

Age of FS66 Kimberlite Beneath Murray Basin, South Australia: Laser Ablation ICP-MS Dating of Kimberlitic Zircon, Perovskite, and Rutile

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Grains of zircon, perovskite and rutile (0.3-1.0mm in size) have been recovered from a deeply buried kimberlite in South Australia. U-Pb ages of these grains have been determined using *in situ* LAM-ICPMS techniques at GEMOC, Macquarie University, Sydney. The kimberlitic pipe, designated FS66, is located 10.6 kilometres NNW of the town of Blanchetown along the Murray River, beneath 214 metres of Tertiary Murray Basin sediments. Another similar intrusion, designated FS3, is located nearby (Fig. 1). While described as breccia kimberlite (Lewis, 1985), the recovery of sample was limited to only very fine drill chips, with most minerals replaced by secondary carbonate and clays.

for the perovskite analysis, and the accuracy of the methodology have been demonstrated by Batumike *et al.*, (2007). Here we show that an analogous methodology can also be applied to rutile. All zircon and perovskite grains produced similar ²⁰⁶Pb/²³⁸U ages within analytical uncertainty (Fig. 2). The weighted mean age of the FS66 zircon age is 179±2 Ma (n=10, Fig. 3). The perovskites contain significant initial Pb, and the scatter in the data suggests that there is some heterogeneity in the isotopic composition of the initial Pb. On the inverse-Concordia plot (Fig. 4) the mean lower intercept age is 181±16 Ma (n=74). We accept the more precise zircon age as the emplacement age of the kimberlite. A single kimberlitic Nb, Cr-rich rutile gave a weighted mean Concordia age of 197±6 Ma (5 analyses) suggesting that it is a mantle-derived xenocryst (Fig. 5). The kimberlite has a strong positive-polarity magnetic anomaly, which is consistent with the normal (positive) paleomagnetic polarity for the period 180-179 Ma (Jones *et al.*, 2001) matching the zircon age.

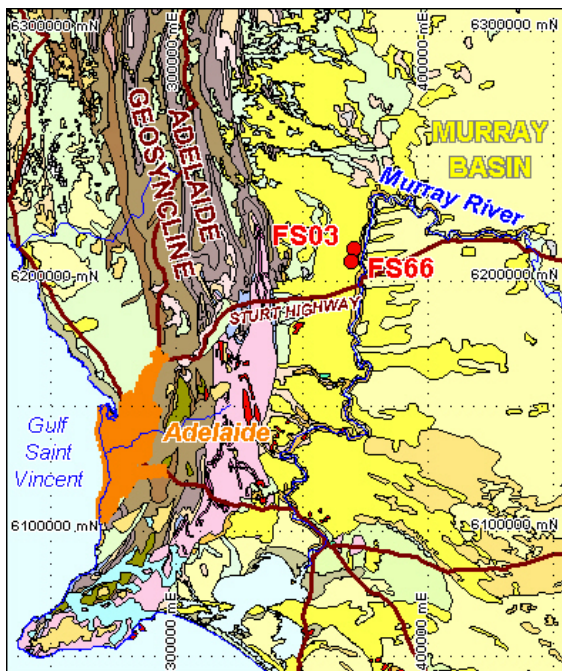


Figure 1. Location map of FS66 and FS03 kimberlitic pipes.

This is the first reported dating of zircon, perovskite and rutile from the same kimberlitic body. All analyses were performed using the laser ablation ICP-MS technique. The validity of using a zircon standard

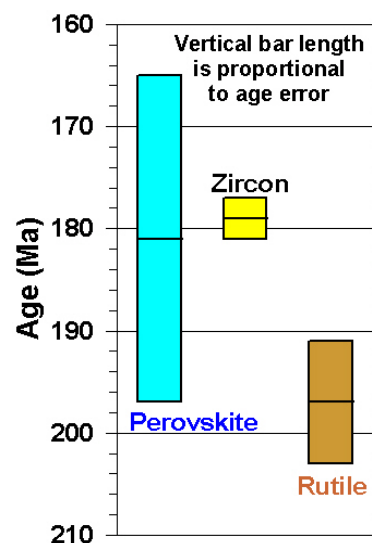


Figure 2. Ages of perovskite, zircon, and rutile from FS66 measured by LAM-ICPMS.

