ALH77005: The magmatic history from rehomogenized melt inclusions. C. Calvin[1*] and M. Rutherford[1], [1]Brown University 324 Brook Street, Box 1846, Providence, RI 02912. *Christina_Calvin@brown.edu.

Introduction: Melt inclusions in rocks such as the SNC meteorites contain a record of the rock's magmatic history because they preserve melt that was present during phenocryst growth. After entrapment, a melt inclusion can be modified by processes such as reaction with the host crystal and diffusion through the host [1]. We have studied two thin sections of, and rehomogenized melt inclusions from 7 chips of ALH77005 to better understand the magmatic history of the meteorite. We have attempted to address the following questions: 1) What was the composition of the early magmas that formed ALH77005? 2) How does these magmas compare to other SNC meteorites? 3) What is the origin of the differences in composition between melt inclusions in ALH77005?

Experiments: Experiments were performed in argon-pressurized, TZM pressure vessels. Samples were surrounded with graphite, which reacts with ferric iron to fix the oxidation state of the experiment. The graphite also prevents sample tube reaction (Fe-loss to Pt tubing). The tubes were brought to either 0.8 or 1.0 kbar. The temperature of the samples was then raised to 1150, 1160, 1165, and 1185ºC. Samples were run for durations ranging from 3 to 72 hours. After a rapid quench, polished sections were made for analysis by electron microprobe.

Results: Based on experimental data from rehomogenized melt inclusions, a liquid line of descent has been outlined for ALH77005 (Fig 1). Although there are two different textures in the natural sample's melt inclusions, the major element composition of the rehomogenized melts falls concisely along a trend with decreasing MgO content. There is considerably more variability in the minor elements TiO_2, Na_2O and K_2O, particularly at low MgO contents (Fig 1).

ALH77005 thin sections analyzed during this study contain the two different types of melt inclusions that were reported by [2, 3b, 4b]. The first type of melt inclusion tends to be less than 50 Ìm and have few daughter crystals. The second type of melt inclusion is larger (i.e., 100 Ìm) and contains high-silica blebs that appear to be either immiscible melt glasses or a quartz polymorph formed during extremely late-stage fractionation. In addition to observations made by previous authors, we noted that melt inclusions that contained silicate blebs have predominantly high-Ca pyroxene rims separating the host from the inclusion (Fig 2a). Melt inclusions that did not contain silicate blebs had rims that were composed primarily of low-Ca pyroxene (Fig 2b).

Chromites found in melt inclusions or poikilitically

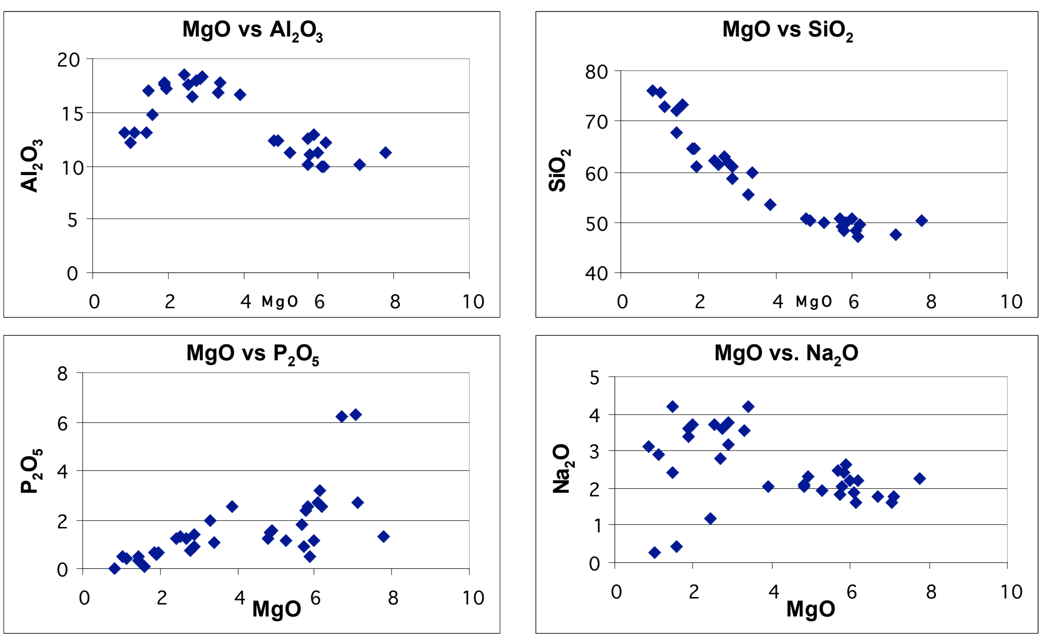

Figure 1: Liquid line of descent determined from rehomogenizing melt inclusions.

