MAGNETIC RESONANCE PROPERTIES OF SOME LUNAR MATERIAL: MOSTLY APOLLO 12*

J. L. Kolopus, D. Kline[1], R. A. Weeks[2], and A. Chatelain[3]
Solid State Division, Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

Electron paramagnetic resonance (EPR) measurements have been made on samples of the following fines: 12001-15,16, 12030-16, 12024-48 and 12070-125; and crystalline rocks: 12021-55 and 12075-19. Nuclear magnetic resonance (NMR) measurements have been made on samples 12001-16, 12021-55-2, 10046-58, 10047-50, 10057-70, and 10062-21. While the NMR measurements were made on whole, bulk samples, the EPR measurements were made on two types of samples: 1) homogeneous fractions of each specimen encapsulated under a vacuum in a quartz tube and 2) identifiable mineral separates which were selected under a microscope from the crystalline rock samples. EPR measurements were made at frequencies of 9 and 35 GHz at temperatures between 77°K and 300°K while NMR measurements were made from 12 to 16 MHz at room temperature.

The most intense component of the EPR spectra of homogeneous specimens of soil and breccia samples from the Apollo 12 collection is similar in intensity for the same specimen weights, in shape and g-value ($g = 2.1$), in width, frequency, and temperature dependence to the most intense component of the spectra of soil and breccia samples from the Apollo 11 collection upon which we have made measurements. This resonance has been identified by Manatt et al.[1] as being principally ferromagnetic resonance absorption and our data indicate that probably most of the absorption is of this type. Another, much weaker absorption peak ($g \simeq 4.2$), observed in all these samples, appears to arise from an independent magnetic complex. The spectra of homogeneous specimens from crystalline rock samples, 12021-55 and 12075-19 and

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[1]State University of New York at Albany, Albany, New York.

[2]Distinguished Visiting Professor, American University in Cairo, Cairo, Egypt, U.A.R. (On leave of absence from Oak Ridge National Laboratory).

[3]Ecole Polytechnique, Lausanne, Switzerland.

the spectra of homogeneous samples of 10057-70, 10047-49, and 10062-21 differ markedly from the spectra of the soil samples. However, the spectra of pyroxene and plagioclase fragments separated from soil samples are similar to those of the same minerals separated from 10057-49 and 12021-55. The spectrum of Mn^{2+}, detected in plagioclase and pyroxene specimens separated from 10047-49, 12021-55, and 12075-19, and in all terrestrial and most meteoritic olivines upon which we have made measurements, was not detected in an olivine fraction of 12075-19. Alterations of the spectrum of the plagioclase fraction of 10047-49 and 12021-55 when gamma-ray irradiated at temperatures of 77°K and 300°K are discussed in terms of valence changes of certain of the impurity ion spectra. The production of oxygen vacancy centers (E' centers) in separate fractions of sample 12021-55 by 2 Mev Van de Graaff irradiation is also discussed.

The frequency dependence of the NMR dispersion mode spectra of ^{27}Al and ^{23}Na from samples 12001-16, 12021-55-2, 10046-58, 10047-50, 10057-70, and 10062-21 can each be described in terms of second-order quadrupole broadened "central" ($m_I = 1/2$ $m_I = -1/2$) transitions with slightly differing distributions of asymmetry parameters and quadrupole coupling constants. On the basis of computer simulations of line shapes small internal magnetic fields of 5 to 10 gauss which oppose the laboratory field are required for both ^{27}Al and ^{23}Na for best fit. The NMR dispersion mode spectrum of ^{29}Si from 12021-55-2 also appears to be affected by an internal field of a similar magnitude and sign. Comparison of the ^{27}Al spectra from lunar samples with that of a powdered sample of terrestrial anorthite showed strong qualitative similarities and confirmed, with the aid of computer simulations, that the upper and lower bounds of the distributions of quadrupole coupling constants and asymmetry parameters in the lunar samples correspond in large part to those of the eight sites of anorthite. One feature of the ^{27}Al spectrum from anorthite is not seen in any of the lunar spectra, reflecting possible differences in relaxation processes. For the ^{23}Na spectra from lunar material, which resemble qualitatively that of terrestrial BCR-1 Basalt, it is estimated that the distributions of quadrupole coupling constants lie mainly in the range 2-4 MHz and asymmetry parameters largely in the range 0.2 to 0.8.

REFERENCES

1. S. L. Manatt *et al.*, Science *167*, 709 (1970).

James L Kolopus

J. L. Kolopus
Principal Investigator