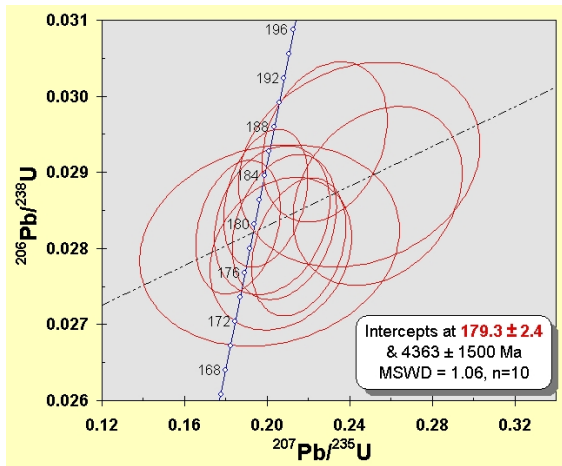


Figure 3. Concordia plot for FS66 zircons.

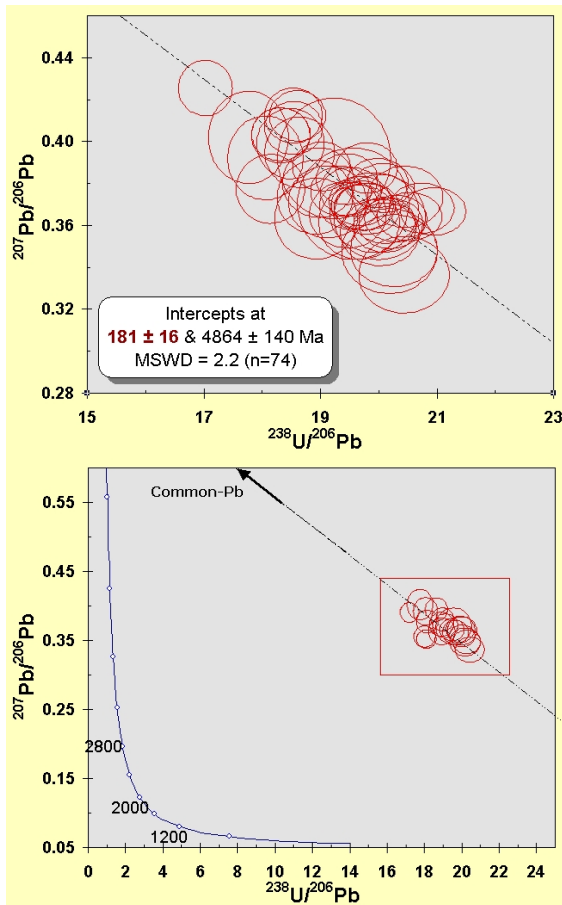


Figure 4. Inverse-Concordia plot for FS66 perovskites, all analyses (n=80). The intercepts of the regression line diagram provide both an estimate of the $^{207}\text{Pb}/^{206}\text{Pb}$ of the initial-Pb component (upper intercept) and the inferred crystallisation age (lower intercept).

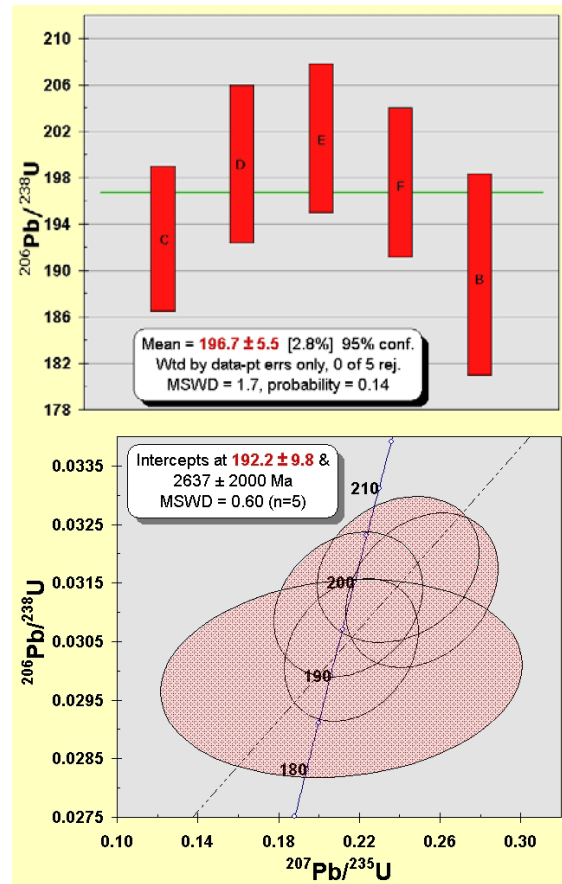


Figure 5. Weighted mean $^{206}\text{Pb}/^{238}\text{U}$ age and Concordia plot for FS66 rutile.

