Probably a magma body of basanite was still stored in the magma chamber. The volume of basanite still stored during this time may have evolved to a more explosive magma and hence increases the volcanic risk in the area.