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Temporal evolution of Sr isotopes in island arc rocks

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Island-arc magmatism is generated from melts of the subarc mantle that include contributions of elements derived from the depleted upper mantle and from fluids and melts derived from the downgoing subducting slab. These contributions are well known to affect both the chemical and isotopic composition of island-arc basalts, but the relative contributions to modern arc basalts remains debated. Sr concentrations and isotopes are important tracers of the contributions of various sources to island-arc basalts. Island-arc basalts are characterized by $^{87}Sr/^{86}Sr$ ratios that are elevated above values expected for melts of the depleted upper mantle [1]. For example, the well-constrained $^{87}Sr/^{86}Sr$ value for modern day MORB is 0.7026 [2], but modern-day island-arc basalts are >.7029 [1]. Additionally, elevations in $^{87}Sr/^{86}Sr$ vs. depleted upper mantle values have been reported for island-arc-related metabasaltic rocks of Proterozoic age, even in cases where post-eruptive seawater alteration, metamorphism, and contamination by continental material can be precluded [3]. However, a detailed temporal record of island-arc $^{87}Sr/^{86}Sr$ ratios has not existed to examine how addition of radiogenic Sr to the subarc mantle has or has not changed over geologic time. Such may help identify plausible sources of Sr to island-arcs.

To address this, we compiled $^{87}Sr/^{86}Sr$ ratios for relatively unaltered, uncontaminated, unmetamorphosed island-arc rocks aged 0-2500 Ma. We found that initial $^{87}Sr/^{86}Sr$ ratios in island-arcs are elevated relative to the depleted mantle curve throughout this interval and there is a notable rise in initial $^{87}Sr/^{86}Sr$ values in the Neoproterozoic, which coincides with an increase in seawater $^{87}Sr/^{86}Sr$ over the same interval. Most modern island-arc $^{87}Sr/^{86}Sr$ data can be explained by invoking a 15-40% contribution from seawater $^{87}Sr/^{86}Sr$. We find that such a range (15-40%) of seawater-derived Sr can explain ~80% of the island-arcs compiled. We interpret the observed temporal variation of island-arc Sr isotopes and close association with seawater $^{87}Sr/^{86}Sr$ to indicate that changes in marine geochemistry strongly influenced the Sr isotopic record of an important class of igneous rocks.

[1] Perfit et al (1980), Chemical Geology 30, 227-256.
[2] Salters & Stracke (2004), G^3 5, 1-27.
[3] Nelson & DePaolo (1984), Nature 312, 143-146.