MAGNETIC AND MÖSSBAUER STUDIES OF APOLLO 16 ROCK CHIPS 60315,51 AND 62295,27., A. Brecher*, D.J. Vaughan*, R.G. Burns*, D. Cohen**, and K.R. Morash†
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We have carried out Mössbauer and magnetic studies of two Apollo 16 rock chips, both classified as metamorphosed igneous crystalline rocks. Optical microscopy revealed a higher content of large metal spherules in 60315,51, than in 62295,27.

Rock chips of Apollo samples 60315 and 62295 were each crushed to a fine powder and studied by Mössbauer spectroscopy. The spectra obtained are shown in Figure 1. Spectrum A may be attributed to iron metal and troilite, the former being more abundant. Two intense quadrupole doublets near the center of the spectrum have parameters consistent with olivine (the outer doublet) and pyroxene. Preliminary computer analysis of the spectrum suggests the following distribution of iron between the phases: pyroxene 52%, olivine 35%, iron 10%, troilite 3%. However, an appreciable percentage of iron is probably present in spinel and ilmenite phases not resolved in the preliminary work. Also, some of the intensity attributed to olivine may represent Fe^{2+} in the pyroxene M1 site. Spectrum B (rock 62295) differs from spectrum A in the reduced intensity of the magnetic peaks and in the considerable reduction of the intensity of the innermost quadrupole doublet, i.e. the amount of pyroxene relative to olivine. A preliminary analysis of the spectrum suggested the following iron distribution: olivine 71%, pyroxene 28%, metal 1%. Traces of troilite are also apparent in the spectrum. Rock 62295 therefore appears to be depleted in iron and troilite and enriched in olivine relative to 60315.

We undertook nondestructive magnetic measurements to determine the nature, relative amounts and sizes of magnetic mineral grains. Apparatus used included a point-contact SQUID magnetometer in a magnetically shielded room, an AC-demagnetizer and P.A.R. spinner and parallel-field vibrating sample magnetometers. Preliminary results from an analysis of hysteresis loops taken at 185°K, which is the lunar night temperature, confirm conclusions from Mössbauer data regarding the distribution of iron between reduced and oxidized phases: 1) Values of saturation magnetization (M_s/m) of 3.8 emu/g for 60315,51 and 0.825 emu/g for 62295,27, imply maximum contents of Fe metal of 1.72 wt % and .37 wt %, respectively. 2) Values of paramagnetic susceptibility (χ_p in gauss/oe.g) of 39.4×10^{-6} for 60315,51 and $\sim 57 \times 10^{-6}$ for 62295,27 correspond to equivalent weight fractions of Fe^{++} of 17% and 20%, respectively. If χ_p is contributed mostly by pyroxenes, ~55 wt % for 60315 and ~78 wt % for 62295, are suggested. Alternatively, χ_p could be

