TRANSITION TO LOW OXYGEN FUGACITIES IN THE SOLAR NEBULA RECORDED BY EH3 CHONDRITE ALHA81189. T. J. Fagan[1], S. Kataoka[1], A. Yoshida[1] and K. Norose[1], [1]Department of Earth Sciences, Waseda University, 1-6-1 Nishiwaseda, Shinjuku-ku, Tokyo, Japan 169-8050 (fagan@waseda.jp).

Introduction: Variations in Fe/(Fe+Mg) in silicates, Fe,Ni-metal compositions and sulfide minerals in chondrites show that a wide range of oxygen fugacities occurred in the solar nebula. One approach toward constraining controls on oxygen fugacity is to identify chondrites that record transitional stages of oxygen fugacities between the well-established chondrite groups.

This project focuses on ALHA81189, a highly unequilibrated (possibly the most primitive) EH3 chondrite. The highly unequilibrated state of this meteorite has been determined previously based on high abundances of Fe-rich silicates and of olivine and silica [1-3]. In this study we compare troilite compositions and chondrule textures of ALHA81189 with other EH chondrites to argue that the primitive nature of ALHA81189 is due to less extensive thermal processing in a reducing environment in the solar nebula. Of course, metamorphic effects must have been relatively minor; however, the main differences between ALHA81189 and other EH3 chondrites are probably due to different nebular histories, not variable equilibration during parent body metamorphism.

Analytical Methods: Polished thin sections of ALHA81189 (EH3); ALH 84170 (EH3); Sahara 97096 (EH3); St. Marks (EH5) and LEW 88180 (EH5) were examined using a petrographic microscope and electron microprobe (JEOL JXA-8900) at Waseda University. X-ray elemental maps were collected from each sample and used to collect quantitative analyses of troilite (and mafic silicates and kamacite) on grid patterns. Grids were used to ensure that analyses were collected over a wide area of each sample. Elemental maps were also combined with petrographic microscope observations to characterize chondrule textures. In addition, we have determined silica polymorphs in ALHA81189, ALH 84170 and St. Marks by Raman spectroscopy (Jobin Yvon LabRam 300 Raman microspectrometer [Horiba, Ltd.] equipped with confocal optics and air-cooled CCD detector at Waseda University).

Results: The EH3 chondrites show obvious differences in texture from the EH5 chondrites. The type 3 chondrites have well-defined silicate chondrules and sulfide +/- kamacite nodules. Olivine occurs in the type 3 chondrites, but was not identified in the type 5 samples. Pyroxene Fe/(Mg+Fe) shifts to lower values and lower ranges in composition from type 3 to type 5. These observations are consistent with increasing extent of equilibration and recrystallization of the type 5 chondrites during parent body metamorphism under low oxygen fugacities.

Differences within the EH3 chondrites are more subtle, but can be discerned. The relatively high abundance of olivine in ALHA81189 has been noted previously [2]. Olivine in this meteorite often occurs in the cores of POP chondrules, and many of these chondrules have silica or silica-rich rims (Fig. 1). The presence of olivine in chondrule cores and silica in rims indicates a lack of equilibrium during chondrule formation. In contrast, although silica rims on chondrules are present in ALH 84170 and Sahara 97096, they are not nearly as abundant as in ALHA81189. The chondrules in ALHA81189 are distinguished further by their lower degree of fragmentation (Fig. 1).

Our Raman results also indicate that ALHA81189 is distinct. Of 71 analyses of silica grains, 61 were identified as cristobalite and the other 10 gave ambiguous results. The key is that no quartz or other silica polymorphs were identified. In contrast, both cristobalite and quartz were identified in ALH 84170, consistent with the results of [4] (who identified tridymite as well), and only quartz was identified in St. Marks.

A distinct setting for formation of ALHA81189 is supported by minor element concentrations in troilite. Detectable concentrations of Ti and Cr (which are typically lithophile elements) in troilite in enstatite chondrites are considered evidence of the reducing conditions of the EC-forming region [5,6]. Troilite in ALHA81189 has lower concentrations of Ti than troilite in the other ECs we analyzed (Fig. 2). One explanation is that ALHA81189 formed at slightly higher $f(O_2)$ than the other ECs. This is consistent with the abundance of Fe-bearing pyroxene in ALHA81189 [1].

