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Kimberlites from Chicoria Creek, Juina, Brazil: Two broadly differing diamond and indicator mineral suites pointing to subduction and plate melting

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Introduction:

Juína area kimberlites carry a broad variety of mantle minerals, including diamonds with ultra-deep inclusions, as well as more common kimberlite indicator minerals (KIMs) Cr-pyrope garnets, eclogitic garnets, Mg-ilmenites, chromites and chrome diopsides (e.g. Hayman et al. 2004). The mantle sample varies broadly between kimberlites, which were reportedly emplaced over 15 million years during the Late Cretaceous (80.1 to 94.6 Ma; Nannini et al. 2017; Kaminsky et al. 2010).

Within the central Juina area, large diamonds up to 420 carats have been produced from a short (< 5 km) stretch of the Chicoria Creek drainage (Vantage internal records; Kaminsky et al. 2010). Vantage Brazil Minerals Ltd. has studied the diamond potential of kimberlites from Chicoria Creek, in two phases:

Phase1: Vantage sampled the Acuri-02 (7 microdiamonds/102 kg) and JV-40 (37 microdiamonds/67 kg) kimberlites for microdiamonds and kimberlite indicator minerals (KIMs) at CFM Laboratory in Kelowna B.C.

Phase 2: De Beers collected samples of the Acuri-01 (100 litres), Acuri-02 (300 litres), ADK-13 (100 litres) and JV-40 kimberlites (300 litres) for analysis of KIMs. These samples were not processed primarily for microdiamonds, but significant microdiamond counts were recovered by the SGS Laboratory in Brazil where concentrates were picked by hand.

As a result of Phase 1 (CFM) and Phase 2 (De Beers) exploration, Vantage has identified two very different types of mantle diamond sources from Chicoria Creek kimberlites:

1. **JV-40 TYPE** – Abundant **eclogite garnets** with compositions similar to most diamond inclusions *and* much higher (6x) abundance of microdiamonds. Possibly with higher quality diamonds, although more data needed.
2. **AC-02 TYPE** – Lacks **eclogite garnet**. Small scale garimpo has produced numerous very large diamonds up to 420 carats, some of very high quality.

Phase 2 (De Beers) exploration - Vantage Diamond's Chicoria Creek Property in Juina contains multiple kimberlites, four of which were sampled for De Beers.

The De Beers sampled kimberlites are JV-40 (19 microdiamonds), Acuri-01 (0 microdiamonds), Acuri-02 (4 microdiamonds), and ADK-13 (1 microdiamond). The samples were pan concentrated in the field, and then picked for kimberlite indicator grains (including the 24 diamonds) at the SGS lab in Brasilia. Indicators and diamonds were sent to De Beers' South Africa laboratories for electron microprobe, laser-ablation trace element ICP-MS and FTIR analyses.

A total of 16,935 microprobe analyses were reported to Vantage by De Beers, focused on pyrope garnets (both purple Cr-pyropes, and orange low-Cr eclogite), chromites, Mg-ilmenites, and Cr diopsides

We identify two broad types of mantle sources among the four sampled kimberlites, based on the microprobe data. The JV-40 type features diamond-associated eclogite garnet and chromite compositions, as well as lherzolite Cr-pyropes comparable to most garnet inclusions in diamonds from the Victor Diamond Mine in Canada (Fig. 1). MnO content of Cr-pyropes has been shown to be inversely related to temperature and depth of origin in the mantle (Grütter et al. 2006). Cr-pyropes from JV-40 split into an elevated TiO_2 population below MnO = 0.36%, and low TiO_2 population above MnO 0.36%, which is the approximate dividing line between diamond-bearing mantle below and non-diamondiferous mantle above (Fig, 1; Grütter et al. 2006). Trace element data also has notable enrichment in Ni, Sr, Hf, and Pr in the lower MnO split. This split in TiO_2 content supports different mantle rock types in diamondiferous and non-diamondiferous mantle sampled by JV-40. We speculate the more TiO_2-rich population may correlate to an eclogite-rich, diamondiferous subducting plate mantle source.