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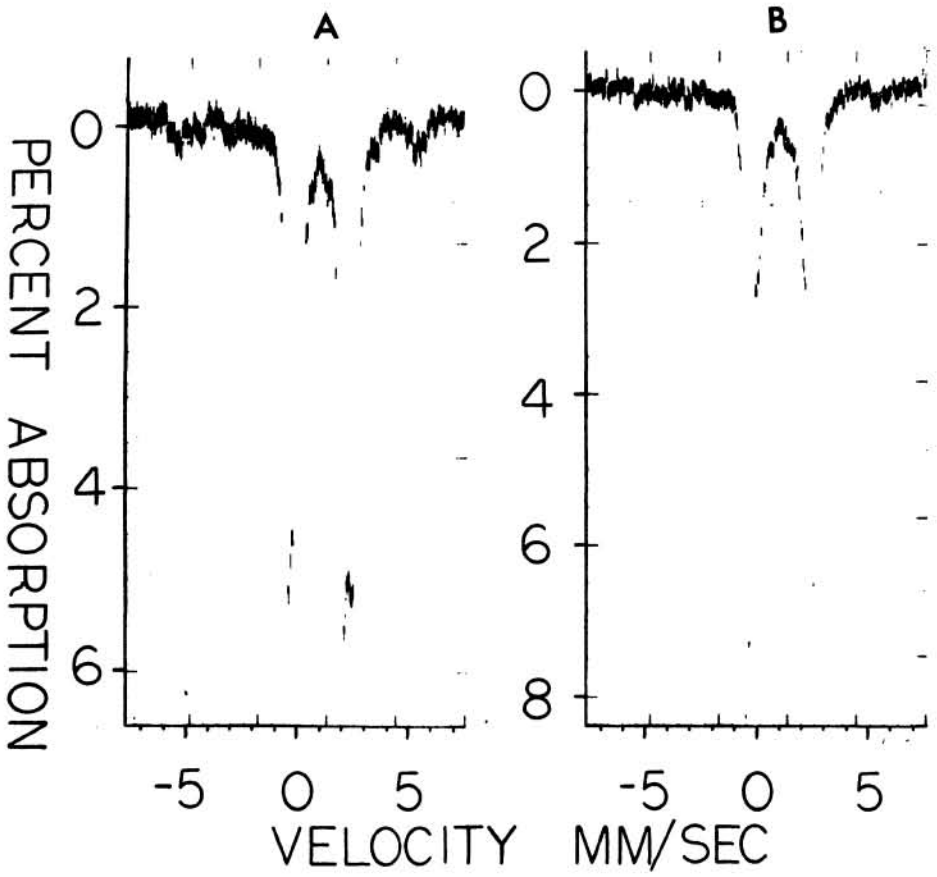

FIGURE 1. Mössbauer spectra of Apollo 16 whole rock samples at 300°K.

A. Sample 60315,51
B. Sample 62295,27

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due to ∿40 wt % of olivine for 60315, and ∿50 wt % for 62295.

The value obtained for natural remanence (NRM) of 62295,27 was .2 x 10^{-5} emu/g. The much higher values for two 60315,51 fragments (2.69 x 10^{-5} emu/g and 4.06 x 10^{-5} emu/g) point both to a larger metal content and to its inhomogeneous distribution. Such NRM values are within the range of previous data on igneous rocks. Repeated thermal cycling (300° to 77°K) in field free space showed no evidence for secondary remanence residing in iron oxide phases. Large (>3 NRM) viscous remanence (VRM) was easily acquired by both rocks, denoting the presence of a large, magnetically soft grain fraction. A rapid decay (by a factor of 2 in 24 hrs) of saturation remanence (M_s^{IRM}) was observed in 60315 after storage in field free space.

The predominance of magnetically unstable, mostly multidomain (MD) rather than superparamagnetic (SPM) grains in 60315 was also supported by: 1) The low stability of NRM to AF-demagnetization. 62.6% of NRM was removed by 50 oe fields and only 26% survived cleaning in 250 oe peak fields. 2) The rather low stability of saturation remanence ($M_s^{IRM}/m \simeq .75 \times 10^{-2}$ emu/g) acquired in H = 10 koe; 28% was lost in H_{AF} = 50 oe and only 31% remained after 250 oe cleaning. 3) The low reduced saturation ratio (.002) indicating a high content of MD + SPM grains relative to stable, single-domain (SD) material.

The coercivity spectrum of 60315, approximated by increments of magnetization in ΔH = 1 koe field intervals up to 10 koe, revealed a mean coercivity (H_c) well below 1 koe, and a high saturating field (H_s ∿ 10 koe).

In 62295, H_c ∿ 300 oe and H_s ∿ 7.5 koe, which suggests a higher content of fine (SPM) iron grains. Values of initial susceptibility (χ_i ∿ 35 x 10^{-4} in 60315 and 12.6 x 10^{-4} in 62295), M_s/χ_i ratios (1025 and <660) and shapes of hysteresis loops confirm that iron grains are generally larger in 60315, than in 62295.