Sources of diamonds from Orapa, Botswana and evolution of the Kaapvaal-Zimbabwe cratons

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The sources of diamonds and their mineral inclusions provide an important constraint on the timing and scale of geologic processes occurring in mantle lithospheric keels and the delivery of fluids to the base of the lithospheric mantle. The 93 Myr old Type I Orapa kimberlite, erupted through the Mogondi Metamorphic Belt of the western Kaapvaal or Zimbabwe cratons, has exceptionally high diamond grade and contains gem-quality macrodiamonds, fibrous cuboid/coated diamonds, and polycrystalline diamonds. Sm-Nd ages on eclogitic silicate inclusions [1] and Re-Os on eclogitic sulfide inclusions in gem macrodiamonds (this study) give ages that range from Mesoproterozoic to Neoarchean - essentially in concert with diamond ages from the Jwaneng kimberlite in a similar geologic setting 370 km to the south [2]. Re-Os data for both Orapa and Jwaneng fall into four age clusters (1.0, 1.5, 2.0, and 2.9 Ga) of which 2.9 Ga and 2.0 Ga are the best represented. Since eclogitic compositions dominate the population, $^{187}Re/^{188}Os$ (5 to 600) and $^{187}Os/^{188}Os$ (0.72 to 9) are extremely high. Initial $^{187}Os/^{188}Os$, though imprecise, are also extemely high (0.65 to 1.1) and must derive from precursors with high Re/Os such as those with basaltic compositions. Such elevated initial Os isotopic compositions for sulfide inclusions are typical of other localites (e.g. [3] [4]) derived from craton edges.

An integrated model of diamond formation and craton evolution would have 2.9 Ga diamond formation result from micro-continent collision and westward-dipping subduction within the Kaapvaal-Zimbabwe craton system whereas at 2.0 Ga diamond formation results from eastward-dipping subduction placing sublithospheric Bushveld magmatism in a back-arc setting. Elevated initial Os isotopic compositions of sulfides likely record a prehistory in Archean-Proterozoic oceanic lithosphere that could be older by 300 Myr or more.

[1] Richardson et al. (1990) Nature **346** 54-56. [2] Richardson et al. (2004) Lithos **77** 143–154. [3] Aulbach et al. (2009) CMP **157** 525–540. [4] Smit et al. (2010) GCA **74** 3292–3306.