Applications of Atom Probe Tomography in Geological Science

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Atom probe tomography (APT) [1] has proven to be valuable for characterization of a range of materials types. The classes of materials that can be studied with APT has been broadening markedly since the introduction of modern laser pulsing to APT instruments about 2005 [2,3]. Whereas simple materials like metal alloys and silicon structures were the earliest candidates for study, materials of ever-increasing complexity have been the object of APT analyses since that time. Compound semiconductors such as GaAs, GaN, InGaN quantum wells [4], CdTe solar cells [5], and oxide semiconductors such as ZnO and AlZnO, and InSnO have been studied. Synthetic ceramics, including SiO_2, CrO_2, FeO, and Al_2O_3, have been studied in the past six years [1 cites many of these].

These efforts clearly suggest feasiblity for analyses of geological materials but it was not until the past two years that actual efforts were initiated. This presentation will provide an overview of the basic operating principles of APT, and the process by which data are collected and analyzed. It will then examine the unique strenghts and the limitations of APT for geological analysis. These include sub-nanometer compositional mapping, isotopic sensitivity, and high analytical sensitivity (<10 ppm). Some of the recent example applications include:

- Zircon geochronology where U/Pb isotope dating has been shown to agree very well with SIMS data and nanoscale microstructural features have geatly enhanced the understanding of the material's history [6]
- Magnetite and hydroxyapatite minerals as models for biominerals [7]

Other examples will be shown to highlight the types of information that can be obtained from APT.

[1] Kelly and Larson, *Ann. Rev. Mat. Sci.* (2012) **42**, 1-31 [2] Gault et al., *Rev. Sci. Instrum.* (2006) **77**:043705 [3] Bunton *et al Microsc. Microanal.* (2007) **13**:418-27 [4] Choi *et al Microsc. Today*, (2012) **20(3)**, 18–24 [5] Larson *et al Micros. Microanal.* (2012) **18**, 928-929 [6] Valley *et al Nature Geoscience* (2014) accepted. [7] L. Gordon, Ph.D. thesis Northwestern University (2014).