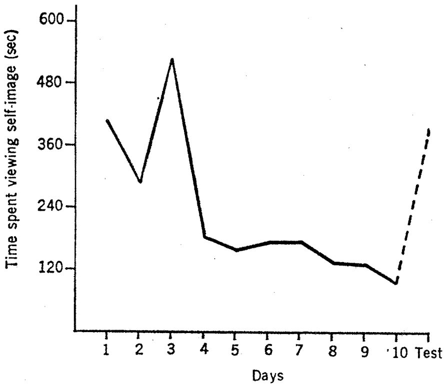


Fig. 3. Average amount of time, during two 15-minute sessions, spent viewing the reflected image in the mirror over days.

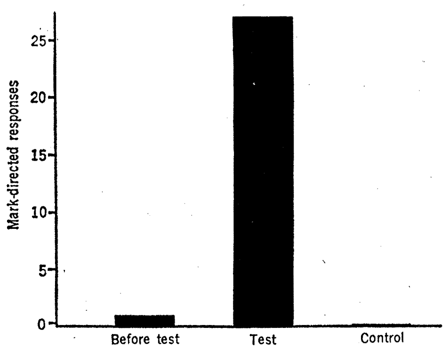


Fig. 4. Number of mark-directed responses made by experimental animals before being exposed to a mirror and by experimental and control animals during the test of self-recognition.

mals appeared to have fully recovered and were fed and watered. Four hours after having been marked, each animal was then directly observed for 30 minutes to determine the number of times any marked portion of the skin was touched spontaneously. The mirror was then reintroduced for a test of self-recognition at a distance of 0.6 m from the front of the cage, and behavior was monitored from behind the wall for an additional 30 minutes (Figs. 1–3).

The number of mark-directed responses went up dramatically upon reexposure to the mirror, as did viewing time (Figs. 3 and 4). During the test, the frequency of mark-directed responding per animal ranged from 4 to 10 as compared to only one response prior to exposure to the mirror, and viewing time increased over the previous two sessions by a factor of more than four. On occasion, mark-directed behaviors also took the form of direct visual inspection of the fingers which were used to touch marked areas even though the dye had long since dried and was not transferable to the fingers. In one particularly noteworthy instance there was olfactory as well as visual inspection of the fingers which had been used to touch marked areas.

As a further check on the source of these reactions two naive wild-born chimps, a male and a female, of approximately the same age as the previous subjects, but with no mirror experience, were also anesthetized, marked, and studied as controls. After they were marked and confronted the mirror for the first time, the controls made no mark-directed responses (Fig. 4), which indicates that the capacity for self-recognition had presumably been learned by the other animals sometime during the previous 10 days of exposure.

As a test for this capacity in other primate species, two male and two female adult stump-tailed macaques (*Macaca arctoides*; formerly *M. speciosa*) and two adult male rhesus monkeys (*M. mulatta*) were given prolonged exposure to mirrors in a comparable situation for 12 hours per day and tested in the same fashion as the chimps. Mark-directed responses were nonexistent in all animals after 14 days of mirror-image confrontation. Moreover, informal observation indicated little decline over days in the incidence of social behavior directed toward the mirror and virtually no evidence of self-directed or self-recognition patterns. As a further check, three male and one female preadolescent cynomolgus monkeys (*Macaca fascicularis*; formerly *M. irus*) were exposed for more than 250 hours to mirrors (3 weeks). Tests yielded uniformly negative results with, again, no apparent decrease in social responsiveness to the mirror image.

Such a decisive difference between monkeys and chimps is particularly interesting in view of the fact that most investigators have found only relatively slight quantitative differences on other, more traditional, behavioral tasks (*2*). Recognition of one's own reflection would seem to require a rather advanced form of intellect; it is known, for example, that at least some mentally retarded children apparently do not have the capacity to recognize themselves in mirrors (*3*). Moreover, insofar as self-recognition of one's mirror image implies a concept of self, these data would seem to qualify as the first experimental demonstration of a self-concept in a subhuman form.

Over and above simple self-recognition, self-directed and mark-directed behaviors would seem to require the ability to project, as it were, proprioceptive information and kinesthetic feedback onto the reflected visual image so as to coordinate the appropriate visually guided movements via the mirror. Our data suggest that we may have found a qualitative psychological difference among primates, and that the capacity for self-recognition may not extend below man and the great apes.

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10 November 1969

## Lunar Surface Rocks and Fines: Chemical Composition

A critical examination of the chemical abundance data on 12 specimens of lunar surface material has led to several conclusions of remarkable geochemical and cosmochemical interest (*1*). It is indeed true that "The chemical composition of the Tranquillity Base fines and igneous rocks are unlike those of any known terrestrial rock or meteorite." Nevertheless, some abundance features appear to us to be distinctly eucritic.

