Geochemistry of igneous rocks in Iceland: a review

Olgeir Sigmarsson\textsuperscript{1,2}, John Maclennan\textsuperscript{3} and Marion Carpentier\textsuperscript{1,4}

\textsuperscript{1}Laboratoire Magmas et Volcans, Centre National de la Recherche Scientifique et Université Blaise Pascal, 63038 Clermont-Ferrand, France
\textsuperscript{2}Institute of Earth Sciences, University of Iceland, Sturlugata 7, IS-107 Reykjavik, Iceland
\textsuperscript{3}Department of Earth Sciences, University of Cambridge, CB 2 3EQ, UK
\textsuperscript{4}Laboratoire de Géodynamique des Chaînes Alpines, Université J. Fourier, 38400 St-Martin d’Hères, France

\textsuperscript{1}olgeir@opgc.univ-bpclermont.fr, \textsuperscript{2}olgeir@raunvis.hi.is, \textsuperscript{3}jmac05@esc.cam.ac.uk, \textsuperscript{4}marion.carpentier@ujf-grenoble.fr

Abstract — Two important large-scale geochemical trends are observed in Iceland and the adjoining spreading ridges, one along the ridges and active rift zones, and the other between the rift zones and off-rift areas of recent volcanism. Along the ridges, basalt compositions are increasingly enriched in incompatible elements (i.e. elements which preferentially partition into melts) towards Iceland, reflecting enhanced melting of fusible, fertile components of a heterogeneous mantle. These heterogeneities may be garnet pyroxenites that are derived from recycled oceanic lithosphere. Recent basalts erupted outside the rift zones are more enriched in incompatible elements than those of the rift zones. These two trends reflect variations in mantle temperature, compositional structure and flow field as well as the role of tectonics. Mantle melts move rapidly from their deep source regions towards the surface in porous channels or dykes. These melts mix and cool in lower-crustal magma chambers before eruptions. The limited basalt production rate away from the rift zones results in a relatively low crustal thermal gradient, facilitating the production of silicic magmas by fractional crystallization of incoming basalts. However in the hot rift zones, where hydrothermal activity is plentiful, crustal anatexis may result to produce silicic melts. Thorough mixing of crustal melts and solid crustal material with basalts may account for the compositional features of large fissure eruptions such as Laki.

INTRODUCTION

Icelandic magmatism is unique for several reasons. The presence of an island with a substantial shelf that straddles a spreading ridge is indicative of unusually high mantle melt production rates: typical ridges are submerged in kilometres of ocean. Faults and fissures, caused by rifting, open access for rainwater into the crust’s interior. Interaction of these waters with hot crustal rocks leads not only to conspicuous geothermal activity at the surface but also to metamorphism of basalt and gabbro at depth. The large proportion of silicic magmas produced in Iceland relative to other oceanic islands is often linked to anatexis of these metabasalts. Finally, the presence of glaciers results in abundant formation of hyaloclastite that upon subsidence may affect the mechanical strength of the crust and locations of magma chambers beneath the currently active volcanoes. The wide range of resulting magmatic processes can be studied in great detail due to excellent exposures. Iceland has therefore become a focus not only for an international community of mid-ocean ridge specialists but also for those investigating magmatic processes that may operate in any global tectonic setting.

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