ALHA81189, a transitional EH chondrite? The population of chondrules in ALHA81189 appears to be distinct (high proportion of POP types, silica rims and unfragmented textures) from chondrules in other EH3 chondrites. Thus, although ALHA81189 is highly primitive, it may not be the metamorphic protolith of more equilibrated EH3 chondrites. The prevalence of cristobalite in ALHA81189 indicates high-T, low-P and rapid cooling rates consistent with nebular heating and cooling during chondrule formation. Quartz in other EH3 chondrites might have been emplaced by impact processing after the onset of parent body metamorphism. Relatively low Ti in troilite and high

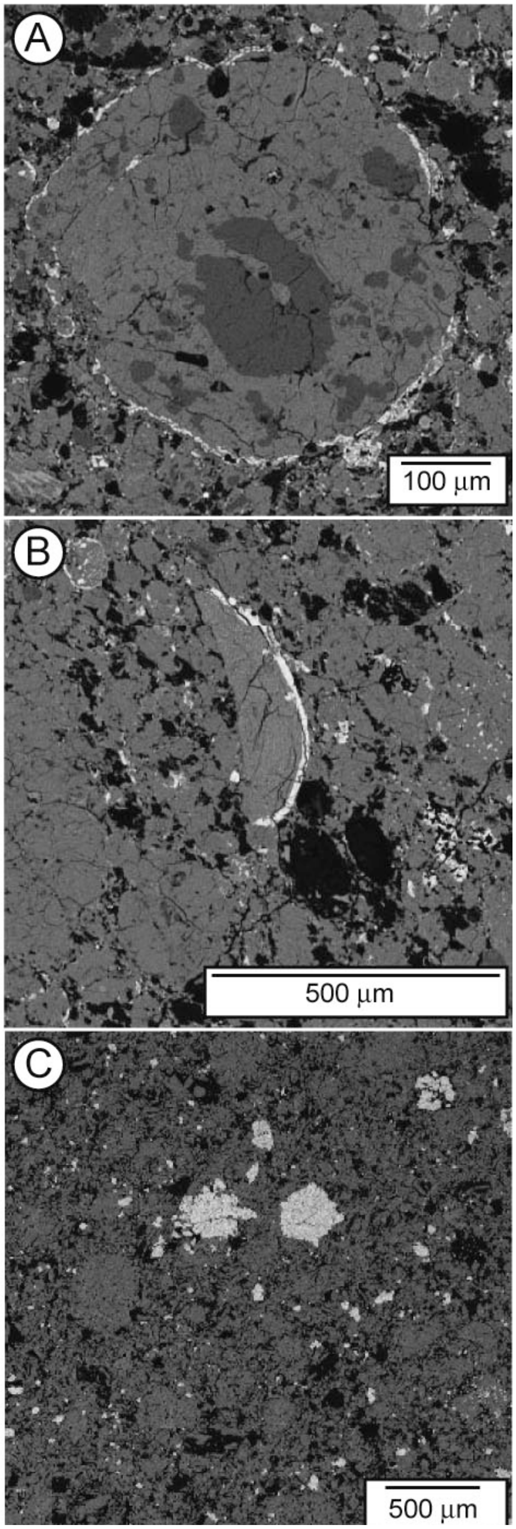

Fig. 1. Si Kα maps of: (A) POP chondrule with silica-rich rim from ALHA 81189; (B) fragmented RP chondrule from ALH 84170; (C) coarse grained quartz in St. Marks.

Fe/(Fe+Mg) in pyroxene suggest that ALHA81189 formed at slightly higher $f(O_2)$ than other EHs.

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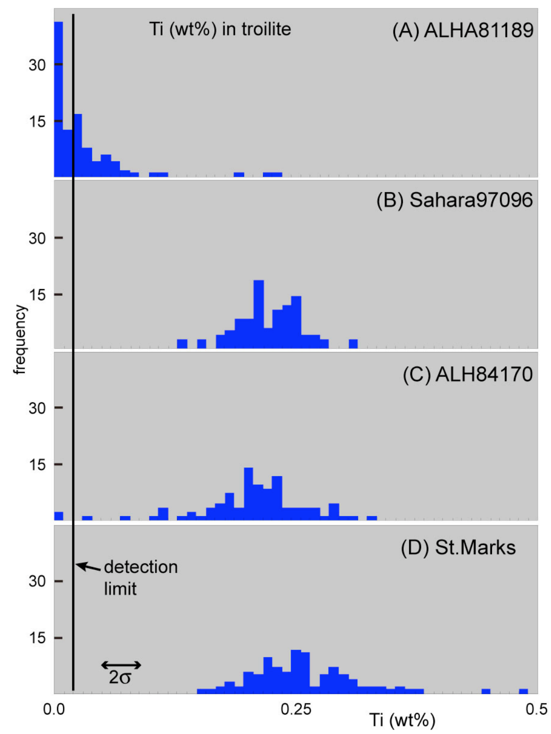

Fig. 2. Histograms of Ti concentration (wt%) in troilite from ALHA81189 (EH3, n = 102, A); Sahara 97096 (EH3, n = 87, B); ALH 844170 (EH3, n = 85, C); St. Marks (EH5, n = 102, D).