Are Archaean provinces juxtaposed terranes? Isotope and trace element geochemical considerations

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The processes of formation of the early continental crust are still the subject of much interest and not yet well understood.

To test the lateral accretion model of de Wit *et al.* (1992) for the Archaean continent of southern Africa we studied metapelites and leucocratic gneisses from two of its provinces; the granulite facies Southern Marginal Zone (SMZ) from the Limpopo Belt and the adjacent greenschist to amphibolite facies northern Kaapvaal Craton (KC).

There is very little difference between tonalitic gneisses and metapelites in terms of their trace element and isotope characteristics, which indicates that the metapelites are partly derived from the gneisses.

Both provinces studied are characterised by a depletion of heat producing elements. The U-content of the rocks is generally below 1 ppm and even zircons contain only 100 ppm U. The metapelites are distinctly depleted in all incompatible elements, compared to the Early Archaean Upper Crust average of Condie (1993).

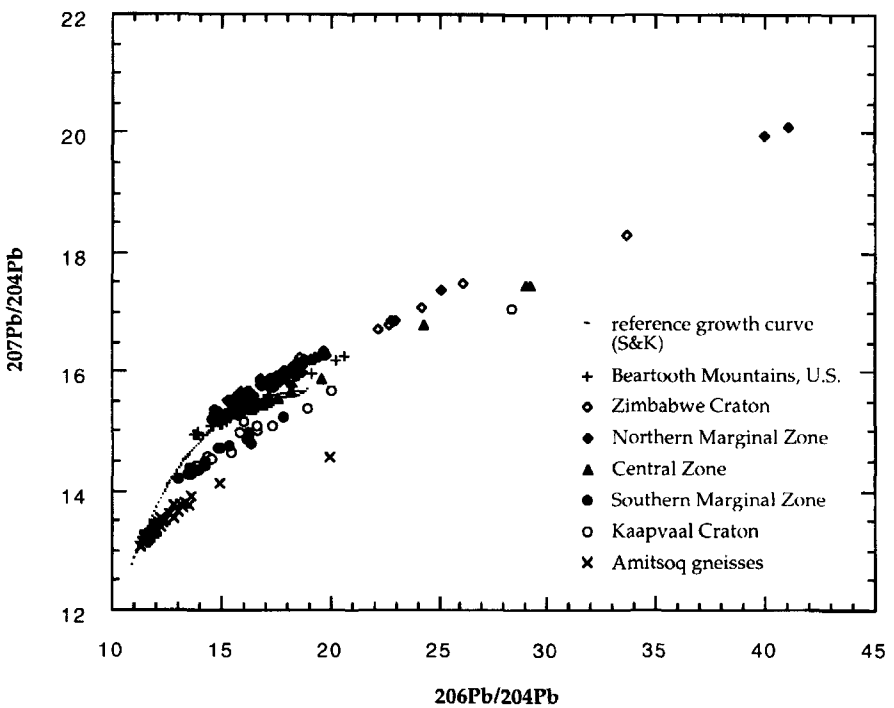

FIG. 1. Pb isotope data from the Zimbabwe Craton, from the Southern Marginal Zone of the Limpopo Belt and the northern part of the Kaapvaal Craton compared with those from the Northern Marginal Zone (Berger and Rollinson, 1997), the Central Zone (Chavagnac *et al.*, subm.) the Beartooth Mountains, Montana (Wooden and Mueller, 1988) and the Amitsoq gneisses, Greenland (Kamber and Moorbath, subm.).

The *REE*-patterns show a strong fractionation, less *HREE*-depletion for the metapelites than for the gneisses but never as extreme as for some Amitsoq gneiss-samples (O'Nions and Pankhurst, 1974). The metasediments of both provinces define a very narrow Nd model age range of 2.9–3.05 Ga which is the best estimate for the average crustal age of their cratonic source region. Somewhat larger variations of Nd model ages in the gneisses indicate some age heterogeneity within the crust, but the data from both terranes completely overlap. This conformity and the strong indication that SMZ and KC actually represent the same original crustal province is supported by the Pb-isotope data. Figure 1 shows a uranogenic lead diagram in which samples from all Limpopo-Zones, from the adjacent cratons (Zimbabwe and Kaapvaal Craton) as well as samples from the Beartooth Mountains and from the Amitsoq-gneisses are plotted for comparison. The uniform SMZ-KC-array is characterised by low $^{207}Pb/^{204}Pb$ ratios relative to their $^{206}Pb/^{204}Pb$. This contrasts clearly to the other samples, except the older Amisoq gneisses which display the most unradiogenic Pb-values known until now.

The similarities in trace, *REE* and isotope characteristics are remarkable and do not allow to distinguish the rocks of the SMZ from those of the KC. This supports earlier suggestions that the SMZ is part of the KC exposed at a deeper crustal level and contradicts a model involving separate terranes.

Low U-contents of some Archaean rocks have been interpreted as a result of U-mobilisation during granulite facies metamorphism. The overlap of the Th/U-ratios of the high grade SMZ and the low to middle grade KC samples on one hand and metapelites and gneisses on the other conflicts with this concept. In addition there are no correlations between U and Zr or U and Yb, which would allow the conclusion that either a low U/Pb crustal precursor or a U-depleted mantle have been existed for these Archaean provinces of southern Africa. No currently existing model can explain the observed features.

References

Berger, M. and Rollinson, H. (1997) *Geochim. Cosmochim. Acta*, **61**, 4809–29.

Condie, K.C. (1993) *Chem. Geol.*, **104**, 1–37.

O'Nions, R.K. and Pankhurst, R.J. (1974) *Earth Planet. Sci. Lett.*, **22**, 328–38.

De Wit, M.J. and 8 others, (1992) *Nature*, **357**, 553–62.

Wooden, J.L. and Mueller, P.A. (1988) *Earth Planet. Sci. Lett.*, **87**, 59–72.