SURFACE PROPERTIES OF A NORTH RAY CRATER SOIL (APOLLO 16)\(^1\)

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Soils from the rim of North Ray Crater are considered to be immature and have had a relatively simple flux history. The coarser soils all have relatively low abundances of agglutinates as well as relatively low nickel contents.\(^2\) These three factors suggest that these soils have been subjected to gardening processes (e.g., micrometeorite impact) for a shorter time than the typical soil. One of these soils (67481) has an agglutinate age of 58 m.y. while a soil (66341) from the adjacent Station 13 has an agglutinate age of 101 m.y.\(^3\) Since the surface properties of 63341 have been studied, it seemed desirable to do a similar study of 67481 in search for a correlation of surface properties with soil maturity.

The experimental technique for the gravimetric measurement of adsorption isotherms for gases on lunar samples has been adequately described.\(^4\) The specific sample used in the present study was a 400 mg aliquot of 67481.\(^5\) All particles greater than 1 mm had been removed by sieving.

Initially, the sample was outgassed at 300\(^\circ\)C to remove gases adsorbed from the laboratory atmosphere while loading the sample on the microbalance. Following this, the adsorption of nitrogen was measured at -196\(^\circ\)C (77\(^\circ\)K). The resulting adsorption isotherm is shown in Figure 1. Reversibility of the isotherm on desorption is good evidence that the sample is devoid of that type of porosity which affects the adsorption of gases. A BET treatment\(^5\) of the adsorption data up to a relative pressure of 0.35 gave a specific surface area of 0.46 m\(^2\)/g. Both of these results are in agreement with the seemingly inherent nonporosity and low specific surface area of lunar fines.\(^4\)

Next in the experimental sequence was the measurement of water vapor adsorption at 20\(^\circ\)C. The results will not be presented in this paper, but the adsorption isotherm was typical of those that we have previously observed.\(^4\) Important features were massive adsorption as the pressure approached saturation, extensive hysteresis on desorption, and the irreversible adsorption of a relatively large quantity of water. The specific surface area as deduced by a BET treatment\(^5\) of the adsorption branch, was 0.61 m\(^2\)/g. This is not a valid estimate of the surface area, but reflects the specific nature of water vapor sorption and includes chemisorption effects. Irreversibly adsorbed water remaining on the sample after evacuation at the end of the experiment was 0.785 mg/g (about the same as 63341\(^6\), but much more than for the orange soil 74220\(^5\)). This is much larger than can be explained on the basis of a monolayer of chemisorbed water. However, this result can be explained on the basis of irreversible adsorption of molecular water, both on the open surface and in any pores which may have been produced:

Any changes induced in the sample by the reaction with water vapor are best determined by measuring the adsorption of inert gases such as nitrogen.
Two such isotherms are shown in Figure 1. Data obtained after outgassing at room temperature (25°C) indicate very little change in the specific surface area (0.44 m²/g) although there is a well-defined capillary condensation hysteresis loop which is indicative of a porous sample. Data taken after outgassing the sample at 300° reveal that there has been a significant increase in the specific surface area (to 0.73 m²/g) and an increase in the size of the hysteresis loop. Both of these results are explained by the blocking action of irreversibly adsorbed water. The blocking action of adsorbed water has been observed, to some degree, with every lunar fines sample we have examined.

Additional information concerning the changes induced in the sample by the reaction with water can be obtained by comparing the adsorption of nitrogen before and after the reaction with water. This is done in Figure 2 which is a variation of the "t-plot" method developed by de Boer. One can question the absolute value of the thickness assigned to the reference isotherm (pre-H₂O), but there is no doubt about the relative behavior of the two sets of data. The upward deviation is due to capillary condensation in mesopores having curved surfaces while the intercept is due to adsorption in micropores (equivalent surface area, \( S_\text{m} \)) which fill at low relative pressures. The slope of the straight line is a measure of the open surface area, \( S_\text{t} \). Both \( S_\text{m} \) and \( S_\text{t} \) are included in the BET surface area, \( S_\text{BET} \), as denoted in Figure 2. Thirty-seven percent of the increase in surface area is in micropores; the corresponding value for 63341 is 35%.

In summary, we are led to conclude that the surface properties of this sample from North Ray Crater are very similar to those of soils from other locations on the lunar surface. In particular, this sample behaves much like 63341 from the adjacent station with respect to its reaction with water vapor (BET surface areas for the same pretreatment differed by no more than 0.03 m²/g). We conclude that the difference in agglutinate age of these two samples has little effect on the surface properties that we measured.
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