LITHOSPHERE EVOLUTION IN RIFTED, CRATON AND MOBILE BELT ENVIRONMENTS FROM ZIMBABWE AND IMPLICATIONS FOR DIAMOND PROSPECTIVITY

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The diamond prospectivity of Zimbabwe is broken down into three major components with different tectonic settings. These are the stable Archaean craton, the Archaean to Proterozoic Limpopo belt and the Mesozoic rift basin of the Zambezi Valley (fig. 1).

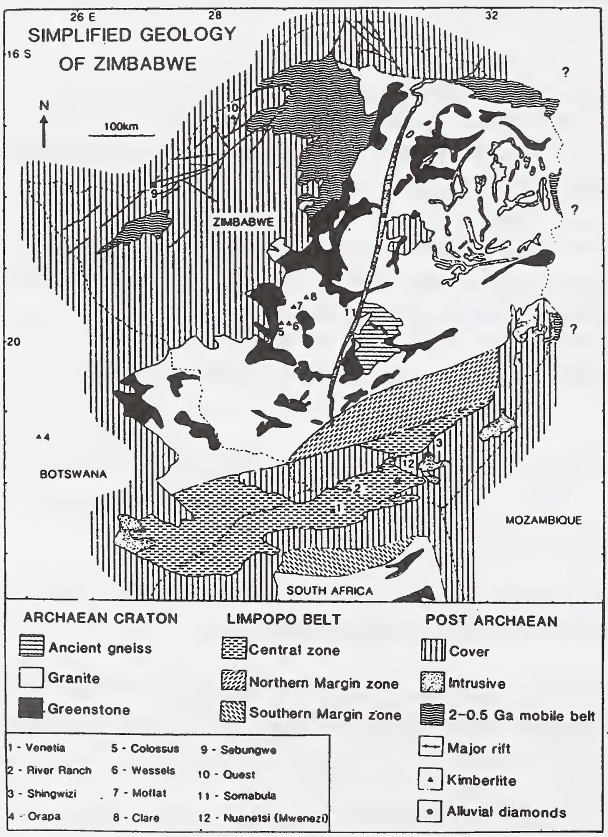

Fig. 1. Simplified geology of Zimbabwe and surrounding regions to the south and southwest, with emphasis on features relevant to mantle root formation and preservation, and showing kimberlites and diamondiferous gravel locations.

Geophysical information that provides clues about the present day lithosphere thickness beneath Zimbabwe comes from poor resolution data that suggests relatively fast shear wave velocities up to a depth of at least 200 km. These velocities are not as high as those under the Canadian, Baltic or Western Australian shields, but they are similar to those below the Kaapvaal craton. There is a general increase in velocity, suggesting a thicker mantle root, to the southwest. The three tectonic settings of the kimberlites appear to have similar shear wave velocities beneath them. (Fig. 2). A similar present day lithosphere thickness between the Archaean craton and the Limpopo belt would be consistent with other information. However, the Zambezi Valley also having a similar thickness would not. If this is not due to the poor resolution of the data, post-extensional mantle healing beneath the rift could explain the unexpectedly high velocities.

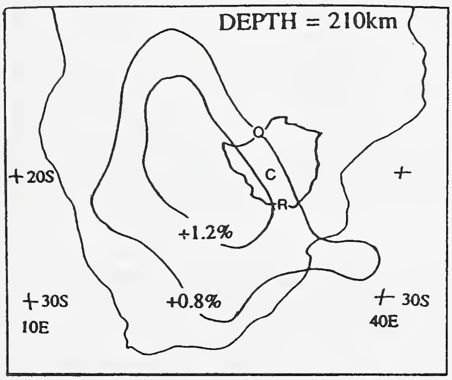

Fig. 2. Shear wave velocity variations at 210 km depth beneath southern Africa (Zhang and Tanimoto, 1993). The +0.8% and +1.2% contours of velocity variation from a global average of 4.40 km/sec are also shown. Note that variations at this depth beneath the Canadian and Baltic shields are up to around +3%. The geographical outline of Zimbabwe is shown. C = Colossus, R = River Ranch, Q = Quest.

