Geophysical Research Abstracts
Vol. 20, EGU2018-3506, 2018
EGU General Assembly 2018

Chemical differentiation, compositional bimodality, cold storage and remobilization of magma in the Earth's crust

Matthew Jackson (1), Jon Blundy (2), and Steve Sparks (2)

(1) Department of Earth Science and Engineering, Imperial College London, United Kingdom (m.d.jackson@imperial.ac.uk),
(2) School of Earth Sciences, University of Bristol, United Kingdom

The formation, storage and chemical differentiation of magma in the Earth's crust is of fundamental importance in igneous geology and volcanology, yet many of the underlying physical and chemical processes remain unknown. Here we use numerical modelling to show that several apparently unrelated and puzzling features of crustal magmatism arise in response to reactive flow of melt through low melt fraction 'mush reservoirs'. Increasing evidence suggests that magma is usually stored in such reservoirs, rather than in the high melt fraction 'magma chambers' that have underpinned conceptual models of crustal magmatism for over a century. We model the intrusion of basaltic (mafic) magma in the mid- to lower-crust and show that reactive flow produces low crystallinity, chemically differentiated (felsic) magmas which can leave the reservoir and ascend through the crust to form shallow intrusions or erupt to the surface. The majority of the reservoir remains a low melt fraction mush throughout its life, consistent with geophysical data. Reactive melt flow produces low crystallinity felsic or mafic magmas but not intermediate magmas, consistent with observed bimodal melt compositions sourced from mid- to lower-crustal reservoirs. Moreover, the evolved magma that leaves the reservoir can contain much older crystals, creating the age disparity recorded in many crustal magmas. These older crystals are stored at sub-solidus temperatures before being remobilized by the accumulation of melt sourced from deeper in the mush, consistent with crystal chemistry data. Modelled trace element profiles, preserved after solidification, are similar to those observed in a crustal reservoir now exposed at the surface. Our results suggest that magma storage and differentiation primarily occurs by reactive flow in long-lived mush reservoirs, rather than fractional crystallisation in magma chambers.