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Mixing Experiments with Natural Shoshonitic and Trachytic Melts: A comparative Study Under Contrasting Rheological and Fluid Dynamic Conditions

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Isotopic evidence for open system processes within the Campi Flegrei magma chambers, (Arienzo et al., 2008, Bull. Volc.) and previous experimental studies on the behavior of major, minor and trace elements during mixing of alkaline magmas (De Campos et al., 2008, Chem.Geol.) motivated this study. In order to simulate the evolution of the mixing process, we performed experiments using natural volcanic samples from this region. The end-member melts derive from the Agnano-Monte Spina (trachytic) and Minopoli (shoshonitic) eruptions. Based on previous isotopic data, these are thought to be the most suitable counterparts for replicating the extreme interacting compositions in this system.

Variable time series of advection-diffusion experiments using two different techniques have been carried out: 1) a high-temperature centrifuge and 2) a viscometer. For the centrifuge experiments the rotating speed was 1850 revolutions per minute and the acceleration 10 ^{3} g. In this way, dynamic conditions closer to those calculated for magma chambers (Reynolds Numbers [Re] around 10^2) could be simulated. For every experiment, a 4 mm thick disk of previously homogenized crystal free shoshonitic glass and an 8 mm thick disk of homogenized crystal free trachytic glass were loaded in a 5mm diameter Pt capsule. The capsule was then sealed on both sides, but for a small opening on the upper end, allowing interstitial degassing during the acceleration. Samples were arranged in a buoyantly unstable geometry, where the denser material is placed at the inner side of the rotating circle (basaltic trachyandesite, ρ=2.63 g/cm^3 at 1169^{o}C) and the lighter material at the external side (trachyte, ρ=2.45 g/cm^3 at $\sim$1000^{o}C). Viscosity ratio was around 35. Temperature has been kept constant at 1,200^{o}C during all experimental runs, with a negligible thermal gradient ($<$ 1ºC). Forced convection was applied via centrifugal acceleration and density instabilities. Results from all experimental runs with the centrifuge after 5, 20 and 120 min will be discussed.

The second set of experiments consisted of two experimental runs (25- and 168-hours duration) under Taylor-Couette flow, according to De Campos et al. (2008, Chem. Geol.). Higher amounts of the same end-members, in different proportions, have been mixed together using a concentric cylinder viscometer. For the second set of experiments forced convection has been simulated by stirring with a spindle. Experimental conditions were constrained by: 1) constant angular velocity (0.5 rotations per minute) and 2) constant temperature (1,300˚ Celsius). It this case the viscosity ratio between melts was around 30 and the Reynolds Number around 10^{-7}. The experiments terminated by stopping all movement, extracting the spindle from the sample and letting the sample cool to room temperature. Cylinders of the resultant mixed glasses were recovered by drilling and, prepared for microprobe analysis.

Microprobe and ICP-MS analyses along longitudinal lines from sections of all the resulting products reveal a complex non-linear mixing process with different mobility for different elements. Comparative studies from both experimental sets highlight the importance of chaotic advection in enhancing the mixing efficiency. . At higher Re (centrifuge) and very short mixing times, higher viscosity contrast between the mixing melts (lower temperature - 1,200^{o}C) can be compensated by chaotic dynamics. At very low Re (concentric cylinder), longer mixing times and chaotic dynamics may equally enhance mixing, therefore contrasting with calculated predictions from the literature.