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Geochemical Interpretation of Collision Volcanism

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Collision volcanism can be defined as volcanism that takes place during an orogeny from the moment that continental subduction starts to the end of orogenic collapse. Its importance in the Geological Record is greatly underestimated as collision volcanics are easily misinterpreted as being of volcanic arc, extensional or mantle plume origin. There are many types of collision volcanic province: continent-island arc collision (e.g. Banda arc); continent-active margin collision (e.g. Tibet, Turkey-Iran); continent-rear-arc collision (e.g. Bolivia); continent-continent collision (e.g. Tuscany); and island arc-island arc collision (e.g. Taiwan). Superimposed on this variability is the fact that every orogeny is different in detail. Nonetheless, there is a general theme of cyclicity on different time scales. This starts with syn-collision volcanism resulting from the subduction of an ocean-continent transition and continental lithosphere, and continues through post-collision volcanism. The latter can be subdivided into orogenic volcanism, which is related to thickened crust, and post-orogenic, which is related to orogenic collapse. Typically, but not always, collision volcanism is preceded by normal arc volcanism and followed by normal intraplate volcanism. Identification and interpretation of collision volcanism in the Geologic Record is greatly facilitated if a dated stratigraphic sequence is present so that the petrogenic evolution can be traced. In any case, the basis of fingerprinting collision terranes is to use geochemical proxies for mantle and subduction fluxes, slab temperatures, and depths and degrees of melting. For example, syn-collision volcanism is characterized by a high subduction flux relative to mantle flux because of the high input flux of fusible sediment and crust coupled with limited mantle flow, and because of high slab temperatures resulting from the decrease in subduction rate. The resulting geochemical patterns are similar regardless of collision type with extreme LILE and significant HFSE enrichment relative to MORB and with large negative Nb-Ta and Ti anomalies. Post-collision volcanism is usually ascribed to combinations of slab detachment, delamination, and slab roll back (orogenic) and extension (post-orogenic). The magma source is typically conductively-heated, sub-continental mantle lithosphere with composition and depth of melting depending on the nature and evolution of the collision zone in question. Geochemical patterns may be similar to those of syn-collision basalts or of intraplate, continental basalts - or transitional between these. This variability in space and time, though problematic for geochemical fingerprinting, can give clues to the polarity and development of the collision zone, for example by highlighting the distribution of subduction-modified mantle lithosphere and hence of pre-collision subduction zones. One characteristic common to this setting is a high crustal input resulting from the presence of a hot, thick ‘crustal chemical filter’ which is evident on geochemical projections that highlight AFC-type processes. Using this, and other, geochemical features it is possible to develop methodologies to at least partly see through the complexity of collision terranes.