Canonical trace element ratios in mantle melting – a revisit

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Canonical trace element ratios, discovered in the 80s by serendipity, were originally thought to constrain bulk-silicate-Earth (BSE) values of elements such as Rb, using the apparently uniform Ba/Rb ratios of global MORB and OIB. Later, it became clear that some of these "uniform", now widely called "canonical", ratios (e.g. Nb/U and Ce/Pb) differ dramatically between crustal and mantle-derived settings and cannot possibly represent BSE values. This meant that such ratios should be more useful as tracers of intra-oceanic (MORB, OIB) versus arc-type and continent-derived melts, opening the possibility of using them as tools in geodynamics.

However, several studies raised questions, partly based on statistical grounds, about the entire concept. More seriously, trace elements in several OIB groups deviate systematically from the canonical values, thus raising the question whether these should be interpreted as true exceptions or merely as a demonstration of circularity. Thus, OIB data may not offer a very good basis for defining canonical ratios in the first place.

To remove this circularily as well as other issues, I re-evaluate canonical ratios using recent, very high-quality datasets on MORB samples only. These data represent nearly global coverage, and they include both depleted and enriched samples, but exclude on-ridge OIB and back-arc samples. They span about two orders of magnitude of incompatible element concentrations, and the canonical ratios clearly reflect source ratios in much the same way as isotopoe ratios do. Improvements include a first-order correction for plagioclase fractionation on Ce/Pb ratios, an effect neglected in the original 1986 treatment. Remarkably, perhaps by coincidence, the "new", MORB-based canonical values for Ce/Pb and Nb/U are virtually identical to those published in 1986.

The well-constrained, MORB-based canonical trace element ratios can serve as a stable and, perhaps more important, independent basis for evaluating equivalent ratios in OIBs, which are more variable, not only in isotopically extreme OIB groups but also in more "ordinary" OIBs such as Iceland or Hawaii. When combined with isotope data, canonical ratios can thus provide a much richer picture of the nature of OIB sources than isotope ratios alone.