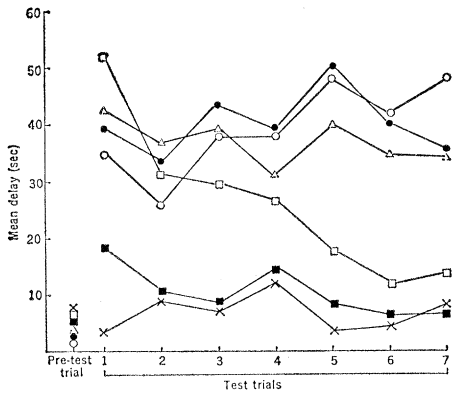

Fig. 1. Mean delay of hurdle-crossing, in seconds, for each injection condition on the last pretest trial and over all test trials. Key: saline, ×; strychnine: ●, 0.2 mg/kg; ○, 0.1 mg/kg; △, 0.05 mg/kg; □, 0.025 mg/kg; ■, 0.0125 mg/kg.

a second experiment evaluated the possible aversive effects of strychnine injections alone on hurdle-crossing behavior. This experiment replicated the procedures and injection conditions ($N = $ five rats per group) of the first experiment except for the procedures on the shock day (the 5th day). On this day, in the second experiment, the rat was placed in the shock box but no shock occurred. Thus, test-trial performance presumably reflected the effect of the injection conditions alone.

Figure 1 shows the results of the first experiment. Mean delay of hurdle-crossing is presented for all groups for the last exploratory (the pretest) trial and over all test trials.

Since maximum strychnine effects might reasonably be expected on the test trial immediately following injection, data for trial 1 were analyzed separately. The treatment effect was reliable ($P < .05$). Scheffé comparisons (*6*) showed no reliable differences among strychnine-dose groups, but each such group, except the 0.0125 mg/kg dose group, showed reliably longer delays in crossing the hurdle than did the saline group ($P < .05$ or better). The effects of strychnine over all tests trials were evaluated with a repeated measures analysis of variance (*7*). Only a reliable treatment effect was obtained ($P < .05$). Scheffé comparisons showed that delays of hurdle-crossing for the 0.2 and 0.1 mg/kg dose groups were reliably longer than those of the 0.0125 mg/kg and saline groups ($P < .05$). the 0.05 mg/kg dose group's delay of hurdle-crossing was also reliably longer than that of the saline group ($P < .05$) but only marginally longer than that of the 0.0125 mg/kg dose group ($P = .05$ to .10).

In the second experiment, test-trial performance of all groups was slightly and nonsignificantly below that of the saline group shown in Fig. 1. Analyses over all the second experiment's data showed no reliable effects of injection conditions.

Since hurdle-crossing behavior in the second experiment showed no reliable effects of injection conditions alone, the results of the first experiment suggest that strychnine injections facilitated the rats' learning to inhibit reentry into the situation where they were previously shocked. These data were consistent with expectations from a consolidation viewpoint. Presumably, memory traces of the shock experience were enhanced by strychnine injections in the first study.

However, the facilitative effects of strychnine seemed to have been regulated by the dosages used. Inhibition of hurdle-crossing was reliably shown over all test trials (relative to saline controls) following 0.2 mg/kg, 0.1 mg/kg, and 0.05 mg/kg injections. Following a 0.025 mg/kg injection, however, inhibition was reliably shown on test trial 1 but decayed thereafter; a 0.0125 mg/kg injection provided no reliable evidence for inhibition at all. These results suggested that strychnine dosage determined both the initial appearance and the apparent maintenance of response inhibition. The finding of a dose-response relationship here was consistent with previous findings with Metrazol (*8*) and strychnine (*4*) in similar hurdle-crossing situations.

JOSEPH J. FRANCHINA
Department of Psychology, De Paul University, Chicago, Illinois 60614

MARK H. MOORE
Department of Psychology, Southern Methodist University, Dallas, Texas 75225

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5 April 1968

Surveyor V: Chemical Observations

The observation that the lunar soil is of basalt-like composition at the Surveyor V site is taken by many (*1*) to substantiate the view, previously widespread, that volcanism formed the bulk of the lunar surface and that it supplied a differentiated type of rock. The case for this is, however, by no means simple and clear (*2*). The arguments against the explanation that a widespread differentiation occurred on the moon are now still valid and indeed have been strengthened in some cases by recent observations. They are concerned with the following points.

1) The lunar ground has suffered very little horizontal deformation in the whole of the history as depicted by its present surface. Even the oldest craters show as much tendency to circularity as the youngest. There are no chains of folded mountains and none of the large distortions of the high ground that would have been expected had large volumes been displaced in pouring lava over the low ground.

2) There is no widespread stratification visible on the lunar ground, even on the steep slopes of large fresh craters. Corresponding slopes on the earth would generally demonstrate much more clearly visible stratification, in respect both to color or albedo and to the tendency of erosion to cause terracing.

3) The large increase in resolution that the pictures from Lunar Orbiter give over terrestrial telescopes has led to little new morphological information indicating volcanism. The expectation that high resolution pictures would demonstrate a mass of clear volcanic features has not been fulfilled. The observed features that are internally caused are thought by many to be explicable in terms of movements of subterranean ice and water, rather than of magma (*3*). Subterranean water may have become available in the moon at a much lower temperature than that which would cause large-scale melting of rock.

