PETROGENESIS OF THE ALLAN HILLS 77005 ACHONDRITE. Harry Y. McSween, Jr.[1], Lawrence A. Taylor[1], Edward Stolper[2], Richard A. Muntean[3,4], G. Davis O'Kelley[3,4], and James S. Eldridge[4]: 1-Geological Sciences, Univ. of Tennessee, Knoxville, TN 37916; 2-Geological Sciences, Harvard Univ., Cambridge, MA 02138; 3-Chemistry, Univ. of Tennessee, Knoxville, TN 37916; 4-Oak Ridge National Laboratory, Oak Ridge, TN 37830.

ALHA 77005 is a unique achondrite recovered from the Antarctic ice sheet (1). The meteorite is texturally heterogeneous. Euhedral to subhedral olivine and chromite crystals are poikilitically enclosed by low-Ca and high-Ca pyroxenes. Small troilite grains are associated with olivines. Maskelynite, ilmenite, chromite, troilite, whitlockite, and minor pyroxene are interstitial to subhedral olivines in other areas of the meteorite. Olivines have average compositions of Fo74 and are unzoned. Large pyroxenes enclosing olivine (sample 34 in Fig. 1) are more magnesian than interstitial pyroxenes (sample 31 in Fig. 1). Maskelynite is normally zoned from An54Ab45Or1 to An45Ab53Or2 in extreme cases (Fig. 1). The rock is relatively fresh except for isolated areas associated with troilite and altered to magnetite/maghemite + FeO(OH). Cl and Cr in the alteration products suggest the possible former presence of lawrencite and daubreelite. No metal was observed.

The inferred crystallization sequence was as follows: accumulation of olivine and chromite phenocrysts, possibly wetted by troilite; crystallization of low-Ca and high-Ca pyroxenes which enclosed cumulate phases; continued crystallization of intercumulus liquid to form plagioclase, slightly more Fe-rich pyroxenes, ilmenite, and whitlockite. Chromites enclosed by pyroxene were protected from later reaction, although they do have slightly aluminous rims (arrow P in Fig. 2). Chromites in contact with interstitial maskelynite (arrow M in Fig. 2) are zoned toward ulvöspinel compositions (in which ~10 wt % of the Fe is ferric) and/or have rims of ilmenite (5-6 wt % MgO, with minor chromite and negligible hematite molecules). Shock metamorphism has transformed plagioclase to maskelynite and produced undulatory extinction and deformation twinning in pyroxenes. Small patches of olivine vitrophyre intrude cracks and have recrystallized and bleached the surrounding grains. Skeletal olivine grains in the vitrophyre have compositions

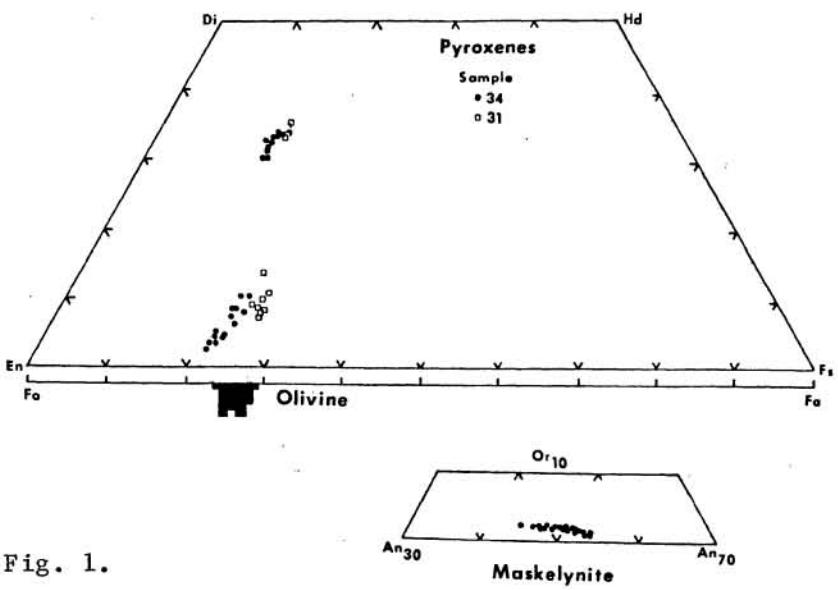

Fig. 1.

more magnesian (Fo78-86) than the cumulus olivine. Small dendritic chromite crystals also occur in the glass. If the vitrophyre represents impact melt, it did not form in situ.

