The Brockman Creek Kimberlite, East Pilbara, Australia

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The Brockman Creek kimberlite dyke was discovered in March, 1998 by De Beers Australia Exploration Limited (formerly Stockdale Prospecting Ltd.) during a regional reconnaissance program in the east Pilbara craton, Australia. The dyke is in fact annotated on the 1972 Geology map of the Marble Bar 1:250 000 sheet as a fault (Hickman & Lipple 1978). It strikes 080/260 degrees, and can be traced for about 20 kms (Fig. 1). Although offset in places, it is continuous and varies in width from approximately 12m to 1m. The strike of the dyke parallels other linear features, both mapped and evident in the magnetic data, and may have exploited D_2 deformation (Archaean) features traversing the length of the Pilbara Block. The main dyke is associated with several, but lesser parallel and sub-parallel dykes. The kimberlite intrudes the Corunna Downs granodiorite and adamellite batholith, through the Warrawoona greenstone belt, and the Mt. Edgar foliated granodiorites and adamellites. The dyke was probably emplaced along a pre-existing en-echelon fault system. It is highly silicified in places, especially on the margins, and has been affected by carbonate alteration. The country rock shows evidence of thermal metamorphism, and/or is metasomatically affected along some contacts. The dyke has a magnetic expression and is also observable in spectral data, which includes a significant MgOH and carbonate signature.

Petrography

Petrographically, the dyke is a macrocrystic, spinel and phlogopite bearing hypabyssal facies kimberlite with globular segregationary textures. Petrographic variations across the width of the dyke and along strike suggest multiple intrusive events.

Geochronology

$^{40}Ar/^{39}Ar$ dates obtained on two mica separates from hypabyssal facies kimberlite give an average of 1867±8 Ma. Two single mica grains extracted from a granite xenolith in the kimberlite give an $^{40}Ar/^{39}Ar$ age of 1809±8 Ma (White 2000). $^{87}Rb/^{86}Sr$ geochronology on phlogopite from hypabyssal kimberlite give an isochron age of 1917±360 Ma (White 2000). These dates are consistent with similar ages obtained for some of the Yilgarn kimberlites (Shee et al. 1999, White 2000), indicating that kimberlite events in the early to mid-Proterozoic are not uncommon. Apatite grains extracted from the granite xenolith referred to above give a mean fission track age of 257±19 Ma with a mean track length of 12.26 mm and standard deviation of 1.93 (White 2000).

Mineral Chemistry

The upper mantle mineral suite associated with the Brockman kimberlite is dominated by spinels that include chromites with high MgO contents and of diamond inclusion-type chemistries (Fig. 2). The kimberlite in some places along the length of the dyke, also contains peridotitic garnets with a significant sub-calcic population (Fig. 3). Both the sub-calcic garnet population and the high MgO spinels indicates that the lithosphere from which the kimberlite was derived was quite refractory in terms of its basaltic component, implying a harzburgitc composition. Ni-garnet geothermometry suggests a cool mantle geotherm at the time of intrusion of about 40 mW/m^2 (Fig. 4). A significant proportion of the garnets lie within the diamond stability field. Furthermore, Y, Zr, Ti and REE relationships of the garnets suggest a highly depleted (that is, MgO rich) lithospheric mantle. The kimberlite is diamondiferous, but so far has not been shown to be economic.

Discussion

It is noteworthy that the alluvial diamonds from Nullagine some 60 kms to the south (Fig. 1) are considered to ultimately derive from Proterozoic, or perhaps Archaean kimberlites, based on the presence of brown spotted diamonds and stratigraphic inferences. The mineral chemistry data indicate that the kimberlite had its origins within 'cold' lithospheric mantle, and that the lithosphere had, at least geochemical, completely stabilised in Pilbara by about 2.0 Ga. The apatite fission track age of 257 Ma however, is substantially younger than the emplacement age, and can be used to support, but not prove, a hypothesis that significant erosion may have taken place some time during the Phanerozoic. Thus, the east Pilbara craton in spite of a stable lithosphere, may not have remained isostatically stable since cratonisation and emplacement of the Brockman Creek kimberlite.

