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Eclogitic and Ultrahigh-Pressure Crustal Garnets and Their Relationship to Phanerozoic Subduction Diamonds, Bingara Area, New England Fold Belt, Eastern Australia*

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Abstract

At Bingara-Copeton in the Phanerozoic New England fold belt, New South Wales, Australia, about two million diamonds were mined from Tertiary alluvial deposits that are more than 1,500 km distant from the nearest craton. The diamonds contain unique eclogitic inclusions, some of which gave Phanerozoic age dates and are unlike diamonds from ancient cratons. Few heavy minerals accompany the diamonds.

An exploration program of the modern drainage system and soils in the Bingara district was undertaken to search for a hard-rock diamond source. Eight prospects were identified by regional magnetic anomalies, and 118 samples were processed for heavy minerals. Five diamonds were recovered; two rounded macrodiamonds and three small diamonds that retain some delicate features. More importantly, abundant high pressure- (HP) and ultrahigh-pressure (UHP) metamorphic minerals also were recovered, particularly garnet. These were not derived from the low metamorphic grade country rock in the district.

Using the major element classification scheme of Schulze (2003) we separate Bingara garnets into "crustal" and "mantle-derived" groups and the following subgroups: eclogite (Group I diamond and Group II lower grade), peridotite (lherzolite), and Cr-poor megacrysts. Major element chemistry and rare earth element analysis of selected garnets identifies their deeply subducted protoliths, including midoceanic ridge basalt (MORB) and picrite, and arc-related basalt. We also define here a new subgroup of distinctive ultrahigh-pressure crustal (UHP-crustal) garnet from the crustal group above with almandine-spessartine compositions and enrichment in Na_2O and heavy rare earth elements. These compare with garnets from exhumed UHP schist and/or orthogneiss from Dabie Shan, central China, which formed from deeply subducted leucocratic continental crustal material, and also with rare garnet inclusions in diamonds from Sloan diatremes in Colorado and Wyoming and the Finsch kimberlite pipe, South Africa. Decompression microstructures, such as crystallographic exsolutions of rutile, apatite, or ilmenite in some eclogitic and Fe-Mn–enriched Bingara garnets, confirm their partial exhumation from mantle depth.

Garnet types and proportions vary significantly by prospect in the Bingara area, reflecting variations in assemblages sampled at depth by several local igneous sources. Garnets from Group I eclogite and one rounded (resorbed) white diamond (0.265 carat) were recovered near a composite basanite body dated at 181.5 ± 0.4 Ma. UHP-crustal garnets were recovered near the three small diamonds.

A conceptual model is presented for subduction formation of Bingara-Copeton diamonds, eclogitic, and UHP-crustal garnets in Carboniferous and Triassic slabs, and their two-stage delivery to the surface, first by partial exhumation, then by capture in local shallow-sourced basaltic magmas without deep-sourced kimberlitic or lamproitic volcanism. This two-stage delivery mechanism explains how diamonds may be sourced within buried UHP terranes, whereas in exposed UHP terranes macrocrystals of diamond are normally extremely rare, variously abundant but completely graphitized, or apparently never formed. This work has calibrated an exploration technique for locating sources of unusual subduction-formed diamonds in collisional tectonic settings using eclogitic and UHP-crustal garnet as an indicator mineral.

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