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## Geological Applications of Atom Probe Tomography

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Atom probe tomography (APT) makes it possible to study the 3-dimensional compositional structure of geological materials at the nanoscale [1,2]. This type of information has not heretofore been available. For a typical sample of approximate dimensions 100nm x 100nm x 500nm the Atom Probe will map, in 3 dimensions, the location of each atom detected to a resolution of the order of 0.3nm, labelling each by element and isotope. The dataset from a typical Atom Probe Tomography experiment might consist of tens or even hundreds of millions of such atoms, so delivering the data for subsequent 3D compositional nanostructure analysis.

We outline the 3D sub-nm compositional analysis capabilities of Atom Probe, with a brief overview of the technical method, together with sample preparation techniques. This is followed by a brief outline of the powerful 3D compositional analysis means, such as “proxigram” and 3D concentration contouring.

We then show recent APT data[1,2] by John W. Valley et al and Aaron J. Cavosie[3] et al so measured from lunar and terrestrial zircons of different ages. The resulting data show clusters of ~10nm – 20nm size, spaced apart by some tens of nm.

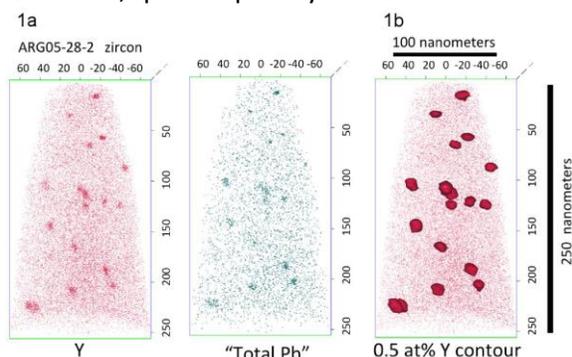


Figure 1 a) Atom maps of Y and Pb in 2.5 Ga Zrc-2. b) Isoconcentration surface for Y in Figure 1a

The 3 dimensional structure on the nanoscale so derived was used to argue[1,2,3] that the early earth was cool and could have supported life processes as early as 4.3 Ga (billion years ago), 800 myr before the oldest known microfossil evidence<sup>2</sup>.

Figure 2 a) Atom maps of Y and Pb in 2.5 Ga Zrc-2. b) Isoconcentration surface for Y in Figure 1a

These are 2D slices (selections) from the 3D map

Hills[1,2]: Zrc-4: 4.35 Ga, Apollo 14, Moon[5].

The samples study within this sample include Zrc-1: 4.007 Ga, Jack Hills, W. Australia[2,3]: Zrc-2: 2.542 Ga core, 29 Ma rim; Grouse Creek Mts., Utah[2,3]: Zrc-3: 4.374 Ga core, 3.4 Ga rim; Jack

These examples show how Atom Probe Tomography offers a powerful and unique extension of the scale of such 3D nanoscale compositional analysis for rocks which has not hitherto been available.

References:

- [1] JW Valley et al. (2014) *Nature Geoscience* 7, 219-223.
- [2] JW Valley et al. (2015) *American Mineralogist* 100, 1355-1377. Open access: DOI: <http://dx.doi.org/10.2138/am-2015-5134>
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- [4] A Strickland et al. (2011) *American Journal of Science* 311, 261-314.
- [5] TB Blum et al. (2014) *Amer. Geophysical Union*, fall meeting abstr. V34A-06