Gaul (1993) determined a minimum temperature of 1100°C at the base of the lithosphere based on garnets from FS66 and FS3, and concluded that the lithospheric mantle volume sampled by the intrusions was not in the diamond stability field; this is consistent with the lack of microdiamonds in the drill samples (Lewis, 1985). Additional trace element work on recovered pyropes and chromites now improves this local lithospheric section. The maximum temperature of the rutile calculated from the Zr thermometer (Zack *et al.*, 2004) is 1150°C . This is slightly higher than the $900\text{--}1100^{\circ}\text{C}$ and 20-30 kb range suggested for the stability of Cr-Nb-rutile formed by the reaction of peridotite with metasomatic fluids (Haggerty, 1983). The dated rutile grain has a fine lamellar intergrowth pattern of ilmenite (Fig. 6) and is distinguished from rutile in MARID xenoliths by high Cr values. The large phenocrysts of perovskite suggest an evolved kimberlitic intrusion. Perovskite REE patterns show strong LREE enrichment (Fig. 7).

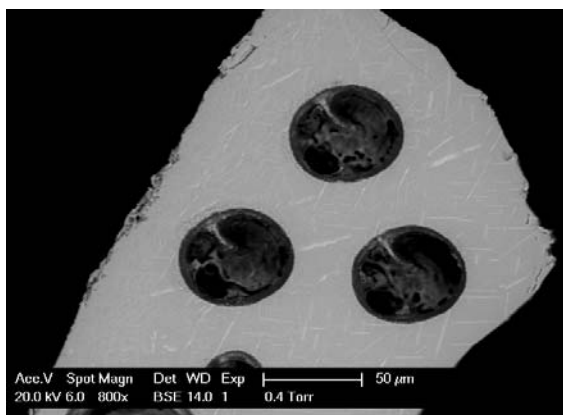


Figure 6. Backscatter image of rutile grain showing fine lamellar intergrowth and laser ablation spots used for dating,

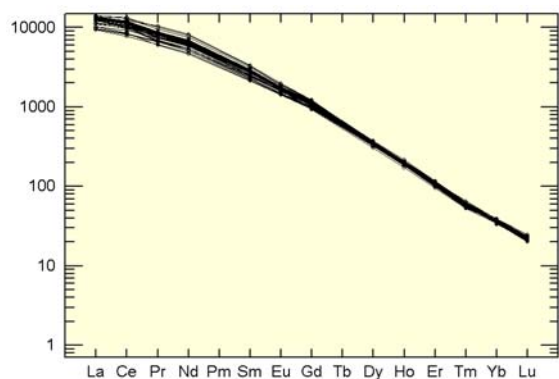


Figure 7. Chondrite-normalised REE plot for FS66 perovskites.

Trace element studies (Yao, 1999; Belousova *et al.*, 2002) of the chromites and zircons indicate that they are kimberlitic in nature, but no whole rock analyses are available to confirm the lithology. Sr and Nd isotopes in the perovskite, and Lu-Hf isotopes in the zircons and rutile constrain the composition and origin of the lithospheric mantle, and the sources of the kimberlitic intrusion. The initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios are 0.70417 ± 0.00004 (2sd) and $^{143}\text{Nd}/^{144}\text{Nd}$ ratios are 0.51274 ± 0.00007 (2sd) for perovskite. The isotopic data for FS66 perovskite plot in the depleted quadrant on a Nd-Sr isotope diagram, and are close to those of many Jurassic-Cretaceous kimberlites.

References

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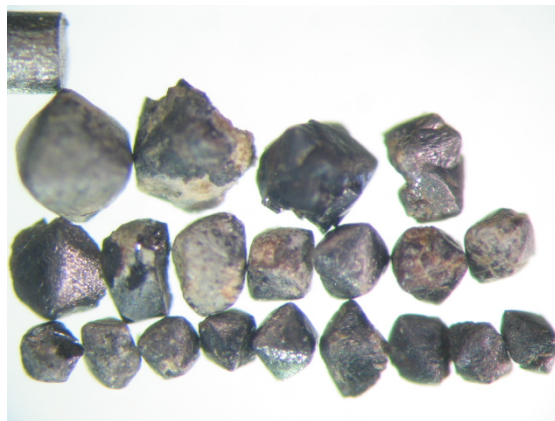


Figure 8. Perovskite from FS66 drillhole, scale (top left) is 0.5mm wide.