4) The structural strength of the moon is high enough to allow the persistence of the present large departure from equilibrium in the distribution of its mass. A hot interior leading to a large amount of lava flooding on the surface is not compatible with this. The existence of substantial convection in the mantle has been proposed as the solution of the similar dilemma on the earth. Convection seems very unlikely

for the case of the moon because of the absence of horizontal deformations.

5) The moon loses very little gas at the present time. Many terrestrial volcanoes send out bursts of millions of tons of gases and smoke, and yet 1/100,000 of these amounts would be in the range of giving the moon a temporary atmosphere that can be discovered by optical or radio means. The presence of liquid rocks at a shallow depth at the present time seems to be excluded by the paucity of any gas emission.

6) The mean density of the moon is lower than that which it would have if it were initially composed of the same material as the earth. One has therefore to suppose that some type of differentiation had taken place before the formation of these two bodies, and it thus cannot be regarded as certain that any differentiated material was differentiated on the body where it is now found.

7) The value of C/ma^2 (where C is the largest moment of inertia; m, the mass; and a, the radius) is now known to be close to 0.4, indicating the absence of any substantial central condensation. Although this is perfectly compatible with the formation of a differentiated crust, it does indicate that any melting was limited and did not lead, as in the case of the earth, to the formation of a dense core.

It may be possible to interpret recent findings in several ways that are less in discord with all these points. The meteorites demonstrate that differentiation to various degrees has taken place in the solar system in bodies other than those that now exist. Since it is generally assumed that these bodies were shattered by collisions, one may ask whether the present-day meteorites represent a selection of material left over from these earlier phases, and which type of such material was responsible for building the moon or for adding the outermost layer to it. If the basaltic achondrites represent this material, the composition would fit, and one may then even wonder whether the basaltic layer that covers most of the deep oceans on the earth has a similar origin. Of course it is generally thought that this layer in the oceans is comparatively young, but the determinations of age are based on samples that have been raised and heated in a recent epoch. There may be a new interest now, both in age determinations of the seismically observed deep ocean layer and in detailed observations of the chemical composition, in order to compare this with lunar samples when they become available.

Other possible ways of better reconciling the known evidence must be sought so that one will ask the appropriate questions of the lunar exploration program. A disservice would be done to the lunar exploration program if one of the major questions came to be regarded as settled by an answer that still leaves a mass of conflicting evidence, such as the answer given in the official Surveyor V report published in *Science* (*1*).

Note added in proof. The results of the chemical analysis of Surveyors VI and VII show a strikingly similar composition in widely different regions. The Surveyor VII sample probably represents deep subsurface material excavated by the Tycho explosion, suggesting that the same composition extends to a considerable depth. Such a similarity would be quite unexpected on the earth. The slightly higher iron content of the two lowland samples may merely represent an enrichment of the longer-exposed surface material with iron-rich present-day meteorites.

T. GOLD
Center for Radiophysics and Space Research, Cornell University, Ithaca, New York 14850

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4 March 1968

Deformation Lamellae in Quartz

In a recent contribution Greenwood (*1*) reports the occurrence of planar deformation features in quartz which he believes are identical to those considered by other investigators (*2*, *3*) as indicative of shock-wave action and meteorite impact in ancient "cryptoexplosion" structures. Greenwood's specimens occur in rocks for which a meteorite impact origin is implausible, and his conclusions, if taken at face value, appear to undermine the use by other workers (*2–5*) of unusual planar features in quartz as evidence of ancient meteorite impact.

In view of Greenwood's (*1*) conclusions, it is unfortunate that his report does not include (i) some discussion of his measurement techniques, in order to justify the assignment of exact crystallographic indices to his planar features, and (ii) a summary of all his measurements in tabular, stereographic, or histogram form, in order to allow comparison with data that has been obtained from other studies of quartz from both metamorphic and shock-metamorphosed rocks.

It has long been recognized that planar deformation lamellae develop in quartz deformed at low strain rates during normal tectonic metamorphism (*6–8*). No extraterrestrial origin has ever been proposed for such "deformation lamellae" in the narrow sense.

The "shock lamellae" or "planar features" observed in quartz from shocked rocks are quite distinct from normal metamorphic deformation lamellae, particularly in such characteristics as the number of sets per grain and the orientation of the planes within the quartz crystal (*2–5*, *9*). These unique planar features are believed characteristic of shock-wave action. They have been observed in rocks from accepted meteorite craters and have also been formed under controlled shock conditions in experiments involving nuclear and chemical explosions (*10*).

Some justification is needed for Greenwood's statement that his planar features are in fact parallel to $\{10\bar{1}3\}$. Such exact identification of the orientation is not possible unless the absolute orientation of the host quartz crystal can be established, and it is not possible to tell, from Greenwood's (*1*) description, whether such absolute orientations were actually obtained.

Measurements performed by several workers on shocked rocks (*2*, *3*, *9*) do indicate that certain of the shock lamellae are in fact parallel to $\{10\bar{1}3\}$. However, in many natural samples, particularly metamorphic rocks, such exact measurements are difficult or impossible. An alternate procedure, therefore, has been to measure the angle between the poles to the planar features and the *c*-axis of the quartz grain and to plot the distribution of these angles as a histogram (*3*, *4*, *9*). Such histogram plots facilitate the qualitative comparison of the distribution of shock lamellae with that of normal metamorphic deformation lamellae (*2*), but it must be remembered that it is not possible to