Nano-geochronology?

R. A. STERN[1,2] , I.R. FLETCHER[2,3], B.RASMUSSEN[3], N.J.MCNAUGHTON[3] AND B. DE WAELE[4]

[1] Geoscience Australia, Box 378, Canberra, ACT 2601, Australia; richard.stern@ga.gov.au
[2] Centre for Microscopy and Microanalysis, The University of Western Australia (UWA), 35 Stirling Hwy, Crawley, WA 6009 Australia; ifletche@cyllene.uwa.edu.au
[3] School of Earth and Geographical Sciences, UWA; brasmuss@cyllene.uwa.edu.au, nmcnaugh@cyllene.uwa.edu.au
[4] Tectonics Special Research Centre, UWA; info@bdewaele.be

U–Pb dating at the sub-µm scale would be a powerful complement to advances in geochemical analysis at high spatial resolution. Small minerals and those with fine growth structures are becoming increasingly important in studying geodynamics and economic mineralization, and the behaviour of Pb atoms could be studied more closely to understand properties such as diffusion.

Nanometer-scale dating is possible using ion probe depth profiling, applicable in cases where sheet-like domains can be exposed on, and lying parallel with, a surface. A 100 nm deep x 20 µm diameter cylinder of zircon excavated during a depth profiling interval has a mass sufficient for current large-radius ion probes to achieve useful analytical precision in $^{207}Pb/^{206}Pb$ (~±1%) for >1000 Ma samples with 200 ppm U.

Achieving sub-µm *lateral* resolution with oxygen-ion probes is a more difficult technical problem. It is currently possible with the Cameca NanoSIMS 50, but the corresponding primary ion densities are impractical for most geochronology. Even if probe performance and secondary ion yields could be improved, precision for $^{207}Pb/^{206}Pb$ would be acceptable only for the most favourable minerals. For example, a 100 nm x 100 nm cylinder excavated from a 1.8 Ga uraninite (~7 fg) contains ~4 x 10^5 ^{207}Pb atoms, and if the useful ion yield is 1%, the best precision possible for $^{207}Pb/^{206}Pb$ ratios would be ~ ±2%. For the same age zircon with 200 ppm U and identical analytical constraints, only 1 atom of ^{207}Pb could be detected.

We have been pushing the spatial boundaries of typical ion probe U–Pb dating using the NanoSIMS 50 and SHRIMP II ion microprobes. The goal is to fully exploit the potential of *in situ* dating of small (typically <20 µm) U-rich minerals such as monazite, xenotime, and zirconolite. Application areas include dating of metamorphism, diagenesis, hydrothermal alteration, and mafic magmatism. The use of 3-10 µm-diameter oxygen probes is feasible, although difficult in practice. We hope that technological improvements in the coming years will permit analyses at a lateral resolution closer to 1 µm. It's not nanogeochronology, but a significant change of scale.