Dating monazite at the nanoscale with atom probe tomography

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Monazite ($REEPO_4$) is a widely used U-Th-Pb chronometer in the geosciences (*1*). Monazite crystals often have micrometre to sub-micrometre textures which develop during (re)crystallisation, metamorphism, alteration, or deformation. However, resolving the timing of such small features can be challenging using conventional dating techniques. Atom probe tomography is the highest spatial resolution technique capable of isotopic measurements, and provides the opportunity to date monazite at an unprecedented scale (*2*). The analytical volume for atom probe data is typically <0.008 μm^3, compared to a volume of >50 μm^3 for secondary ion mass spectrometry analyses. In this contribution, we analyse monazite reference materials in order to define a protocol for $^{208}Pb/^{232}Th$ dating of monazite crystals by atom probe tomography. We observe a instrumental fractionation between Th and Pb which can be corrected using a linear regression fit between the $^{208}Pb/^{232}Th$ fractionation coefficient and instrument parameters. The fractionation correction results in acurate ages with a 15 to 20% uncertainty for individual analyses. Nonetheless, the approach provides the possibility of obtaining $^{208}Pb/^{232}Th$ ages with sufficient precision to address geological questions on a sub-100 nanometre scale.

1. R. R. Parrish, U-Pb dating of monazite and its application to geological problems. *Canadian Journal of Earth Sciences* **27**, 1431-1450 (1990).
2. D. Fougerouse *et al.*, Nanoscale distribution of Pb in monazite revealed by atom probe microscopy. *Chemical Geology* **479**, 251-258 (2018).