It is instructive to compare this meteorite to other achondrites. Petrogenetic relationships among achondrites have been explained as resulting from compositional differences between the source peridotites which produced achondritic melts by partial melting (2). Source region compositions could differ due to addition of varying amounts of a volatile-rich, low-temperature component, which has the effect of simultaneously increasing the ratio of high-Ca to low-Ca pyroxene, the oxidation state, the alkali content of the feldspar, and the bulk volatile content of the source region. Fig. 3, a schematic olivine-saturated liquidus diagram, illustrates such a progression of source region compositions. Basaltic achondrites are derived from S_1-type source regions, shergottites from S_3, and nakhlites and chassignites from S_6 (2). The crystallization sequence determined for ALHA 77005 is consistent with its derivation from either regions S_3 or S_4. Similarities between 77005 and the shergottites (3) in terms of mineralogy and mineral chemistry (Fig. 4), oxidation state, and shock effects suggest that this unique meteorite may be derived from an S_3 region as well. ALHA 77005 may represent an earlier differentiate from the same or a similar parent magma that produced the shergottites, because shergottite pyroxenes are more Fe-rich and olivine is absent, except for minor fayalite in mesostasis.

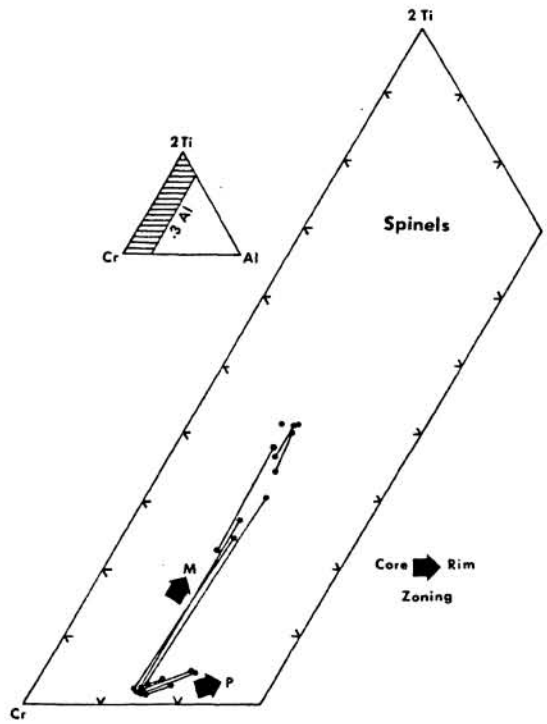

Fig. 2.

Ratios of volatile to refractory elements should increase progressively in the sequence S_1 to S_6, provided that both of the elements compared are not fractionated from each other during igneous processes (2). K/U ratios do exhibit this trend in the sequence basaltic achondrites - shergottites - nakhlites and chassignites; thus, determination of the K/U ratio in ALHA 77005 provides a test for its proposed assignment to an S_3-type source region. The K/U ratio for 77005 was determined by non-destructive gamma-ray spectrometry (4) as $\sim$10,000. This ratio is consistent with that of the shergottites. Refinements of the measurement are under way to correct for a small, unexpected amount of ^{137}Cs present in the sample.

Therefore, a number of petrologic similarities point to a relationship between ALHA 77005 and the shergottites. This unique meteorite may provide an additional sample of the only other known solar system body to be petrologically similar to the earth (3).

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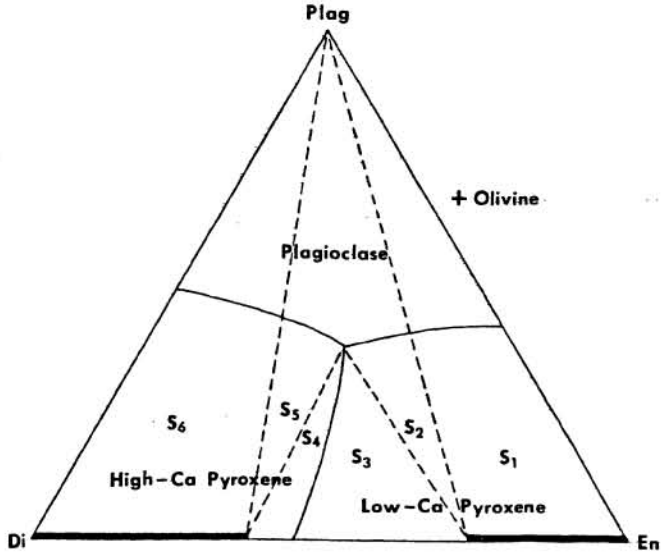

Fig. 3.

References:
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Fig. 4