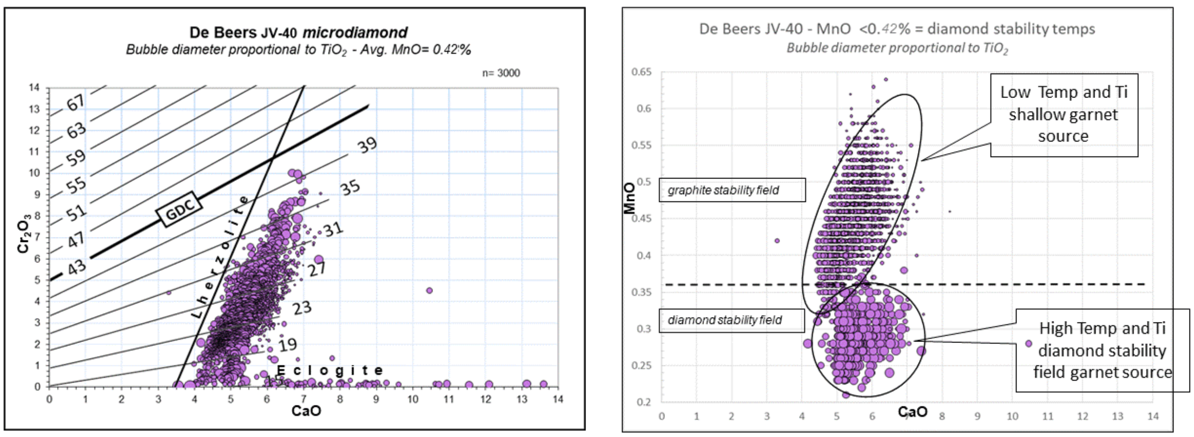

Figure 1: Garnets from kimberlite JV-40. Note abundant Cr-poor eclogite garnets, and lack of Cr-rich examples. Cr-pyropes with elevated MnO average 0.57%TiO_2 compared to shallower lower temperature field with just 0.16% TiO_2.

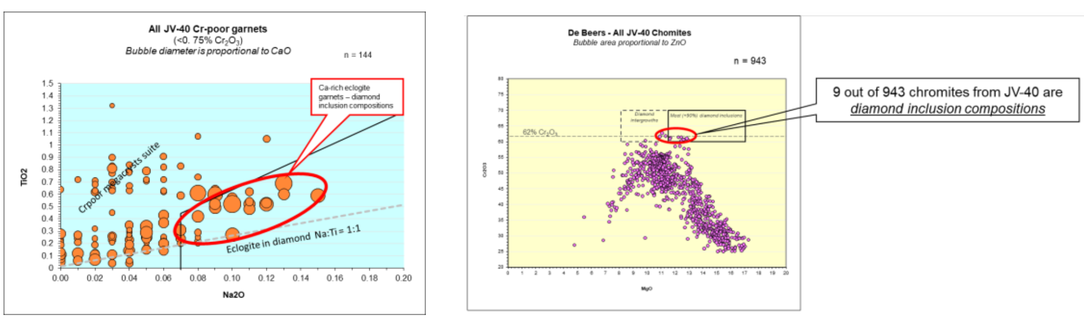

Figure 2: Abundant Cr-poor eclogite garnets from JV-40 with low TiO_2 and elevated Na_2O comparable to most eclogite inclusions in diamond (left), and chromites (right) with a small population of Cr- and Mg-rich examples potentially associated with diamonds (Cookenboo and Grütter 2010).

The second mantle source type of Chicoria Creek kimberlite (Acuri-02 type) lacks diamond-associated eclogite garnets (Fig. 2 and Fig. 4), and yields only a few potentially diamond-associated chromite compositions, although it has more G10 Cr-pyropes (low Cr and low Ca), as well as high Cr-pyropes that plot on the lherzolite trend from within the diamond stability field (Fig. 3). This source may be younger and associated with post-subduction heating of the lithosphere. Notably, this mantle type characterizes the Acuri-02 pipe (+6 ha.) which has sourced many very large diamonds (at least 30 diamonds between 12 and 420 carats) in small scale garimpo activities over 20 years.

