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Ontong Java Plateau lithosphere and its relation to craton formation

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While there is general agreement that the roots of cratons formed in Archean times, there has been considerable debate as to whether the very high-degrees of melt extraction accompanying their formation was accomplished via deep plume melting or shallow melting in subduction environments. Increasing geochemical evidence from cratonic peridotites now suggests a low-pressure melting origin, favoring the subduction-stacking model for craton formation. However, the plume model is also an attractive scenario in that it provides a straightforward explanation for the widespread occurrence of ultradeep diamonds. Hence the role of mantle plumes in the lithosphere formation remains an important issue to understand. A suite of mantle xenoliths from Malaita, Solomon Islands provides a rare opportunity to investigate how normal oceanic lithosphere was subsequently influenced by large-scale plume activity, because these peridotites were derived from beneath the most voluminous large igneous province on the Earth - the Ontong Java Plateau (OJP). Accumulated geological evidence suggests that the OJP lithosphere was created essentially in an oceanic environment at Jurassic-Cretaceous time and is not associated with any known subducting slab or subduction-related structures (e.g. accretion/stacking). Hence the characteristic features of the OJP peridotitic lithosphere may dominantly reflect plume-related lithosphere generation and hence can be used to test the plume hypothesis for cratonic mantle formation.

Principal thermal/compositional characteristics of the OJP lithosphere constrained from xenolith thermobarometry and geochemistry are clearly different from those of typical Archean cratons. The OJP lithosphere mainly comprises fertile lherzolites with subordinate clinopyroxene-bearing harzburgites (degree of melt extraction ~30%), with a thickness of only ~120 km. The thermal state is consistent with that expected for old oceanic lithosphere whose geothermal gradient is significantly higher than that of cratonic mantle. However, several features could be shared by other on- and off-craton continental lithosphere, for instance the occurrence of low-Cr megacrysts and two-groups of garnet pyroxenite (low- and high-Mg). The most salient feature of the OJP lithosphere is the marked stratification in lithological composition. Re-Os isotope studies of Malaita peridotite/pyroxenite xenoliths demonstrate that vertical Os isotopic variations correlate with compositional stratigraphy. The shallow lithosphere ($<$85 km) is dominated by fertile lherzolites showing a restricted range of $^{187}Os/^{188}Os$ (0.1222 to 0.1288), consistent with an origin from ~160 Ma Pacific lithosphere. The mid-section of lithosphere (85-95 km) is comprised of Os-depleted harzburgites interpreted as residues from plateau magma production. The basal section (95-120 km) shows strong heterogeneity in rock types, containing (1) refractory harzburgites with highly unradiogenic $^{187}Os/^{188}Os$ (0.1152 to 0.1196), which yield Proterozoic model ages of 0.9-1.7 Ga, and (2) low-Mg garnet pyroxenites with highly radiogenic $^{187}Os/^{188}Os$ ratios up to 5. From these observations, we propose that the OJP lithosphere forms a genetically unrelated two-layered structure, comprising shallower, typical oceanic lithosphere underpinned by deeper impinged plume material, which included a component of recycled Proterozoic mantle-crust section. The significance of this variability will be discussed in terms of observations from cratonic lithosphere.

Keywords: Ontong Java Plateau, lithosphere, craton, plume, peridotite