SELECTIVE DISSOLUTION OF PLAGIOCLASE IN SEMARKONA: LOW-TEMPERATURE FLUID-SOLID INTERACTIONS.

E. Dobrică and A. J. Brearley, Department of Earth and Planetary Sciences, MSC03-2040, 1 University of New Mexico, Albuquerque, NM 87131-0001, USA (edobrica@unm.edu).

Introduction: Numerous studies of chondritic meteorites [1-2] show that fluid-solid interactions played a significant role in the earliest geological evolution of our solar system. However, there is still a significant number of questions concerning the mechanisms of aqueous alteration reactions, the sequence of formation of secondary phases, and the compositions of the altering fluids that have not been fully addressed. We are examining the origin and thermal history of matrix lumps, which occur enclosed in chondrules from Semarkona. In this study, we are focusing on evidence of aqueous alteration at the boundary between these matrix lumps and chondrule phenocrysts.

Methods: One thin section of Semarkona (LL3.00) was studied by Scanning Electron Microscopy (SEM) on a FEI Quanta 3D FEGSEM/FIB operating at 30 kV, using backscattered electron (BSE) imaging to identify matrix lumps, which occur enclosed in chondrules. After detailed SEM characterization, quantitative analyses of the fine-grained lumps and chondrule minerals were measured using a JEOL 8200 Superprobe electron microprobe (EMPA), operating at an acceleration voltage of 15 kV and a 20 nA beam current. Transmission Electron Microscopy (TEM) sections of the boundary between the fine-grained matrix lump included in a porphyritic olivine-pyroxene (POP) chondrule was prepared using the focused ion beam (FIB) technique with a FEI Quanta 3D Dualbeam® FIB instrument. Bright and dark-field TEM images and quantitative EDS X-ray analyses were carried out at 200 kV on a JEOL 2010F FEG TEM/Scanning TEM (STEM).

Results and discussion: Fine-grained matrix lumps were identified inside and at the edge of a POP type chondrule (1.4 x 1.7 mm in size). It has been suggested that matrix lumps were captured when chondrules were still molten prior to crystallization [3]. One FIB section from the boundary between the matrix lump and an olivine phenocryst (Fo_{97}, Fig. 1) was analyzed. The boundary between matrix lump and the olivine phenocryst is a region of mesostasis composed of quench euhedral plagioclase ($An_{38-48}Ab_{51-61}$), embedded in glass that has been replaced by fibrous smectite. The smectite has a homogeneous chemical composition. However, it shows different textures from fine- to coarse-grained fibrous crystals. The plagioclase has an elongate morphology with crystal sizes ranging from of 400 nm to 1.3 µm in length and 80 nm to 250 nm in width. These crystals occur in two orthogonal crystallographic orientations. Locally, some plagioclase crystals have been partially or completely dissolved leading to the development of secondary microporosity. The external shape and dimensions of the plagioclase have been completely preserved resulting in the formation of euhedral negative crystals (black regions Fig. 1). This region of alteration reflects a complex series of events at the microscale. First the interstitial glass between the plagioclase grains was completely replaced by smectite before the heterogeneous dissolution of the plagioclase. The dissolution of plagioclase observed in Semarkona is congruent suggesting that the plagioclase was dissolved in a fluid at neutral to basic pH conditions [4]. Recently, [5] have reported evidence for late-stage fluid interaction with plagioclase within LL chondrites type 4 and 3.9. This study shows that dissolution of plagioclase can take place at the lower metamorphic temperatures experienced by Semarkona.

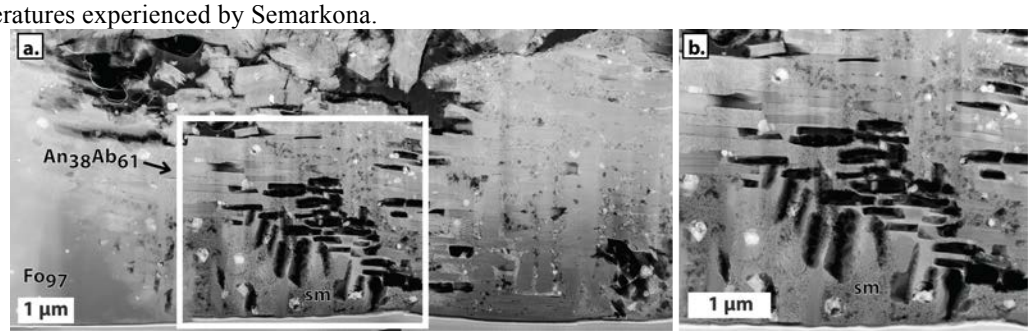

Figure 1. Dark-field images made by STEM showing the euhedral porosity (black) identified in the fine-grained lump inside of a POP chondrule in Semarkona. b) The area outlined by the solid line rectangle in Fig.1b. showing details of the pores. Phases identified in the FIB section: Fo = forsterite, sm = smectite, AnAb = plagioclase.

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