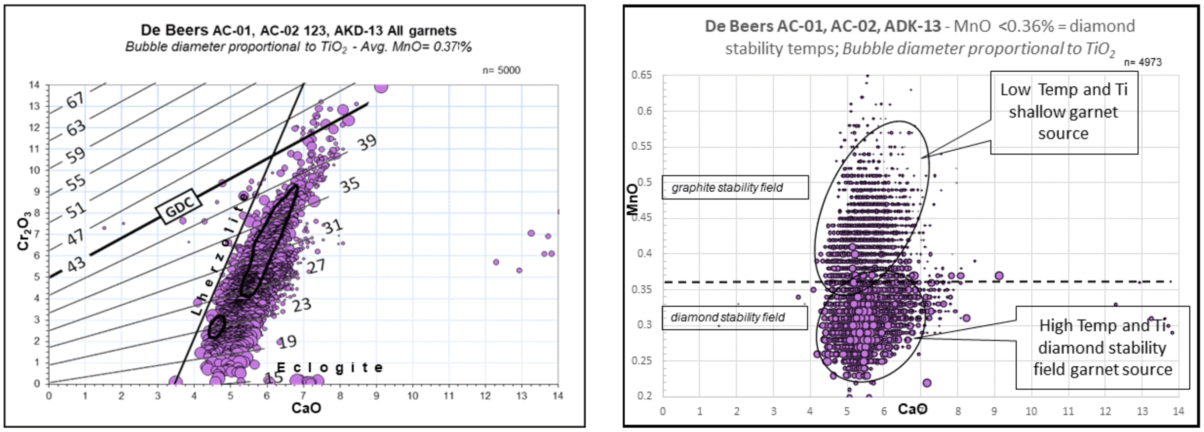

Figure 3: Garnets from kimberlite Acuri-01, Acuri-02 and ADK kimberlites. Note the dearth of Cr-poor eclogite garnets, and abundance of Cr-rich examples from the lherzolite trend as well as low Ca (G10s), including numerous that exceed the Graphite-Diamond-Constraint (GDC) line of Grütter et al. (2006, left), and the considerably less distinct split betwwen low MnO nd high MnO Cr-pyropes when compared to JV-40 above.

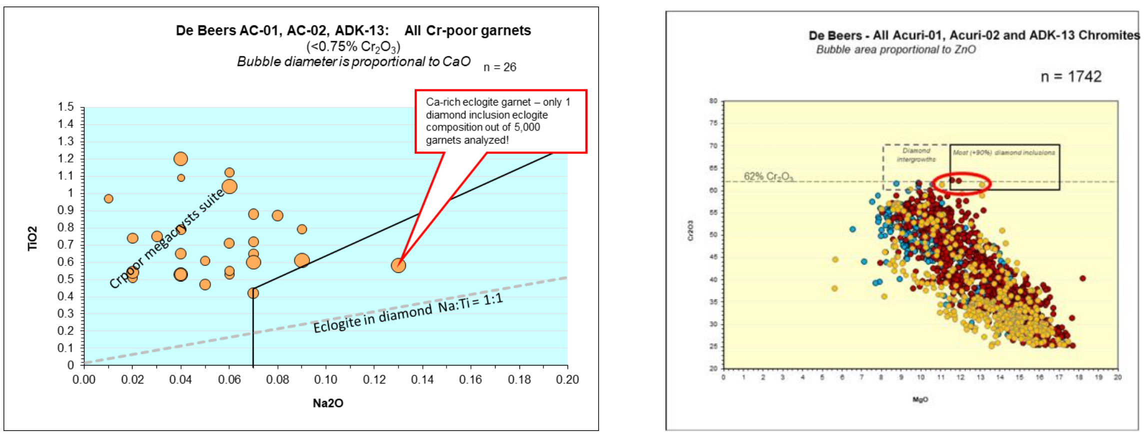

Figure 4: Cr-poor garnets from kimberlite Acuri-01, Acuri-02 and ADK13 kimberlites. Note the dearth of Cr-poor eclogite garnets (left) and Cr-rich chromites (right) when compared to JV-40 above.

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