

ASTEROID COOLING RATES FROM FELDSPAR EXSOLUTION TEXTURES IN THE H4 CHONDRITE AVANHANDAVA

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Introduction: Thermal metamorphism in ordinary chondrites (OCs) is thought to occur through the radioactive decay of ^{26}Al in an onion-shell-like structure [e.g. 1]. However, cooling rates determined by pyroxene diffusion and metallographic methods are inconsistent with onion-shell-like cooling [2-3]. These inconsistencies have led to models of asteroid disruption and reaccretion into a rubble pile, after peak metamorphism [2-4]. To further examine these models, we can obtain cooling rates from observations of feldspar microstructures in OCs. In OCs, potassium-feldspar exsolution occurs in albite, in a perthite texture [5-6]. Here, we report cooling rates determined from feldspar exsolution textures in the H4 chondrite Avanhandava and compare these to cooling rates determined by other methods.

Methods: We examined a thin section of Avanhandava (UNM 88). BSE images were taken on an FEI Quanta FEG-SEM/FIB. Quantitative X-ray chemical analysis was performed using a JEOL 8200 EPMA. A TEM section was prepared using the focused ion beam on the FEG-SEM/FIB and imaged using a JEOL 2010F STEM using a HAADF detector for dark field images. Analytical work was carried out at UNM.

Results: Perthite was investigated in chondrule 6 (Fig. 1a). Broad-beam EPMA analysis of the perthite texture (Fig. 1b) yielded an average composition of $\text{An}_{2.5}\text{Ab}_{64.8}\text{Or}_{32.7}$ from which we estimate the solvus temperature to be 700-765 °C [7-8]. Assuming that exsolution occurred around this temperature, and given a measured exsolution wavelength of 650 nm (Fig. 1c), we determined a cooling rate of 1 °C per 1-4 months over a temperature interval of 765-670 °C. Peristerite is also present in the Na-rich lamellae (Fig. 1c) for which we estimate a cooling rate of 1 °C in 10^3 - 10^4 years from 570-540 °C.

Discussion: Feldspar cooling rates are plotted in Fig. 1d along with cooling rates determined by pyroxene diffusion and metallographic methods. In general, the relatively fast cooling rate determined by perthite is consistent with cooling rates determined by pyroxene diffusion at a similar high temperature [2]. The peristerite cooling rate is closer to the slow, lower temperature metallographic cooling rates [3]. These observations support a breakup and reassembly model [4] in which erosional bombardment causes fast cooling at high temperatures. Residual heat from breakup and reassembly results in the observed slow cooling rates at low temperatures.

References: [1] Pellas P. and Storzer D. (1981) *Proc. Roy. Soc. London. A.* 374, 253–270. [2] Ganguly J. et al. (2013) *GCA* 105, 206–220. [3] Scott E. R. D. et al. (2014) *GCA* 136, 13–37. [4] Blackburn T. et al. (2017) *GCA* 200, 201–217. [5] Jones R. H. and Brearley A. J. (2011) *74th MetSoc*, Abstract #5475. [6] Lewis J. A., Jones R. H., and Brearley A. J. (2016) *47th LPSC*, Abstract #2559. [7] Parsons I. and Lee M. R. (2009) *Contrib. Min. Pet.* 157, 641–661. [8] Elkins L. T. and Grove T. L. (1990) *Am. Min.* 75, 544–559.

Figure 1: Feldspar exsolution and cooling rates. (a) BSE image of chondrule 6 in which perthite (b) is present. Line in (b) indicates region from which TEM section was extracted: darker grey is albite and lighter grey is K-feldspar. (c) HAADF image of perthite with an average 650 nm wavelength and peristerite in the Na-rich lamellae. (d) Plot of cooling rates from feldspar, pyroxene diffusion [2], and metallographic methods [3].

