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Nb/Ta Variation in Ocean Plateau Basalts, Archaean to Present: The Mantle as a Reservoir of Continental Crust

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Conventionally, the Nb/Ta ratio has been considered to be uniform in ocean plateau, ocean island, and ocean ridge tholeiitic basalts, and close to the primitive mantle value of 17.6 (see Münker, 1998 for a summary). Recently, variations of the Nb/Ta ratio have been identified, specifically in arcs. Münker (1998) documented systematic high and low Nb/Ta trends about the primitive mantle value, due to fractionation by rutile-melt and rutile-fluid respectively. Upper continental crust has a Nb/Ta ratio of 14.3 as determined from GLOSS (Plank and Langmuir, 1998). In cratonic eclogite xenoliths, rutile dominates the budget of Nb and Ta, and has a geometric mean value of 24; accordingly, ocean crust processed through a subduction zone has Nb/Ta ratios greater than 17.6 and is complementary to the continental crust (Rudnick et al., 2000). We evaluate the range of Nb/Ta ratios in plume derived ocean plateau basalts of Archaean and Phanerozoic age to address the questions of lithosphere recycling into the mantle source of the plumes. The data are also used to constrain how the Archaean arc crust formed; by slab melt, slab dehydration - wedge melt, or both. Ocean plateau basalts in the 2.7 Ga Wawa sub-province are spatially and temporally associated with komatiites. The tholeiitic basalts are characterized by Mg# of 70 -34, have flat HREE patterns, La/Sm_n ranging from 0.6 to 1.4, and show continuous variations of increasing Fe, Th, Nb, REE, and Y with decreasing Mg#, Cr, and Ni. Nb contents vary from 2.06 to 7.0 ppm, Ta contents ranges from 0.14 to 0.49 ppm, and Nb/Ta ratios span 12.6 to 19.3 (Kerrich et al., 1999). Nb/Ta ratios do not covary with indices of fractional crystallization or alteration. There are no trends with Th/Yb and La/Yb as in the arc volcanics studied by Münker (1998). The Ontong Java and Broken Ridge plateau basalts are compositionally similar to their Archaean counterparts, and also show significant variations of Nb/Ta about 17.6 (Fig. 1). Values greater than 17.6 are interpreted as ocean lithosphere processed through a subduction zone and recycled into the deep mantle source of the plumes, whereas values <17.6 are continental lithosphere recycled by subduction-erosion, and sediment subduction. Consequently, ocean lithosphere recycled into the mantle, that resolves the mass imbalance in Earth for Nb, Ta, and possibly Ti, as discussed by McDonough (1991) and Rudnick et al (2000), must also balance continental crust recycled into the mantle. The results for Archaean plateau basalts signify that significant quantities of arc crust formed by slab-fluid induced melting generating arc magmas with Nb/Ta <17.6, as well as by slab melting that formed voluminous arc tonalites having varied Nb/Ta ratios. Accordingly, prior to eruption of the 2.7 Ga plateau basalts, there was 100's Ma of ocean spreading, arc formation, and recycling of arc lithosphere and ocean crust deep into the mantle sources of the plumes.

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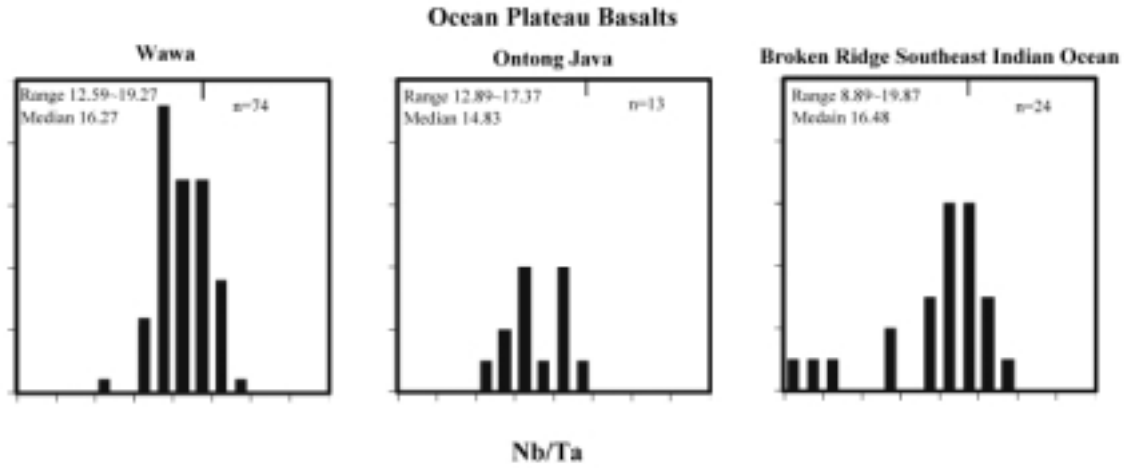

Fig. 1: Histograms of Nb/Ta for 2.7 Ga Wawa ocean plateau basalts, and the Ontong Java and Broken Ridge ocean plateaus (sources: Kerrich et al., 1999; Mahoney et al., 1993; Mahoney et al., 1995)