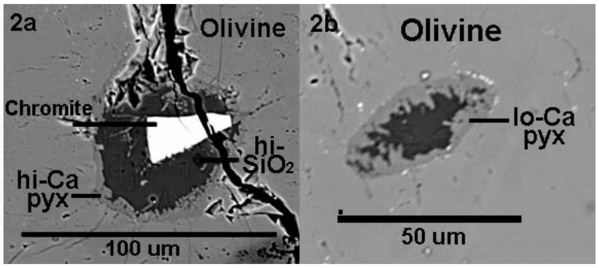

Figure 2: Backscatter images of two melt inclusions that are partially homogenized.

enclosed in olivine had lower Cr/Al ratios than chromites poikilitically enclosed by low-Ca pyroxene. The largest chromites had the highest Cr/Al values. Many chromites regardless of size showed higher Cr/Al values in the cores when compared to rims. The difference was 1-2 wt% Cr_2O_3.

Whitlockite was sometimes observed in melt inclusions in olivine. Melt inclusions in low-Ca pyroxene sometimes contained chlorine-rich apatite.

FeS spherules were found throughout the samples as inclusions in chromite, olivine and pyroxene. They were also found as accessory phases in both types of melt inclusions and along fractures in the rock. Glass in equilibrium with FeS blebs are saturated in sulfur based on the Fe content of the melt [5].

Discussion: The liquid line of descent we have outlined tells us several things about the crystallization history of the magma. First, Al_2O_3 increases with increasing MgO until 2-3 wt % MgO is achieved. This reflects the saturation point of plagioclase. The original melt trapped by olivine had ~10 wt % Al_2O_3, far below plagioclase saturation. P_2O_5 in the early trapped melt varied by 5 wt %, but the average was ~3 wt %. The origin of the high P_2O_5 values is not clear, however the lower P_2O_5 values may represent melt inclusions that retain whitlockite or apatite. Na_2O shows considerable variability at low MgO contents. This may result from variable amounts of plagioclase remaining in melt inclusions that have not been fully rehomogenized. The melt involved with initial olivine crystallization contained ~2 wt % Na_2O and less than 1 wt % K_2O.

Chromite in an evolving magma system tends to change from high Cr and low Al to low Cr and high Al as magma crystallizes in a closed system [6]. Melt inclusions in ALH77005 show a range of chromite compositions (42-54 wt %). The chromites with the least evolved compositions (i.e., high Cr and low Al) were found in melt inclusions that contained high silica phases. [2] suggested that the appearance of kaersutite in pyroxene melt inclusions indicates either assimilation of crustal rock or mixing with a wet magma. In contrast, the increase in the Cr/Al ratio between the chromites found in olivine melt inclusions and the chromites poikilitically enclosed in pyroxene suggests that the magma chamber received one or more injections of a primitive magma with high Cr content between the formation of the olivine melt inclusions and the crystallization of the remainder of the rock. [2] also suggested that chromite crystallized in the melt inclusions. Although this is possible for some of the small chromites in these melt inclusions, the large size of the chromites in the melt inclusions analyzed in this study indicate that the melts were trapped with or possibly even because of the chromite grains.

The origin of the SiO_2-rich blebs in the melt inclusions of ALH77005 has been previously addressed by several authors. [3] suggested that the silicate blebs are coesite rather than high-Si glasses based on the refractive index and that the coesite probably formed during shock. Previous studies of LEW88516, considered to be paired with ALH77005, also report high-Si glasses in olivine melt inclusions. In LEW88516 this texture has been proposed to be immiscibility [4]. Because the major elements of the rehomogenized melt inclusions fall along the same liquid line of descent as melt inclusions without silicate blebs, it is necessary to explain how some of them became immiscible but others did not. This might be accomplished at sufficiently high P_2O_5 contents where magma can separate into an FeO-rich melt and a SiO_2-rich melt [8]. High TiO_2 contents would aid the immiscibility.

The FeS in both the chromites and in sulfur saturated melt inclusions may indicate that the magma was saturated in sulfur throughout its formation. Partitioning of sulfur in a magma is a function of the oxidation state and the H_2O content of the magma. The fluid/melt partition in oxidized magmas is ~47 which means that during degassing, sulfur would exsolve into the vapor phase such that the eruption would rapidly deplete the magma of sulfur [7]. This implies that for the parent magma of ALH77005 to remain saturated in sulfur over the course of its crystallization, the magma either did not degas significantly or that the magma was dry. However, if the melt inclusions have not remained closed since their entrapment, the sulfur saturation may be the result of post-entrapment sulfur migration due to the shock.

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