

Petrological constraints on magma plumbing dynamics of the 2011 El Hierro eruption (Canary Islands)

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A submarine eruption took place off the south coast of El Hierro, Canary Islands, from October 2011 to March 2012. The well-monitored eruption was preceded and accompanied by numerous earthquakes and ground deformation. Eruptive products sporadically rose to the ocean surface and were sampled at different stages of the eruption. We carried out a detailed geochemical and petrological study to constrain magma plumbing dynamics associated with the eruption.

All bulk lava samples are basanites with essentially identical matrix glass compositions, implying very little change in magmatic liquid composition through time. The MgO content of the bulk lava increased at the late eruptive phase due to increasing contents of ferromagnesian crystals. Final phenocryst crystallization took place at 500-710 MPa (17-24 km depth, within the upper mantle), as was determined by 73 clinopyroxene-melt pairs. This depth range for an inferred magma reservoir coincides perfectly with the depths of syn-eruptive seismicity. In contrast, the analysis of 260 CO₂-rich fluid inclusions in phenocrysts yields two pressure ranges, one at 280-440 MPa (10-16 km depth, lower crust to upper mantle) and one at 450-580 MPa (16-19 km). The shallower range corresponds well with the depths of pre-eruptive seismicity, and reflects lateral movement of magma within the lower crust over a distance of ca. 15 km before ascending to the eruptive site.

Detailed analysis of zoning patterns in olivine and clinopyroxene phenocrysts and compositions of melt inclusions reveal that at least two distinct magmas were involved in the eruption. Both magma batches were initially stored in the upper mantle, one probably at 19-25 km depth and one at 15-18 km. Diffusion modelling indicates that mixing of these magmas likely began about three months before eruption, resulting in intrusions to the lower crust and associated seismic crisis and surface deformation. Strikingly, mixing must have continued for many weeks after the onset of the eruption. The abundance of complexly zoned phenocrysts in the late eruptive products is interpreted to reflect mobilization of crystal mush and cumulates as a consequence of magma withdrawal and reservoir collapse.

Established and advanced solid-state NMR spectroscopy for a better understanding of the structure and function of natural organic matter in soils, water and sediments

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In geobiogeochemistry, 1-dimensional solid-state NMR spectroscopy has been proven as a powerful tool for the characterization of natural organic matter (NOM) in soils, sediments and waters. However, compared to solution NMR spectroscopy, this technique suffers from broad resonance lines and low resolution, which could be overcome by the use of 2-dimensional solid-state NMR pulse sequences. Until recently, this approach has been unfeasible as a routine tool in geochemistry, mainly because of the low NMR sensitivity of the respective samples. Alternative to the use of higher magnetic fields, considerable signal enhancements can be achieved with the new developments in the field of dynamic nuclear polarization (DNP) solid-state NMR spectroscopy. Here, the improvement is achieved by a microwave-driven transfer of polarization from a paramagnetic centre to nuclear spins. Application of DNP to magic angle spinning (MAS) spectra of biological systems (frozen solutions) showed enhancements by factors of 40 to 50 (Hall *et al.*, 1997). Applying this technique for the first time on NOM, lower but still promising enhancement factors were obtained which allowed the successful acquisition of 2D solid-state NMR spectra of such samples. In the present contribution, the possibilities and limitation of established solid-state NMR techniques in NOM research are discussed and first results obtained with solid-state DNP NMR are presented. Those first data demonstrate the great potential of the latter and that this approach opens new doors for a better understanding of biochemical processes in soils, sediments and water.