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Principal Science Results from Surveyor 5

L. D. JAFFE,[1] S. A. BATTERSON,[2] W. E. BROWN, JR.,[1] E. M. CHRISTENSEN,[1]
S. E. DWORNIK,[3] D. E. GAULT,[4] J. W. LUCAS,[1] R. H. NORTON,[1] R. F. SCOTT,[5]
E. M. SHOEMAKER,[6] G. H. SUTTON,[7] AND A. L. TURKEVICH[8]

The area of Mare Tranquillitatis in which Surveyor 5 landed appears to be similar to sites in Oceanus Procellarum. The gross elemental composition of the surface material and its response to a magnet are similar to those of a basalt. The debris layer appears to consist of aggregates of the order of 1 cm in diameter consisting of fine grains and set in a matrix of less-coherent fine grains (most of them 2 to 60 μ in diameter) mixed with some rocky fragments 1 mm and larger. The static bearing strength is less than 10^4 dynes/cm^2 for the upper few millimeters and averages approximately 3×10^5 dynes/cm^2 for the upper few centimeters. The evidence suggests that chemical differentiation has occurred in the moon, probably owing to internal heat sources; this is consistent with the hypothesis that the maria are basaltic volcanic flows.

The area of southwestern Mare Tranquillitatis in which Surveyor 5 landed appears generally similar to the sites in Oceanus Procellarum observed by Surveyors 1 and 3. All three areas are fairly level dark maria with rather similar distributions of craters and rocks. A surface layer of weakly cohesive fine particles, aggregates, and rocks is present in both Mare Tranquillitatis and Oceanus Procellarum. Differences between the surface layers in these maria are relatively small.

Surveyor 5 was the first soft-landing lunar spacecraft to obtain information about the chemical nature of the lunar surface. This information was obtained through two experiments, one giving the gross chemical composition by an α-particle backscattering instrument, and the other giving some magnetic characteristics of the surface material with a bar magnet.

The three most abundant elements found by Surveyor 5 at the mare landing site are the same as the most prevalent on the surface of the earth; in decreasing abundance, they are oxygen, silicon, and aluminum. The relative amounts of the chemical elements are similar to the amounts in a silicate rock of a basaltic type.

Lunar surface material of high magnetic susceptibility adhered to the magnet. The quantity of magnetic material observed on the magnet is comparable to that expected if the magnet came in contact with pulverized basalt with 10 to 12% magnetite and not more than 1% admixed metallic iron. Particle size of material attracted by the magnet was less than 1 mm.

Surveyor 5 landed in a dimple-shaped, 9- $\times$ 12-meter rimless crater, which is the largest member of a small chain of rimless craters; a parallel row of very small craters also occurs within the large crater. The long axis of the large crater and the crater chain are approximately parallel with the dominant linear features in the highlands west of Mare Tranquillitatis and with many other elongate craters and crater pairs in nearby parts of the mare. On the basis of its shape and the alignment of small associated craters, the crater in which Surveyor 5 landed may have been formed by drainage of surficial fragmental debris into a northwest-trending fissure.

[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91103.

[2] Dynamic Loads Division, NASA Langley Research Center, Hampton, Virginia 23361.

[3] NASA Headquarters, Washington, D. C. 20546.

[4] Planetology Branch, Ames Research Center, Moffet Field, California 94035.

[5] Division of Engineering and Applied Science, California Institute of Technology, Pasadena, California 91109.

[6] Branch of Astrogeology, U. S. Geological Survey, Flagstaff, Arizona 86001.

[7] Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Hawaii 96822.

[8] Enrico Fermi Institute for Nuclear Studies and Department of Chemistry, University of Chicago, Chicago, Illinois 60637.

Observations of blocky rimmed craters, relatively nearby, indicate that the local thickness of the layer of fragmental debris with low cohesion is not more than 5 meters. The walls of the Surveyor 5 crater provide exposures of the upper meter of this debris layer. Different types of fragments are revealed in the pictures of the debris dislodged from the walls during the landing and in the pictures of the undisturbed parts of the wall. The types of fragments include:

1. Bright, angular objects, which are inferred to be pieces of dense, rocky material.
2. Dark, rounded objects, which are probably aggregates of very fine-grained particles.
3. Dark, lumpy objects, which appear to be aggregates of aggregates.

