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Integrated Insights into Global Subducting Slab Dehydration from Arc Magmas

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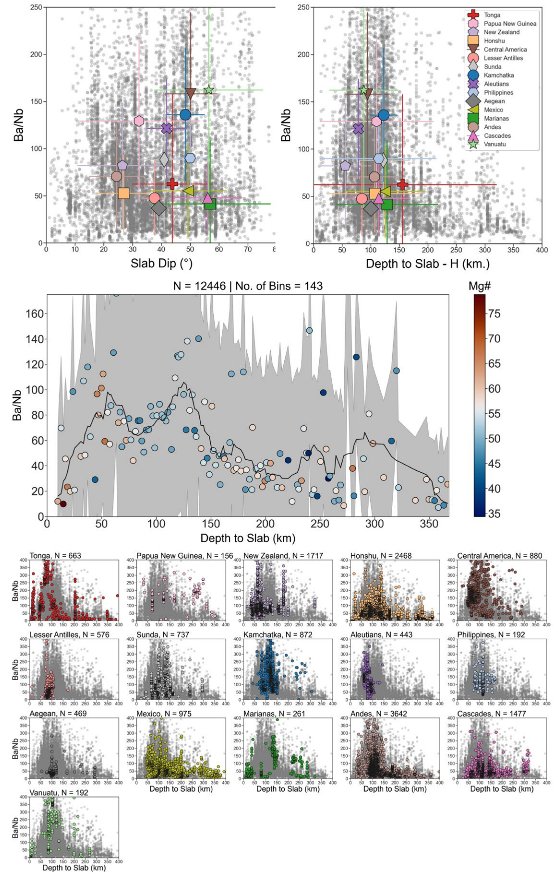

The transfer of material from subducting slabs to the overlying mantle is one of the most important chemical and tectonic processes regulating Earth's geochemical cycles. One of the major processes involved in this material cycling is the de-volatilization of the slab and the release of sediment- and slab-derived fluids to the mantle wedge, where they can trigger subduction zone melting and the generation of arc volcanism. Previous geodynamic, geophysical, and geochemical studies have revealed some of the important controls on global fluid fluxing to the mantle, and its manifestations in arc magmas. However, these studies have often been limited either (1) spatially – choosing to focus either on a limited number of arc segments or to the global "arc front" or (2) compositionally – prioritizing primitive arc basalt compositions with the assumption that these should best reflect the source parameters of melting regions. While such data reduction strategies have great benefits – namely, a much greater control over model variability and sources of error – reductive models inherently lose a large amount of data, particularly where volcanoes manifest beyond the arc front or exhibit atypical magma chemistry. Here we present several key findings arising from our published global compilation *ArcMetals* that combines compositional data from GeoRoc with published datasets of subduction zone tectonics and geology. We show that global arc magma trace element systematics (Ba/Nb, Th/U, Pb/Nd) point to characteristic dehydration depths, or depth-to-slab (DTS), for subduction slabs globally. We observe, for example, three clear peaks in Ba/Nb in arc magma whole rock compositions corresponding to DTSs of 50, 110 km and 260-280 km, which we infer to represent progressive breakdown of different hydrous minerals (e.g., phengite, antigorite, lawsonite). We relate these trace element trends to slab thermal and physical conditions using published thermodynamic and geodynamic models of slab evolution. This study highlights the value of combining large igneous datasets with datasets from other disciplines to produce novel insights into global tectonic and magmatic processes.