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The long-term temporal evolution of the sub-arc mantle: Isotopic evidence for continuous mantle source enrichment

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Addition of a slab-derived component results in mantle-metasomatism. The flux from the subducted slab controls the light rare earth (LREE) and incompatible trace element (LILE) composition of the mantle wedge and ultimately of arc magmas. To answer important questions concerning the relative importance of fluxes, the convection velocity and the thermal state of the mantle wedge our knowledge of the temporal evolution of the sub arc mantle must be improved. It has been proposed, already in the early seventies, that temporal maturation of island arc magmas occurs, possibly linked with an evolution of the sub arc mantle. Recent studies focused on the major element evolution of high resolution tephra record of present-day active Island arcs (e.g. Mariana) indicating a slight increase of slab derived elements through time. However, these studies covered only a limited period (e.g. ˜50 Ma in the case of the Marianas) of the likely long-lasting arc magmatism ($>$ 100 Ma). Additionally, to constrain the mantle evolution the major element composition of arc magmas have to be corrected for fractionation processes, which induces considerable uncertainties. To overcome these drawbacks we focused on an isotopic study of the Kohistan paleo-island arc, an accreted Mesozoic-Tertiary arc complex exposed in NW Pakistan. We present the results of combined high-precision U-Pb ages and Hf isotopic data from zircons and Pb-Sr-Nd whole rock isotopic data on various and widely distributed intrusive units of this arc. The samples document ˜120 Myrs of magmatic activity. The isotopic composition of the studied mafic to granitic rocks can be explained by a mixture of a depleted upper mantle component (DM) and enriched sources (EM). Detailed study of a single intrusion reveals that intra crustal assimilation, a principal source for the enriched components, has only negligible influence on the isotopic signature. Therefore we conclude

that the isotopic composition is derived from the melting region. In agreement with numerous previous studies we assume that the enriched compositions are derived from the subducting slab. The temporal trend displays a steady decrease in Epsilon(Nd) and Epsilon(Hf) and an increase in 87/86Sr and 208,207,206/204Pb. Older samples are generally depleted whereas younger ones yield enriched compositions. The trends indicate a long-term metasomatic enrichment of the Kohistan sub-arc mantle source by a slab-derived component. Our results imply that the sub arc-mantle did not reach a chemical steady state even after 120 Ma of magmatic activity. The influx from the subducting slab likely exceeds the degree of depletion of the sub-arc mantle due to partial melting and the influx of fresh "unmetasomatized" material into the wedge due to convection. However, convection must have been sufficient enough to supply fertile mantle material controlling the major element chemistry of arc magmas. These results can be used to further constrain numerical model simulating subduction zones.