The aggregate character of some of the loose ejected fragments is well demonstrated by the presence of bright angular chips set in a dark fine-grained matrix. At depths greater than about 10 cm, most of the debris layer appears to be composed of slightly compressed aggregates, ranging from a few millimeters up to 3 cm in diameter, set in a matrix of less-coherent finer particles. Rocky chips and fragments larger than a millimeter are dispersed as a subordinate constituent of the debris.

The estimated normal albedo (normal luminance factor) of the undisturbed parts of the lunar surface near Surveyor 5 is 7.9 ± 1.0%, somewhat lower than observed at the Surveyor 3 landing site. Debris ejected on the lunar surface in front of the footpads has a normal albedo of 7.5 ± 1.0%, which is only about one-twentieth lower than the albedo of the undisturbed surface but is similar to the albedo of the material disturbed by the footpads at the Surveyor 3 landing site.

New photometric evidence obtained from the Surveyor 5 pictures shows that the bright angular fragments are denser or at least less porous than the dark fine-grained surficial material and dark aggregates. The surfaces of the bright angular fragments have a photometric function more like that of a lambertian scatterer than like that of the fine-grained lunar material.

A spacecraft vernier engine firing against the lunar surface produced observable erosion resulting from two mechanisms: the removal of particles by exhaust gases blowing along the surface, and explosive blowout of entrapped gas and soil from directly beneath the nozzle immediately following engine shutdown. Analyses of the disturbance indicate the material has a permeability to gases of between 1×10^{-8} and 7×10^{-8} cm², which is comparable to the permeability of terrestrial silts.

As for Surveyors 1 and 3, the landing produced interactions with the surface. Various analyses of phenomena associated with the landing and with the firing of the vernier rocket engines have provided these additional estimates of surface properties.

Static bearing strength:
For upper few millimeters, $<10^4$ dynes/cm².
Averaged over upper few centimeters, $\sim 3 \times 10^5$ dynes/cm².
Angle of internal friction: consistent with Surveyor 3 results (37°).

Pressure developed by the soil against the footpad in resisting the slide during landing was about 7×10^4 dynes/cm², which agrees with results obtained from the soil mechanics surface sampler experiment on Surveyor 3. The estimate of permeability indicates that most of the particles are in the 2- to 60-μ size range; this values agrees with results from photographic observations of the disturbed areas, the match of Surveyor 5 footpad trenches to trenches produced experimentally in pulverized basalts, and analyses of Surveyor 3 footpad imprints. Clods observed in the disturbed areas appear to be similar to the ones observed in previous missions, indicating a similar cohesion. In general, the soil at this site appears similar to, but somewhat weaker than, the soil at the other Surveyor landing sites.

The lunar day temperatures derived from Surveyor 5 observations are in fair agreement with predictions based on telescopic observations. The temperatures of the lunar surface after sunset and during total eclipse suggest that the surface material has an effective reciprocal thermal inertia of approximately 500 cm² sec$^{1/2}$ °K/g cal, in good agreement with Surveyor 3 eclipse data. This value differs from a value of approximately 1000 obtained from data derived on earth.

The evidence that the lunar surface material at the Surveyor 5 landing site is basaltic in composition and the fact that this Surveyor 5 site appears to be typical of the mare areas are consistent with the hypothesis that the mare basins are filled with extensive basaltic volcanic flows. If such flows have occurred, some of the processes and products of lunar magmatic activity are apparently similar to those of the earth. The results suggest that differentiation has occurred in the moon, probably owing to internal sources of heat.

Surveyor 5 provided the first measurements of the brightness of the solar corona (the F corona) at distances of 10 to 30 solar radii from the center of the sun. Since the brightness is produced by the scattering of particulate matter between the earth and the sun, it should prove possible to derive density measurements of particulate matter at distances out to one-third the radius of Mercury's orbit. A good determination of the density distribution with height above the ecliptic plane can be made.

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