ELECTRICAL CONDUCTIVITY OF LUNAR SURFACE ROCKS AT ELEVATED TEMPERATURES+, F.C.Schwerer*, G.P.Huffman*, R.M.Fisher*, and T. Nagata**.
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Previous determinations of the electrical conductivity at elevated temperatures of returned lunar samples were marked by large, irreversible increases in conductivity after heating to above approximately 400°C.[1] It now appears that this thermal hysteresis resulted from sample contamination--most probably from decomposed hydrocarbons from vacuum O-rings, valve packings and pump oil. Identification of contamination as the source of changes in conductivity as large as a factor of $10^6$ was complicated by several apparently contra-indicating observations including (i) the existence of good vacua (better than $10^{-6}$ torr) in the sample chamber during the high temperature runs, and (ii) the absence of degradation of certain test samples and of adjacent insulating (boron nitride) parts of the sample holder. Possibly lunar samples are more sensitive to carbon contamination as a result of their extremely low oxygen activity.

Recently, reproducible dc and low frequency (5Hz) ac electrical conductivity data at temperatures from 100 to 800°C were obtained for a lunar breccia (Ap. 10048) and basalt (Ap. 15555). A three-electrode technique was used to separate surface and bulk conductances and the separation apparently was effective to better than 1 part in 100. Limiting values due to leakage effects are shown in Fig. 1 for dc (solid lines) and ac (dashed line) conductivities. Measurements were made with samples in a silica furnace tube with gaseous buffering systems and with minimal access to potential carbon sources. Atmosphere effects were studied by exposing samples to reducing ($He-H_2$) and oxidizing ($He-O_2$) gas mixtures. Typical data are shown in Figs. 1 and 2 (ac and dc data are represented by closed and open symbols, respectively). In both figures, the upper branches are for samples after exposure to oxidizing atmospheres at 800°C; the lower branches, after exposure to reducing atmospheres at 800°C. All data were reproducible provided samples were buffered with the appropriate atmosphere and the changes in conductivity due to oxidation and reduction are reversible. The observation that the conductivity increases upon oxidation is apparently contrary to the suggestion by Wright[2] that lunar conductivity-profile anomalies[3] may be due to oxygen deficiencies; however, more definitive studies are required.

"Non-equilibrium" atmospheres affected the conductivity of the porous basalt at temperatures above 280°C whereas the conductivity of the breccia appeared stable in a neutral atmosphere (He) to above 500°C. Below the temperature at which the conductivity appeared to be affected by the atmosphere, the data on initial heating coincided with data for samples after heating in a reducing atmosphere (see data represented by triangles in Fig. 1). Consequently data for the "reduced" samples are considered representative of <u>in situ</u> lunar material. The ac conductivities of these two

ELECTRICAL CONDUCTIVITY AT ELEVATED TEMPERATURES

F. C. Schwerer, et al

lunar rocks in the "reduced" state are well represented by the following equations (cf Fig. 2):

$$\sigma(T) = 4.4 \times 10^{-2} \exp(-.85/kT) + 4.3 \times 10^{-3} \exp(-.71/kT) \text{ for } 10048,$$

and

$$\sigma(T) = 2 \times 10^{-1} \exp(-.98/kT) + 3 \times 10^{-4} \exp(-.64/kT) \text{ for } 15555,$$

where k is Boltzman's constant (eV/$^{\circ}$K), T is the temperature ($^{\circ}$K) and the electrical conductivity, $\sigma$, is in units of (ohm-cm)$^{-1}$.

These conductivity values are considerably lower than those reported previously for lunar rocks[1]; however, they are considerably larger than those reported recently by Olhoeft[4] et al for lunar soil. Anderson and Hanks[5] have recently discussed interior lunar temperatures as deduced from conductivity profiles[3] and the experimental conductivities of various materials. These present lunar conductivity values are very close to the values quoted for an olivine (9.4 molar percent fayalite) with no ferric iron and would imply considerably higher lunar temperatures than previously supposed (cf. curve 4, Fig. 1, Reference 5).

More detailed conductivity measurements as well as Mössbauer and electron microscope studies of the effects accompanying the various thermal and chemical treatments are currently in progress on a variety of lunar rocks returned by Apollo missions 11, 12, 15 and 16 as well as for several terrestrial pyroxenes.

References

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ELECTRICAL CONDUCTIVITY AT ELEVATED TEMPERATURES

F. C. Schwerer, et al

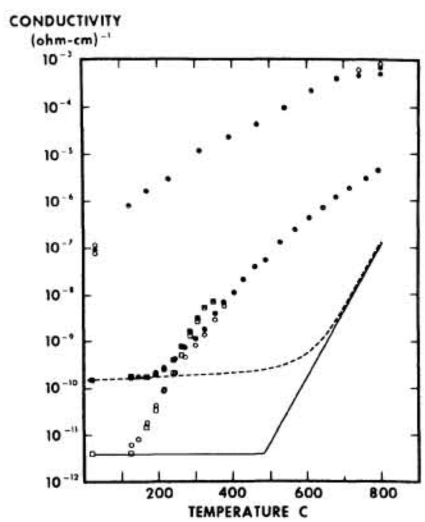


FIGURE 1 - Electrical Conductivity for lunar basalt Apollo 15555.

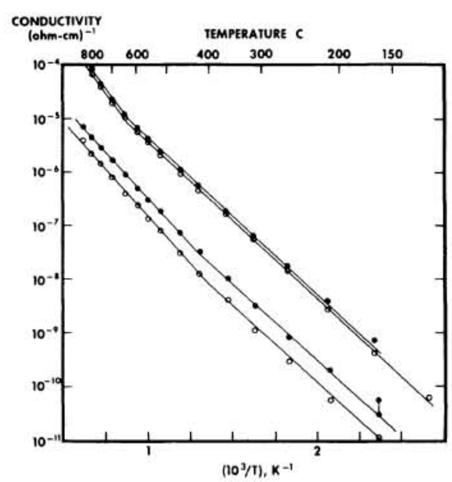


FIGURE 2 - Electrical Conductivity for lunar breccia Apollo 10048.