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Intraplate Volcanism in New Zealand: The Role of Fossil Plume Signatures and Lithospheric Properties

P. Sprung (1), S. Schuth (1,2), C. Münker (1,2), L. Hoke (3)

(1) Universität Münster, Institut für Mineralogie, Germany, (2) Universität Bonn, Mineralogisch-Petrologisches Institut, Germany, (3) Victoria University Wellington, School of Earth Sciences, New Zealand (sprungp@uni-muenster.de)

Cenozoic intraplate volcanism is widespread throughout the whole New Zealand microcontinent. The microcontinent consists of an assemblage of Paleozoic-Mesozoic terranes that were amalgamated by virtually continuous subduction along the active Gondwana margin. New Zealand is truncated by the plate boundary between the Pacific plate and the Australian Plate since ca. 45 Ma ago. On the North Island, intraplate volcanic fields are located above a region of elevated heat flux and lithospheric extension behind an active trench-arc system, whereas on the South Island intraplate volcanism occurred in an oblique continent-continent collision regime. The off-shore Chatham Islands are an area of intermittent intraplate volcanic activity since late Cretaceous time.

Major- and trace element compositions as well as Hf-Nd-Pb-Sr-isotope whole rock data for basaltic to basanitic rocks (all displaying MgO contents $>$6 wt.-%) were obtained to constrain the nature and location of the source regions. The data set covers the regional and temporal range of New Zealand's intraplate volcanism (Cretaceous to Quaternary). Major- and trace element compositions indicate variations in average melting depths ranging into the garnet stability field. The average melting depth is inversely correlated with the degree of melting, resulting in a strong decrease of silica-contents with increasing La/Yb and Gd/Yb. An influence of volatile rich lithospheric minerals is documented by anomalous depletions of K and Pb relative to elements of similar incompatibility. La_N/Yb_N range from 22.4 to 2.7, Gd_N/Yb_N from 4.7 to 1.8.

Hf-Nd-Pb-Sr-isotope relationships imply the presence of three distinct domains in the source regions of the magmas. εHf values range from +3.8 to + 9.9, εNd values

from +3.9 to +7.0, $^{87}Sr/^{86}Sr$ values from 0.7028 to 0.7048, $^{206}Pb/^{204}Pb$ from 18.85 to 20.55, and $^{207}Pb/^{204}Pb$ from 15.60 to 15.77. Two components originate from the subcontinental lithospheric mantle; depleted asthenospheric upper mantle constitutes the third component. The influence of the depleted upper mantle is strongest in samples from the North Island. The lithospheric mantle tapped by New Zealand's intraplate volcanism was (1) modified by Paleozoic-Mesozoic subduction components and (2) infiltrated by small degree melts with strong affinities to HIMU-OIB. In those samples from the South Island that display the shallowest average melting depth, isotope signatures of subducted sediments are most dominant. As illustrated by Pb isotope compositions, the HIMU-like character is strongest in samples from the Chatham Islands, showing a gradual decrease with decreasing average melting depth for samples from the South Island. The presence of the HIMU component in the lithosphere since Cretaceous time argues against an active plume beneath present day New Zealand. In contrast, these relationships suggest that the lithospheric mantle is the source region for the HIMU-like isotope and trace element signatures as well as for the isotope signatures that show an influence of subduction components. Consistent with geophysical models describing the generation of melts at the interface between asthenosphere and lithosphere, the lithospheric and asthenospheric contributions to the source regions of the volcanic rocks are controlled by the degree of extension, lithospheric thickness and by the temperature of the asthenosphere.