Plumes and Blooms in Archean Crustal Evolution

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Many proposals for the origin of continental crust have focused on the modern arc environment as an analogue for crustal production in the Archean. One difficulty with this approach is that in the modern Earth, oceanic arcs are forming without the development of a keel, i.e., a segment of depleted sub-arc lithospheric mantle. Modern plume systems, such as Ontong-Java Plateau, have developed a "keel" that is distinct from the circulating asthenosphere but have not produced the TTG-rich felsic crust that characterizes Archean crust worldwide. Consequently, it is worth considering other possibilities that are uniformitarian in terms of our understanding of petrology and geochemistry, but less uniformitarian in terms of the overall petrotectonic environment. One model that deserves consideration is that proposed by Fred Barker and colleagues in the late 1970's and early 1980's. In this model mantle upwellings (aka plumes) build volcanic-plutonic edifices akin to modern intra-oceanic plateaus with depleted lithospheric keels (Ontong-Java). The mafic and ultramafic volcanic rocks erupted below sea level are hydrothermally altered. As the edifices grow and subside into the hotter Archean mantle with higher internal radio-element contents in the eruptive products, they melt and produce initial TTG liquids. This mechanism allows the TTGs to acquire the HFSE depleted/LILE enriched signature common in arc rocks today in an environment that can also produce a crust keel-system. This plume-to-bloom transition will naturally decrease in importance over time as ambient mantle temperatures decline, radio-elements are sequestered into the preserved crust, and over all radio-element heat production declines.