Archean crust-mantle interaction in the northern Yilgarn Craton: Hf-isotope evidence

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U-Pb analysis of zircons by laser-ablation microprobe inductively coupled mass spectrometry (LAM-ICPMS) provides ages equivalent to those obtained by ion microprobe, with lower spatial resolution but rapidly and at lower unit cost, making it feasible to analyse large populations. Hf-isotope data on the same grains, analysed *in-situ* by LAM-multicollector (MC)-ICPMS (Griffin et al. 2000), provide information on the juvenile (mantle-derived) vs crustal origin of the host magma; this information is equivalent to that provided by whole-rock Sm-Nd systematics, but less susceptible to metamorphic disturbance. Trace-element data obtained by electron microprobe and LAM-ICPMS analysis on single grains of zircon can be used to estimate the composition of the host magma (Belousova 2000).

The application of these techniques to zircon concetrates from modern drainages provides information on the ages, sources (crustal vs mantle) and compositions of magmatic rocks in the catchment area. The combination of data types provides broad-scale information on crustal evolution. The patterns revealed by these integrated studies are "Event Signatures" that characterise specific episodes and sequences of magmatism; they are the fingerprints of the geological history of the crustal block.

This rapid and powerful technique for studying terrane-scale crustal evolution has been applied to drainage samples (ca. 500 zircons) along a traverse across the northern part of the Yilgarn craton and the adjacent Capricorn orogen. The data show marked differences between different domains, and help to define their tectonic and magmatic history. The age of different crustal segments can be evaluated both by zircon ages and by the Hf model ages of younger granitoids.

Results and Discussion

Eastern Goldfields province

In the Eastern Goldfields province (including samples from the Marymia inlier) there is no evidence for the existence of continental crust older than 2.9-3.0 Ga, and most of the magmatic rocks produced at 2.6-2.8 Ga ultimately were derived from a depleted mantle source (mean ε_{Hf} ca. +5; Fig. 1). If this source was located in the lower crust, it was remelted on a very short time scale (ca. 100 Ma). A sample from the Stanley sheet contains a large population of 500-600 Ma zircons of carbonatite-syenite-mafic affinities, derived both from the ca. 2.8 Ga crust and the depleted mantle. Champion & Sheraton (1997) found a gradient in ε_{Nd} in low-Ca granites across this province, indicating the presence of older crust at depth in the west. The lack of any obvious variation in ε_{Hf} values across the province in our data may reflect the broad scale of the sampling, and the lack of samples near the western edge of the province.

Yeelirrie domain (Southern Cross Province)

In the Yeelirrie province, U-Pb ages and Hf isotopes show that juvenile crust formed at 3.6-3.7 Ga and again at 3.3-3.4 Ga, and this older crust was reworked to produce granitoid magmas at 2.6 -2.8 Ga. In a sample from the southern part of area (Fig. 1) there is little evidence of juvenile contribution to the crust during the major 2.6-2.8 Ga magmatism (mean ε_{Hf} <-10), whereas some depleted-mantle contribution is apparent in the northern part of the province (ε_{Hf} –10 to +7; Fig. 1). The overall low ε_{Hf} in this domain is consistent with the low ε_{Nd} values reported in low-Ca and high-HFSE granitoids in the same area by Champion & Sheraton (1997).

Southern Cross domain (Southern Cross Province)

The two samples in the Southern Cross province are dominated by zircons from 2.75 Ga granitoids, which have a strong juvenile component (ε_{Hf} +3 to +5); there is little evidence of older crust.

Murchison province

In the Murchison province, juvenile crust formed at least by 3.3-3.5 Ga; this older crust was reworked at 2.6-2.8 Ga, but significant juvenile material was also added during this time (mean ε_{Hf} ca 0).

Narryer province

In the Narryer province, the oldest zircons in our samples are ca 3.1 Ga old, but low ε_{Hf} values for granitoids extending from 3.0-2.0 Ga indicate the presence of crustal sources as old as 3.5 Ga, consistent with the well-known existence of ancient zircons in sedimentary rocks from this province. Granitoids younger than ca 2.7 Ga were derived mainly by crustal reworking.

Capricorn orogen

Available data on Capricorn-orogen magmatism at ca 2.2 Ga and 1.8 Ga suggest that this magmatism did not involve the generation of new crust (ε_{Hf} <0).