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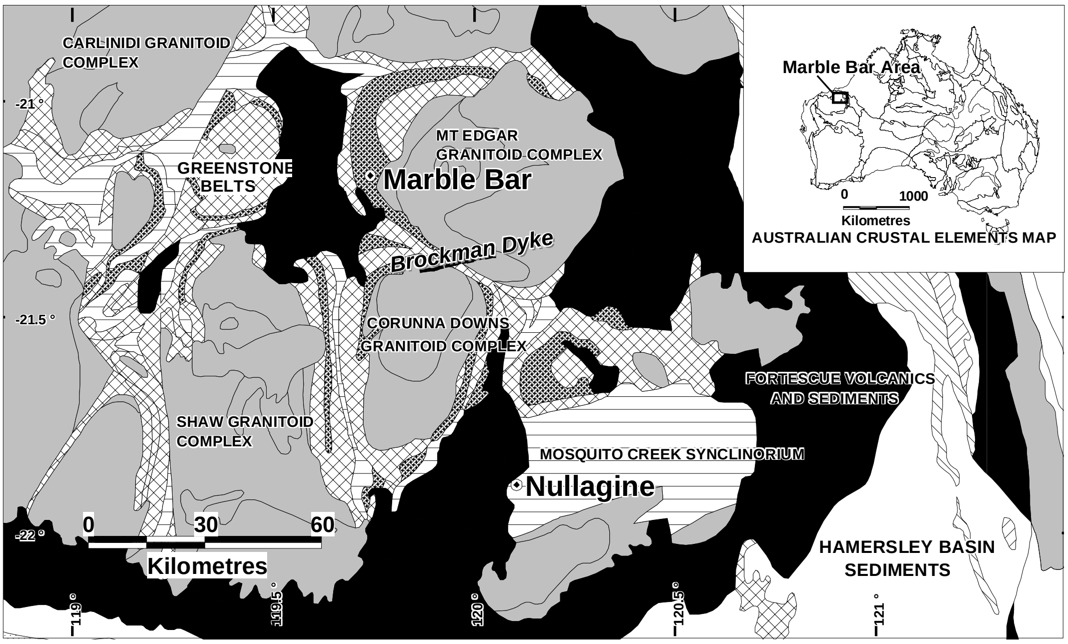
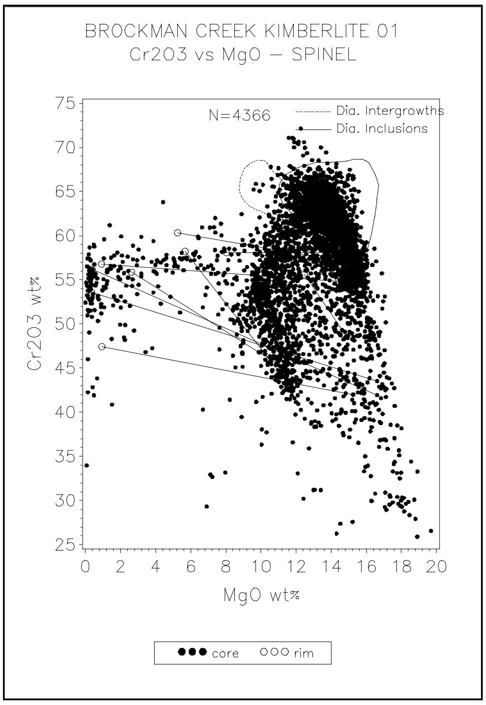


Figure 1. Location (119º 57.5'E, -21º 22.5' S) of Brockman Creek kimberlite in relation to generalised geology (after Meyers & Hocking, 1998, Geol. Surv. of West. Aust.) showing greenstone belts, Archaean granite complexes and late Archaean cover rocks.



