Constraints from Arc Magmas on the Pb Isotope Composition of the Subducted Igneous Oceanic Crust

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Arc magmas have typically low ratios of Ce/Pb<10 that are considered to reflect the addition of Pb-rich components from subducted slab. Quantification shows that the slab flux contributes ca. 80-90% of arc Pb while the mantle wedge contributrion are negligible [1]. Consequently, the slab flux must control the Pb isotope composition of arc magmas, implying that the typical linear arc arrays in Pb isotope space reflect binary mixing between 'continental' (sediment/eroded continental crust) and 'mantle-type' (crust formed at midocean ridges and intraplate volcanoes) components from the subducted slab. Comparative studies of Pb isotope compositions of arc magmas and sediments and/or eroded crust from the conjugate trenches confirmed strong links to recycled continental material, but the connection between the arc chemistry and the subducted igneous crust is less well explored. However, given its large volume, the depleted subducted igneous crust should provide a Pb flux that rivals the Pb flux of the enriched continental components, and that should transmit the Pb isotope heterogeneity of the oceanic crust (e.g. Pacific vs Indian domains, or MORB vs. intraplate domains) to arc magmas.

This hypothesis is being tested by a systematic evaluation of arc magmas composition using combined Pb isotope and trace element systematics. This allows for isolating the Pb isotope signals of the igneous oceanic crust from the signals of the recycled continental crust and the subarc mantle. First results confirm that Pb isotope diversity of the igenous oceanic crust can be traced (e.g Indian vs. Pacific MORB, intraplate crust vs. MORB-type crust). Remarkably, the arc Pb isotope systematics seem to require a normal MORB-type crust that is on average less radiogenic in Pb ($^{206}Pb/^{204}Pb$ ~18.1) than the average global MORB based on surface samples ($^{206}Pb/^{204}Pb$ ~18.4, [2]). This discrepancy may either reflect temporal variations in the Pb isotope composition of MORB, or possibly a systematic difference in the MORB average obtained from the top of the extrusive layer, and the overall Pb flux to arcs that should integrate Pb from the entire subducted MORB-type crust.

References: [1] Straub SM, Zellmer GF (2012) Gondwana Res 21(2-3) 495-516; [2] Gale A, Dalton CA, Langmuir CH, Su Y, Schilling JG (2013) G3 14(3).