FELDSPAR IN THE L4 CHONDRITE SARATOV: THE HISTORY AND TIMING OF METASOMATISM.

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Introduction: Feldspar in ordinary chondrites (OCs) is typically considered to be a secondary mineral: fine-grained albite forms from the crystallization of chondrule mesostasis in response to thermal metamorphism by petrologic type 4, and increasing textural equilibration occurs with increasing petrologic type [1]. However, the details of feldspar development are actually considerably more complex, and reveal important additional aspects of OC parent body processing [2-7]. In type 4 L and LL chondrites, a mix of primary and secondary plagioclase is present in chondrules, with compositions ranging from An85 to An5. This equilibrates to ~An10 by type 6 [2-4]. K-feldspar exsolution from albite is present in petrologic types greater than 3.6 [3-7]. The equilibration process involves a fluid-based coupled dissolution-reprecipitation reaction where anorthitic plagioclase is replaced by albite [3,4]. This process has not gone to completion in type 4 L and LL chondrites, where effects of fluid alteration are ubiquitous. In order to better understand metasomatism in OCs, we have carried out a detailed textural and compositional study of feldspar in the L4 chondrite Saratov, which we know has been extensively affected by alkali metasomatism [6,7].

Methods: We studied feldspar within chondrules in Saratov thin section UNM 1145. Feldspar was identified using BSE imaging and EDS analysis on an FEI Quanta 3D FEG-SEM operated at 10 kV and 16 nA. We acquired quantitative WDS analyses using a JEOL 8200 microprobe operated at 10 kV and 10 nA with spot sizes between 1 and 5 µm and time dependent intensity corrections on Na.

Results: We observed a range of textures indicating fluid alteration of feldspar within chondrules. Anorthite commonly contains numerous submicron, crystallographically oriented dissolution lamellae (Fig. 1a). Other regions of anorthite show albitization along grain boundaries, the development of micropores along the alteration front, and K-feldspar exsolution in albite (Fig. 1b). Primary igneous albite also contains abundant submicron K-feldspar exsolution and associated mesostasis consists of porous, oxide-bearing, fine-grained albite (Fig. 1c). Development of macro-porosity (10s of microns in size) is common in heavily altered regions and K-feldspar is often located adjacent to these pores (Figs. 1b,c). Plagioclase compositions range from An85 to An3 with K-feldspar content up to Or3 in the albitic compositions. The exsolved K-feldspar contains much higher Or content than Or3, as indicated by EDS spectra, but the lamellae are too small (<< 1 µm) to analyze directly using the electron microprobe.

Discussion: The effect of alkali-bearing, presumably hydrous, fluids on OC parent bodies is reflected in the alteration and ultimate equilibration of anorthitic feldspar to albite. Saratov shows a range of alteration textures that can help interpret the timing of alteration. This is possible because alteration is not complete and high An-content plagioclase is affected earlier. First, fluids produce dissolution lamellae in anorthitic plagioclase (Fig. 1a) and assist crystallization of albitic mesostasis during metamorphism (Fig. 1c). Second, alteration advances, albitizing anorthite along grain boundaries and developing porosity (Fig. 1b,c). Third, the additional permeability allows for increased transport of fluids and K is incorporated into albite. Finally, K-feldspar exsolves during retrograde metamorphism (Fig. 1b,c). This sequence of events can be used to interpret I-Xe ages. [8] measured I-Xe ages of two Saratov chondrules. A radiating pyroxene chondrule that shows leaching of the mesostasis has an age ~5 Myr after CAIs, reflecting a formation or metamorphic age from pyroxene. A porphyritic olivine chondrule is younger, ~17 Myr after CAIs. This probably reflects a metasomatic age because I is expected to be present within secondary feldspar, not the olivine phenocrysts [8]. Understanding the evolution of feldspar is essential for interpreting such age data.

References: [1] Van Schmus W.R. and Wood J.A. 1967. *Geochimica et Cosmochimica Acta* 31:747–765. [2] Lewis J.A. and Jones R.H. 2015. Abstract #2067. 46th Lunar & Planetary Science Conference. [3] Kovach H.A. and Jones R.H. 2010. *Meteoritics & Planetary Science.* 45:246–264. [4] Lewis J.A. and Jones R.H. 2016. *Meteoritics & Planetary Science.* In review. [5] Jones R.H. and Brearley A.J. 2011. Abstract #5475. 74th Annual Meeting of the Meteoritical Society. [6] Lewis J.A. and Jones R.H. 2015. Abstract #5119. 78th Annual Meeting of the Meteoritical Society. [7] Lewis J.A. et al. 2016. Abstract #2559. 47th Lunar & Planetary Science Conference. [8] Pravdivtseva O. et al. 2006. Abstract 2418. 37th Lunar & Planetary Science Conference.

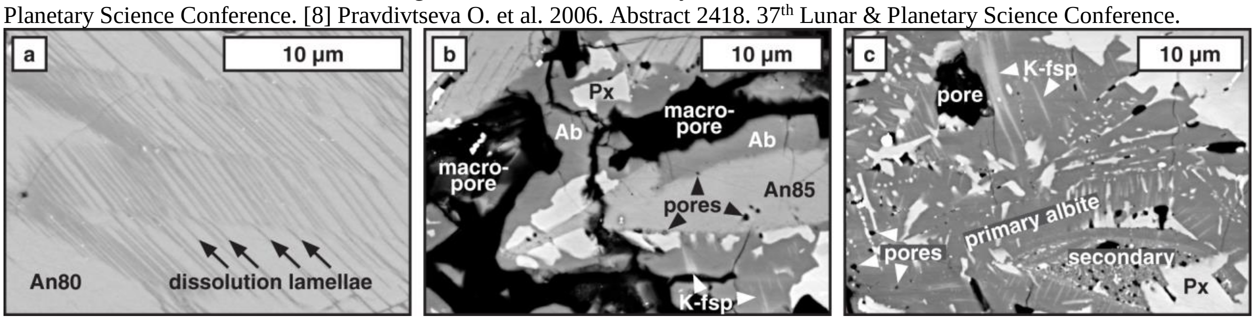

Figure 1: Alteration of feldspar in Saratov chondrules.