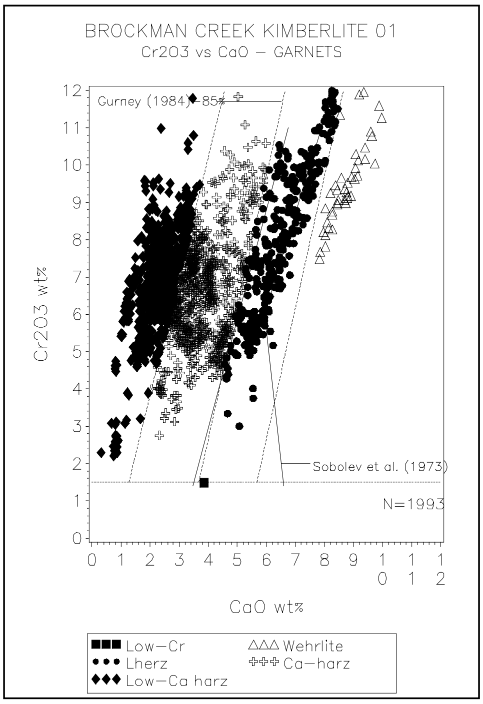


Figure 2. Note the abundance of high MgO and high Cr_2O_3 spinel in the diamond stability field suggesting A paragenesis within a depleted and harzburgitic mantle.
Figure 3. Similar to the spinels (Fig.2), the abundance of sub-calcic garnets is also indicative of an origin for these garnets from a depleted and harzburgitic mantle.

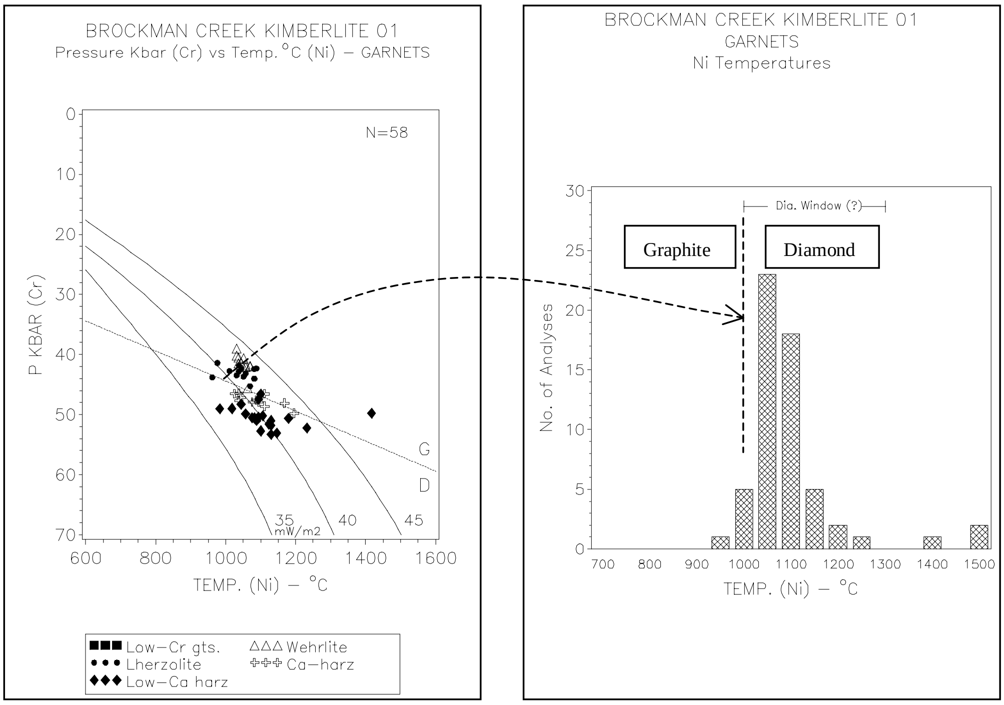


Figure 4. Temperature and pressures calculated from Ni and Cr in garnets (see Ryan et al.1996) extracted from concentrate grains. Geotherm reference curves from Pollack & Chapman (1997). The extent of the 'diamond window' is based on the intersection of the diamond-graphite curve with the inferred geotherm for the data set and the estimated base of the lithosphere.