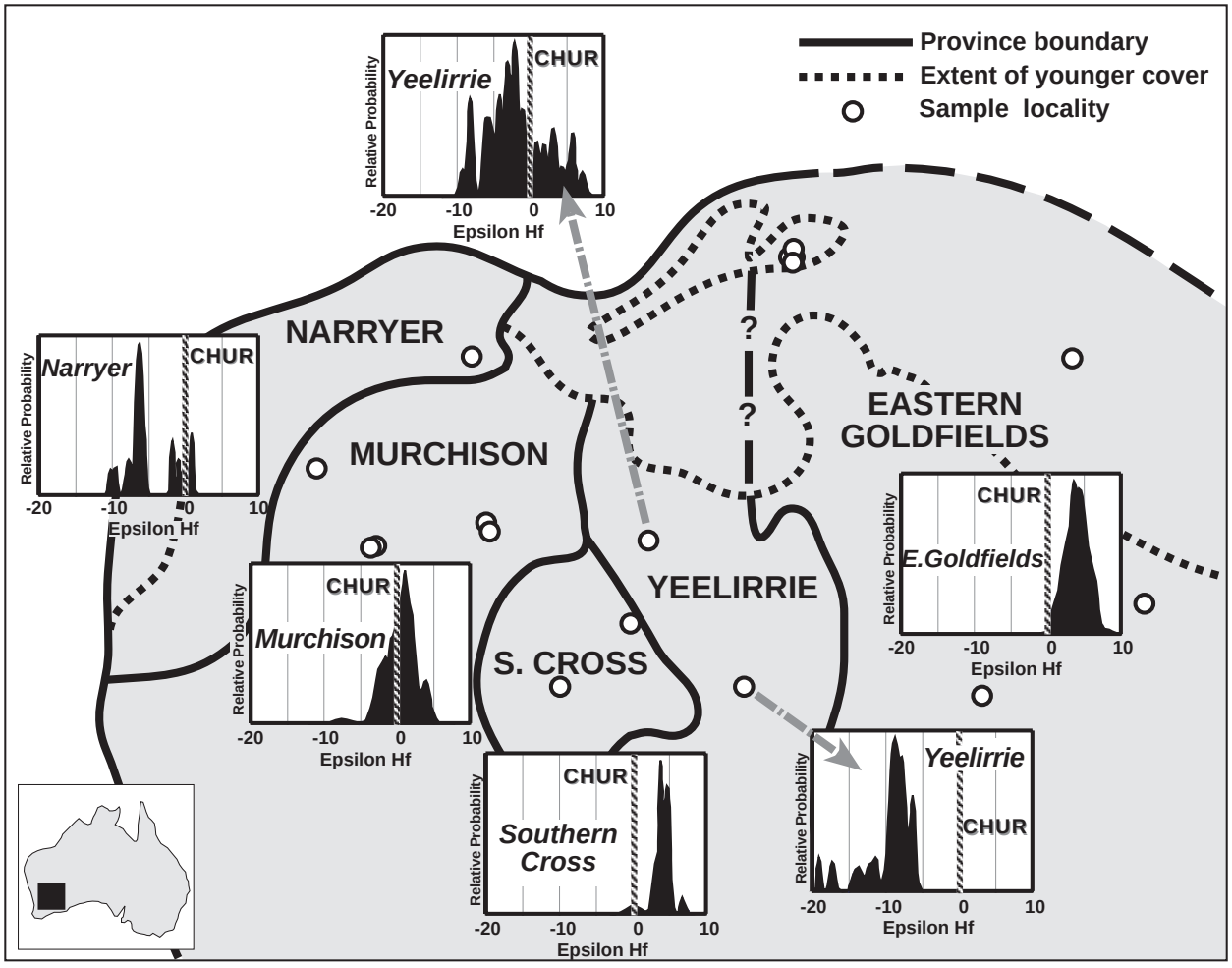

Figure 1. Cumulative-probability plots of ε_{Hf} for 307 detrital zircons with U-Pb ages of 2.6-2.8 Ga, superimposed on a sketch of the northern Yilgarn craton with the province/domain boundaries of Whitaker (this conference). CHUR line in each plot represents the Hf-isotope composition of the chondritic mantle at 2.6 Ga. Negative ε_{Hf} values indicate derivaton of magmas from old crust, whereas positive values imply derivation from depleted-mantle sources, and the addition of juvenile material to the crust. The lack of negative ε_{Hf} values in the 2.6-2.8 Ga magmatic rocks of the Eastern Goldfield province and Southern Cross domain indicates that these blocks contain little, if any, crust older than ca 3 Ga.

Conclusions

The zircon data suggest that the Yeelirrie and Murchison-Narryer Provinces represent old continental fragments, sandwiched between the juvenile terranes of the Southern Cross and Eastern Goldfields provinces (Fig. 1). The data also suggest that the presence of older crust strongly influenced the nature of crust-mantle interaction during the 2.6-2.8 Ga assembly of the craton and the accompanying major magmatism. Where thick older crust was present, the 2.6-2.8 Ga granitoids were produced largely by remelting, and little juvenile material reached the upper levels of the crust. These differences in the style of crust-mantle interaction correlate strongly with known mineral potential.

References

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