Table 1. Average abundances of the major elements in eucrites and in rocks and fines from the Tranquillity Base.

| Element | Tranquillity Base (% by weight) | Eucrite (% by weight) |
|---|---|---|
| Si | 19.2 | 22.8 |
| Fe | 14.0 | 13.6 |
| Ca | 7.4 | 7.1 |
| Al | 5.9 | 6.7 |
| Ti | 5.7 | 0.47 |
| Mg | 4.8 | 3.9 |
| Na | 0.38 | 0.3 |
| Cr | .36 | .25 |
| Mn | .27 | .39 |
| K | .11 | .04 |

Table 2. Abundances of some elements which increase in the order: Tranquillity Base rocks and fines > eucrite Stannern > average eucrite.

| Mineral | Ti (% by weight) | Zr (ppm) | Y (ppm) | Sc (ppm) | U (ppm) | Th (ppm) | Ba (ppm) | Sr (ppm) |
|---|---|---|---|---|---|---|---|---|
| Average eucrite | 0.47 | 50 | 20 | 25 | 0.1 | 0.4 | 35 | 80 |
| Stannern eucrite | 0.58 | 70 | 28 | 32 | 0.18 | 0.50 | 52.5 | 85 |
| Tranquillity Base | 5.7 | 880 | 200 | 88 | 0.54 | 2.3 | 97 | 114 |

Two points should be borne in mind when one considers the data: (i) the estimated accuracy and (ii) the uniformity of chemical composition of the samples (*1*).

The d-c arc spectrochemical method used to obtain the bulk of the analytical data is in large part the same as that described by Ahrens (*2*) and, generally speaking, each abundance value has an uncertainty of approximately 10 percent (*1*). Although the data are therefore not highly accurate, they are nevertheless satisfactory for our purpose. Because of the uniformity of chemical composition in the specimens, an average value is of considerable significance, despite the fact that the number (12) of specimens that have been analyzed is small.

The data to be considered (Tables 1 and 2) are average values for the abundances of some elements in Tranquillity Base material and average eucrite, together with values for the single eucrite, Stannern (some elements only). Data for eucrite Stannern is included because its composition differs somewhat from that of other eucrites and appears to be significant for our discussion.

A few elements in the lunar material, such as Ni, Co, and Sc, will not be considered. Unlike most other elements, the concentrations of Ni, Co, and Sc are variable, and an average value based on relatively few specimens is therefore not significant. The average elemental abundances in eucrite and the data for eucrite Stannern are based on a compilation of Ahrens and Danchin (*3*).

Several major features are apparent in the data (Tables 1 and 2). First, the abundances of several elements (Si, Al, Ca, Mg, Mn, and Sr) in the lunar rocks are either close to or approximately equal to abundances observed in the eucrites. When more accurate data become available, it will be interesting to ascertain whether the ratio of Ca to Al in the lunar surface is the same as that in stony meteorites; in the latter this ratio is uniform with an average value of 1.1 (*4*). The data available at present indicate that the values of this ratio in lunar rocks are similar to those in stony meteorites. The concentrations of a few elements (K, Rb, Ba, Li, U, and Th) in the lunar rocks are somewhat higher than those in the eucrites and resemble concentrations in some terrestrial tholeiites.

Second, the concentrations of several elements, notably Ti, Zr, and Y, are conspicuously higher in the lunar rocks than in the eucrites. Third, and particularly pertinent, some features of the lunar rocks are uniquely eucritic.

Despite their high ilmenite content, the Fe content in the lunar rocks (average, 14 percent) is very close to the average value (13.6 percent) for both eucrites and howardites and is much higher than that in terrestrial basaltic rocks. It has been shown (*5*) that the Fe content in eucrites and howardites tends to be uniform; this uniformity of concentration appears to be a feature of the lunar rocks also.

A characteristic feature of all stony meteorites (chondrites and achondrites) is a high proportion of Cr, relative to that of terrestrial basalts, whose Cr contents range from a few parts per million to a few hundred parts per million. At the other extreme and equally striking is the low Cu content of the eucrites (a few parts per million), a feature also characteristic of the lunar rocks and fines which have been analyzed so far. The Cu contents of terrestrial basalts are far higher.

Mention might also be made of Ga. Although the lunar data on this element are not particularly satisfactory (*1*), the indications are that the Ga concentration (< 4 ppm to 8 ppm) is much less than that in terrestrial basaltic rocks (15 to 25 ppm) and appears to be quite similar to values (1.55 to 3.4 ppm) reported for eucrites (*6*).

The absolute and relative abundances of the alkali and alkaline earth trace elements are also particularly significant in this respect. The Na content of the lunar rocks, for example, is distinctly eucritic and lower than abundance levels in either chondrites or terrestrial basalts. The Tranquillity Base material and eucrites have similar ratios of K to Ba (K/Ba = 10), compared with a value of 300 for chondrites (*3, 7*). The similarity in the ratios of Rb to Sr in the lunar material and eucrites has been noted (*1*).

The ratio of K to Rb in lunar rocks (average, 300), on the other hand, shows the closest similarity to values for the chondritic meteorites (average, 300) as compared with an average value of 1400 in eucrites. Significantly, the ratio of Na to K in lunar rocks (average, 4) is unlike that of either the chondrites or the basaltic achondrites, both of which average about 8.5 (*8*).

Some abundance features of the Stannern meteorite differ somewhat from those typical of other eucrites. The concentrations of many elements (Ti, Zr, Y, Sc, U, Th, Sr, and Ba, for example) which are higher in the lunar rocks and fines than the average eucrite, are also higher (often only slightly but nevertheless quite distinctly) in Stannern compared to other eucrites. Such evidence could be taken to indicate a genetic link between eucrites and the lunar surface material. Moreover, the existence of several distinctly eucritic abundance features in the lunar rocks and fines lends considerable weight to Duke's (*9*) suggestion that basaltic achondrites, and specifically eucrites, are derived from the moon.

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13 November 1969