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U-Th Disequilibrium from Picrites to Tholeiites in the Iceland Rift

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Post-glacial lava sequences in the NE (Theistareykir) and SW (Reykjanes Peninsula) extremes of the Icelandic rift zone show remarkable geochemical characteristics that have generated much interest over several decades (e.g. Jakobsen 1974). The magmas range from tholeiites to the rarer picrites, and are notable for showing coherent variations in major (e.g. SiO_2, FeO, CaO/Al_2O_3) and trace element (e.g. Th, La/Sm) and radiogenic isotope compositions (e.g. $^{143}Nd/^{144}Nd$, $^{206}Pb/^{204}Pb$). Despite their plume setting, the picrites are extremely depleted, (e.g. [Th] ~0.015µg/g, chondrite normalised La/Sm<0.4), and incompatible element contents vary by a factor of fifty between the picrites and more voluminous olivine tholeiites. Although additional mechanisms are needed to account of concomitant radiogenic isotope variations, the range of depletions is most simply accounted for in terms of a dynamic melting model. In this scenario, deep, incompatible element rich melt fractions are variably included in the erupted, aggregate melt. This process should also have a profound influence of the U-Th disequilibrium of the erupted melts, which has been investigated in this study. Representative samples that span the extreme range of compositions described above were analysed, from both Theistareykir and the Reykjanes Peninsula. All are effectively zero-aged and require no post-eruptive decay correction. The striking feature about the new data is the absence of any systematic variations in disequilibrium. Lavas all show significant U-Th disequilibrium with ^{230}Th excesses ranging from 7-17%. However, both the most depleted and enriched sample the same degree of disequilibrium (7%). Even more notable is that $^{230}Th/^{232}Th$ ratios, that would be expected to dominate the variations in disequilibrium in the dynamic melting model are essentially constant. These results pose new problems for the petrogenesis of this lava suite. It is possible to propose a largely melting controlled model to explain the variations, by allowing an initial phase of equilibrium percolation before 'fractional' melt segregation. An outstanding dilemma for this mechanism is the correlation of major elements with highly incompatible trace elements, as changes in the major element characteristics of the melts should occur over a much wider melting interval than for the highly incompatible elements. Alternatively, the variations in major and incompatible element concentrations may be related to difference in the plume source itself. Whilst this makes a link to the long lived radiogenic isotopes simpler to explain, the extreme variations in incompatible element ratios would require rather short lifetimes for such heterogeneities within the plume. Furthermore, such variations in fertility might themselves be expected to produce systematic variations in U-Th disequilibrium.