Tracking Life Cycles of Ancient and Modern Volcanic Arcs Using Immobile Element Geochemistry

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Volcanic arcs may be viewed as having life cycles which extend from birth to death (interspersed with 'mid-life crises' such as ridge-subduction and flat subduction), and conclude with resurrection in post-collision settings. This concept, adapted from that of Shervais (G-Cubed Paper No. 2000GC000080), is potentially useful for identifying and interpreting volcanic arcs in the geologic record. Thus, the focus here is on the elements (HFSE and REE) and isotopes (Nd, Hf) that are robust in the study of altered rocks.

The most distinctive examples of arc birth are those of Western Pacific (IBM) type in which a boninitic protoarc precedes the inception and growth of the normal calc-alkaline or tholeiitic arc. Here, positive Hf anomalies on extended REE plots provide key evidence for hot, shallow slab melting. Other types of arc birth, for example in the South Sandwich, Puysegur, SW Japan and Andean arcs, do, however, reveal other scenarios. As already well-documented, geochemical proxies can track the growth of arcs by providing information on such factors as subduction flux, crustal growth and slab-top temperature. Arc death is taking place in a number of arcs at the present day. Where the cause of death is collision, it is marked by increases in subduction flux and slab-top temperature due to slab deceleration and continent subduction. The final stages of subduction may then be tracked using crustal input proxies such as Th/Nb and quantified using data from sediment melting experiments, Arcs are typically resurrected as post-collision volcanic provinces when delamination, extension and slab-breakoff result in reactivation of inherited subduction components in the sub-continental lithosphere. Ancient arcs vary significantly in lifespan but, if sufficiently well preserved, typically exhibit life cycles from subduction initiation to post-collision magmatism.

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