MINOR AND TRACE ELEMENTS IN CLAST AND WHOLE ROCK SAMPLES OF ALLAN HILLS A81005. William V. Boynton and Dolores H. Hill, Dept. of Planetary Sciences, Lunar and Planetary Laboratory, U. of Arizona, Tucson 85721.

The similarity between Allan Hills A81005 and lunar highlands rocks was noted by Mason (1), based on a preliminary examination of a thin section. Our data suggest a very strong relationship between ALHA 81005 and highlands rocks from Apollo 16. Based on two different sets of data, we conclude that it is most unlikely that this meteorite originated on a parent body other than the Moon.

Samples. - We received two pieces of ALHA 81005 (60 mg. and 20 mg.), which were analyzed separately to check for heterogeneity. Examination under the stereo microscope showed abundant light-colored clasts in a grey matrix. One of the clasts was removed from the larger whole rock sample and analyzed separately. This clast (1 mg.) was among the whitest of the clasts. It had a small pink grain (spinel?) visible on the surface, and a very few dark grains could be seen in the clast.

Experimental. - All data were obtained by INAA following a low-flux irradiation at the University of Arizona reactor. Most of the data to be discussed were taken after the samples had decayed to very low activities (The clast sample was counted at 0.25 cps, over 10^4 times weaker than our optimum count rate.). The samples were counted on our new Fast Anti-Compton Specrometer (FACS), which gives a dramatic improvement in signal-to-noise ratio. It is only because of the capabilities of this detector that we were able to get much of this data. We plan to re-irradiate at much higher flux to get our final data.

Evidence for Lunar Origin. - The first set of data which suggest a lunar origin is Fe and Mn concentrations in the whole rock and the clast. Laul and Schmitt (2) established that plots of MnO vs. FeO can distinguish lunar material from other known differentiated meteorites. Our data for the whole rock and clast plot in their field of lunar data (Fig. 1). The FeO/MnO ratio in the whole rock (65.8) and clast (55) are typical of lunar samples with low abundances of these elements. We feel, however, that these data are necessary but not sufficient to establish lunar origin. A similar FeO/MnO ratio could easily be established in an unsampled parent body. In fact, Laul and Schmitt indicate that FeO/MnO ratios are similar in lunar, meteoritic and terrestrial anorthosites.

More convincing data for a lunar origin of ALHA 81005 is provided by the abundances of incompatible trace elements. Our data for the whole rock and clast are shown in Fig. 2. Also plotted are data from Apollo 16 highlands samples 60626 and 60025 and KREEP (2). The trace element abundances in 60626 show the characteristic KREEP pattern with a linear decrease in abundances of REE from light to heavy and a increase in Hf, Ta, and Th. This shape pattern is found in a large number of highlands rocks with absolute abundances spanning a range of a factor of 50. These elements have different partition coefficients, which are a strong function of the minerals involved in the fractionation event(s), and hence their final abundance ratios will be dependent on the composition and size of the parent body and on the exact degree of fractionation (partial melting or fractional crystallization). There appears to be no agreement on how the lunar KREEP pattern was established, but it is clear that very extreme fractionations are required.

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Because it is so difficult to generate this trace element pattern even on the Moon, there appears to be general agreement that this pattern was established only once, and the KREEP pattern was acquired by other rocks such as 60626 by mixing of this KREEP component (3). It is most unlikely that this pattern could be established on another parent body unless it had a similar bulk composition, size and thermal history as the Moon. Such a parent body clearly does not exist in the Solar System.

Evidence for a Pristine Lunar Clast. - The trace element data from the single clast which we analyzed from ALHA 81005 is also plotted in Fig. 2. The abundances are about a factor of 400 lower than that observed for pure KREEP. According to Warren and Wasson (4), all samples with incompatible elements less than 200 times lower than KREEP are pristine. The incompatible element attribute is second in importance only to low siderophile element in establishing the pristinity of samples. It appears then that ALHA 81005 may contain pristine samples of the early lunar crust. Clearly, more work on this interesting meteorite is in order. We are hopeful that investigations of other clasts will provide new insights into the origin of the lunar crust.

1. Mason B. (1982) Antarctic Meteorite Newsletter, 5:No. 4.
2. Laul J.C. and Schmitt R. A. (1973) Proc. 4th L.S.C, p. 1349-1367.
3. Warren P.H. and Wasson J. T. (1979) Rev. Geophys. Space Phys., 17:73-88.
4. Warren P.H. and Wasson J. T. (1977), Proc. 8th L.S.C., p. 2215-2235.

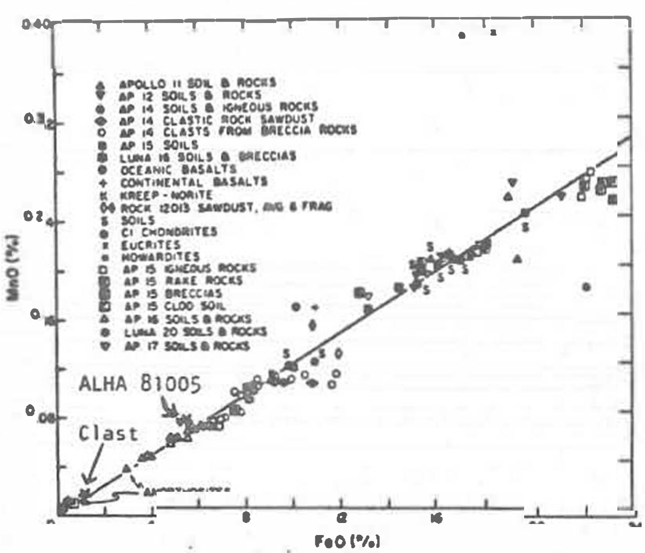

Fig. 1. MnO vs. FeO for lunar samples and samples of other differentiated meteorites (2). ALHA 81005 plots on the lunar line indicating that this meteorite may have come from the Moon, but these data do not demand a lunar origin for ALHA 81005.

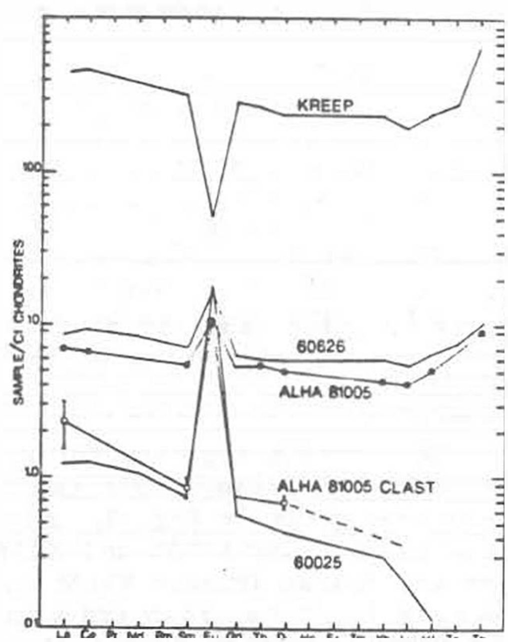

Fig. 2. Trace elements in Apollo 16 samples(2) and ALHA 81005. The presence of a KREEP type pattern in ALHA 81005 requires that this meteorite came from the Moon.