Geotectonic considerations suggest that the Archaean craton should overlie a thick cool mantle root. This is confirmed by the presence of sub-economic quantities of diamond and co-genetic high pressure peridotitic garnets (fig. 3) in the kimberlites present within this setting. The composition of mantle megacryst minerals in these kimberlites confirm the presence of a deep lithospheric mantle root. On the basis of ilmenite compositions, redox conditions at the time of kimberlite emplacement (about 500 Ma) are more oxidising than is ideal for diamond preservation. Overall, the deep mantle root signature within the diamond stability field is only weakly developed.

The Limpopo belt was established by 2.7 Ga, and reactivated at about 2 Ga. Two relatively recently discovered kimberlites in the Limpopo belt (River Ranch and Venetia, fig. 1) of probably late Proterozoic age contain economic quantities of diamonds. The River Ranch kimberlite also has a strong mantle root signature, identified by the presence of garnets (fig. 3) and chromites derived from disaggregated diamond bearing harzburgites. An independent study (Kopylova et al., this volume) of inclusions in River Ranch diamonds has confirmed the association between these minerals and River Ranch diamonds. If the formation of the Limpopo belt is compared to modern collisional zones, convective removal of the mantle lithosphere in the later stages of development would be expected. This clearly has not occurred.

In the Zambezi Valley, no diamonds have been recovered from the known post-Triassic kimberlites and there is evidence in the mantle minerals recovered from these diatremes (e.g. fig. 3) that a deep mantle root is not preserved in this setting. This is consistent with the geotectonic prediction that rifting would have been associated with lithospheric thinning in this Mesozoic basin.

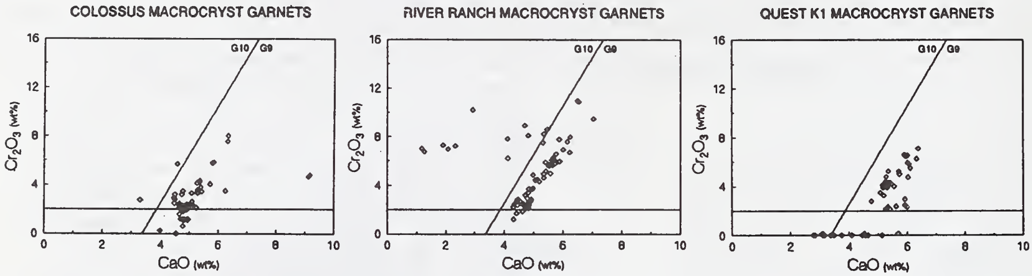

Fig. 3. Cr_2O_3 vs CaO diagrams for garnet macrocrysts from kimberlites considered representative of the Archaean craton (Colossus), Limpopo belt (River Ranch) and Zambezi Valley (Quest K1). Colossus has a few marginally subcalcic G10 garnets, indicating a thick mantle root with a low diamond potential. The River Ranch garnets suggest a thick, highly depleted mantle root with a good diamond potential. The Quest K1 garnets are all Ca saturated, and have a trend that is well to the right of the G9/G10 dividing line, indicating a thin mantle root with no peridotitic diamond potential.

Although the mantle lithosphere below the Archaean craton and Limpopo belt both extend into the diamond stability field, the latter is more depleted and diamond rich. It is possible that this resulted from some fundamental difference in the formation of the Archaean lithosphere associated with the two tectonic regions. This would question the validity of the presumption that the Northern Margin Zone of the Limpopo belt is simply the equivalent of the Zimbabwe craton granite greenstone terrain at higher metamorphic grades.

The evidence presented indicates that the Limpopo belt has very good diamond potential, the Archaean craton has some potential and the Zambezi Valley has no diamond potential.

Reference cited

Zhang, Y.-S., and Tanimoto, T. (1993) High resolution global upper mantle structure and plate tectonics. Journal of Geophysical Research, 98, 9793-9823.