Shallow-level magma-sediment interaction and explosive behaviour at Anak Krakatau

TROLL, V.R.[1,4], JOLIS, E.M.[1], DAHRÉN, B.[1], DEEGAN, F.M [1], BLYTHE, L.S.[1], HARRIS, C.[2], BERG, S. E.[1], HILTON, D.R. [3], FREDA, C.[4] AND SCHWARZKOPF, L.M.[5]

[1] Dept. of Earth Sciences, CEMPEG, Uppsala University, Sweden
[2] Dept. of Geological Sciences, University of Cape Town (UCT), Rondebosch, South Africa
[3] Geosciences Research Division, Scripps Institution of Oceanography, UC San Diego, La Jolla, USA
[4] Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy
[5] GeoDocCon, Konradsreuth, Hof, Germany

Crustal contamination of ascending arc magmas is generally thought to be a significant process which occurs at lower- to mid-crustal magma storage levels where magmas inherit their chemical and isotopic character by blending, assimilation and differentiation [1]. Anak Krakatau, like many other volcanoes, erupts shallow-level crustal xenoliths [2], indicating a potential role for upper crustal modification and hence late-stage changes to magma rheology and thus potential eruptive behaviour. Distinguishing deep vs. shallow crustal contamination processes at Krakatau, and elsewhere, is therefore crucial to understand and assess pre-eruptive magmatic conditions and their associated hazard potential. Here we report on a multi-disciplinary approach to unravel the crustal plumbing system of the persistently-active and dominantly explosive Anak Krakatau volcano [2, 3], employing rock-, mineral- and gas-isotope geochemistry and link these results with seismic tomography [4]. We show that pyroxene crystals formed at mid- and lower-crustal levels (9-11 km) and carry almost mantle-like isotope signatures (O, Sr, Nd, He), while feldspar crystals formed dominantly at shallow levels (< 5km) and display unequivocal isotopic evidence for late stage contamination (O, Sr, Nd). This obeservation places a significant element of magma-crust interaction into the uppermost, sediment-rich crust beneath the volcano. Magma storage in the uppermost crust can thus offer a possible explanation for the compositional modifications of primitive Krakatau magmas, and likely provides extra impetus to increased explosivity at Anak Krakatau.

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Mixing and progressive melting of deep and shallow mantle sources in the NE Atlantic and Arctic

RG TRØNNES[1], V DEBAILLE[2], M ERAMBERT[3], FM STUART[4] AND T WAIGHT[5]

[1] CEED and NHM, Univ. Oslo, r.g.tronnes@nhm.uio.no
[2] Univ. Libre de Bruxelles
[3] Dept. Geosciences, Univ. Oslo
[4] Isotope Geosciences Unit, SUERC, East Kilbride
[5] Inst. Geography Geology, Univ. Copenhagen

NE Atlantic and Arctic MORB and primitive off-rift basalts in Iceland, Jan Mayen and Spitsbergen (late Quaternary alkaline basalts) record variable geochemical interaction between the asthenospheric mantle (AM), material supplied by the Iceland plume and subcontinental lithospheric mantle (SCLM). The SCLM-component was mixed with the local asthenosphere during and shortly after the continental rifting and ocean basin opening. Using combined Sr-Nd-Pb-Os-He-isotope systematics, the Iceland plume can be modelled as a mixture of 70% refractory/primordial lower mantle (LM) and 30% recycled oceanic crust (ROC). Low-degree melts are preferentially from the enriched ROC and SCLM components, before progressive melting gradually consumes more of the the LM and AM components.

The modelled ROC/SCLM-ratio decreases markedly from a maximum of about 2.3 at the Reykjanes Ridge, Reykjanes Peninsula and the Southern Volcanic Flank Zone in Iceland, via 1.2 at the Snæfellsnes peninsula, Western Rift Zone and Mid-Icelandic Belt and 0.7 at Jan Mayen and the Kolbeinsey, Mohns and Knipovich Ridges to less than 0.2 in Spitsbergen and along the Gakkel Ridge. These ratios might be slightly overestimated due to a general background level of ROC (HIMU-component) in an otherwise depleted asthenosphere.

The minor element composition of olivine phenocrysts in primitive off-rift basalts in Iceland and Jan Mayen, sampling preferentially the enriched source components, indicates that the SCLM-lithologies are dominantly peridotitic, in contrast to the ROC-lithologies, recording a higher proportion of eclogites and hybridized pyroxenites. The combined Hf-Nd-isotope systematics also discriminate between these two enriched source components.

The high proportion of the SCLM-component in the asthenosphere along the Kolbeinsey, Mohns, Knipovich and Gakkel Ridges reflects the young, narrow and slow-spreading character of the corresponding oceanic basins. These ridges appear to sample mantle sources with higher proportions of locally derived SCLM-material than other mid-ocean ridges.

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