Voluminous magmas in intra-continental setting: Hf and O isotopes in zircons from Late Paleozoic volcanic rocks in NE Germany

PIETRANIK ANNA[1*], CRAIG STOREY[2], BREITKREUZ CHRISTOPH[3], ELŻBIETA DEJA[1]

[1]University of Wrocław, Geological Sciences, Poland; anna.pietranik@ing.uni.wroc.pl (* presenting author)
[2]University of Portsmouth, Earth and Environmental Sciences, UK craig.storey@port.ac.uk
[3]TU Bergakademie Freiberg, Geology and Paleontology, Germany, Christoph.Breitkreuz@geo.tu-freiberg.de

Voluminous rhyolitic rocks (ca. 34 000 km^3) were formed in the NE German Basin in an intra-continental setting ca. 300 Ma ago. εHf and $\delta^{18}O$ have been measured in dated magmatic and inherited rhyolitic zircons from three drill cores across the NE German Basin. Inherited zircons have crystallisation ages from ca. 1.7 to 0.5 Ga, εHf values of -20 to 7 ε units and $\delta^{18}O$ values of 5.8 to 9.3 ‰. The inherited zircons have Hf model ages of 1.9 - 2.2 Ga, indicating that much of the basement was initially derived from the mantle at that time. High $\delta^{18}O$ magmatic zircons have similar model ages highlighting that the 300 Ma magmatic event involved the melting of sediments derived from basement generated at ca. 2.1 Ga. The εHf values in magmatic zircons vary from -7 to +1 ε units and $\delta^{18}O$ = 6.0 to 9.4 ‰. The range of εHf and $\delta^{18}O$ values in magmatic zircons in the three sites investigated have been modelled by simple assimilation - fractional crystallization processes of mantle derived magma contaminated by sediments with model ages of ca. 2.1 Ga. Zircons record crystallization from magmas with 10-80 % mantle contribution, with an average of 45%. This implies that these silicic magmas contain on average 15000 km^3 of mantle derived material and that they represent a significant contribution to the net growth of the continents. Zircons from the NE German Basin have more inter-grain variability, but they record less complex magma evolution processes than zircon and whole rock data from other large silicic volcanic provinces, e.g. in North America. This is consistent with zircon crystallizing in small magma batches, which are amalgamated in larger, but short - lived upper crustal magma chambers.

The origin of chemical heterogeneity in the Hawaiian mantle plume

AARON J. PIETRUSZKA[1*], MARC D. NORMAN[2], MICHAEL O. GARCIA[3], JARED P. MARSKE[1] AND DALE H. BURNS[1]

[1]San Diego State University, San Diego, CA, USA, apietrus@geology.sdsu.edu (* presenting author)
[2]Australian National University, Canberra, Australia
[3]University of Hawaii, Honolulu, HI, USA

Inter-shield differences in the composition of lavas from Hawaiian volcanoes are generally thought to result from the melting of a heterogeneous mantle source containing variable amounts or types of oceanic crust (sediment, basalt, and/or gabbro) that was recycled into the mantle at ancient subduction zones (e.g., [1-3]). Here we investigate the origin of chemical heterogeneity in the Hawaiian mantle plume by comparing the incompatible trace element abundances of tholeiitic basalts from (1) Kilauea, Mauna Loa, and Loihi Seamount (the three active Hawaiian volcanoes) and (2) the extinct Koolau shield (a compositional end member for Hawaiian volcanoes). Model calculations suggest that the mantle sources of Hawaiian volcanoes contain variable amounts of recycled oceanic crust (ROC) from ~8-16% at Kilauea and Loihi to ~15-21% at Mauna Loa and Koolau. We propose that the Hawaiian plume contains a package of ROC (basalt and gabbro, but little or no marine sediment) that was altered by interaction with seawater or hydrothermal fluids prior to being variably dehydrated in an ancient subduction zone. The ROC in the mantle source of Kilauea and Loihi lavas is dominated by the uppermost portion of the residual slab (gabbro-free and strongly dehydrated), whereas the ROC in the mantle source of Mauna Loa and Koolau lavas is dominated by the lowermost portion of the residual slab (gabbro-rich and weakly dehydrated). The model results suggest that the large-scale distribution of compositional heterogeneities in the Hawaiian plume (at the present time) cannot be described by either a radial zonation [1] or a bilateral asymmetry [4,5]. Instead, the Hawaiian plume is heterogeneous on a small scale with a NW-SE oriented spatial gradient in the amount, type (i.e., basalt vs. gabbro) and extent of dehydration of the ancient ROC.

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