EXSOLUTION IN FELDSPAR IN THE TUXTUAC (LL5) CHONDRITE: A NEW PERSPECTIVE ON COOLING RATES FOR METAMORPHOSED CHONDRITES.

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Introduction: Petrologic type 4-6 ordinary chondrites have undergone metamorphism on their parent bodies. There are currently few means to obtain quantitative estimates of peak temperatures and cooling rates for this process. We recently observed possible exsolution of K-feldspar in albitic plagioclase in the LL5 chondrite Tuxtuac [1], and in L5 Roy (1933) [2]. Since exsolution microstructures can potentially be used as cooling rate indicators, we have studied this feature further using transmission electron microscopy (TEM).

Methods: We obtained quantitative WDS analyses of feldspar using EPMA. A TEM sample was extracted from a feldspar grain in Tuxtuac using focused ion beam (FIB) extraction techniques, and was characterized on a JEOL 2010 200 kV TEM.

Results: Exsolution in albitic feldspar occurs in several relict chondrules in a thin section of Tuxtuac [1]. Textures vary from grains that are predominantly albitic with very fine-scale (sub-μm) K-rich (sub)parallel lamellae, to regions of grains that contain approximately equal amounts of coarser (up to 10 μm) intergrown albite and K-feldspar. EPMA analyses give compositions of $An_9Ab_{89}Or_2$ and $An_3Ab_{18}Or_{79}$ for the two phases, measured in coarse-grained areas with a 5 μm electron beam [1].

We selected a grain with fine-scale (sub-μm) K-rich lamellae, and cut a FIB section perpendicular to the length of the lamellae. The section shows an exsolution texture of K-feldspar lenses in host albite: albite has albite twinning with individual twin widths of 100-160 nm. The section intersects several K-feldspar lenses, which have maximum widths of 90 nm up to ~0.5 μm. K-feldspar lamellae also contain albite twins. In addition, some local regions within the albite have very fine-scale K-feldspar lamellae that are just a few nanometers in thickness and occur on a wavelength of 60-90 nm. The interface between K-feldspar and albite exhibits a zigzag structure and significant strain at the interface. This zigzag interface is caused by the evolution of ordering and development of albite twins in the K-feldspar.

Discussion: Our study shows conclusively that albitic plagioclase in Tuxtuac has an exsolution microstructure. The microstructure is very comparable to that seen in plagioclase of similar compositions in a terrestrial syenite intrusion, that probably cooled through the exsolution interval of around 600 to 500 ºC over a timescale of 10^4 years [3,4]. This cooling rate is significantly faster than metallographic cooling rates calculated for LL5 and LL6 chondrites of tens of degrees per million years, or less [5,6], over a similar temperature range. There is no obvious explanation for this large difference in cooling rates. To date, we have not observed exsolution in any type 6 chondrites, which would be predicted to cool more slowly than type 5, according to an onion-shell model.

References: [1] Kovach H. A. and Jones R. H. 2010. *Meteoritics and Planetary Science* 45: 246-264. [2] Gallegos J. and Jones R. H. 2011. This conference. [3] Brown W. L. and Parsons I. 1988. *Contrib. Mineral. Petrol.* 98: 444-454. [4] Brown W. L. et al. 1983. *Contrib. Mineral. Petrol.* 82: 13-25. [5] Taylor G. J. et al. 1987. *Icarus* 69, 1-13. [6] Willis J. and Goldstein J. I. 1981. *Proc. Lunar Planet. Sci.* 12B: 1135-1143.