esses whose overall response can be resolved into two exponential terms. A similar result can be obtained for three terms or more.

Hence Van Liew's prediction (2) of a multiexponential response from a continuum of linear processes would appear to be pure conjecture—particularly when such speculation is accompanied by no mathematics whatsoever.

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20 November 1967

Implications of the Surveyor V Chemical Analysis

The interpretation of the alpha backscattering chemical analyses of the lunar surface given by Gault *et al.* (*1*) overlooked some important differences between the lunar and terrestrial material. In addition, the inferred chemical differentiation of the moon is not a necessary consequence of the observed chemical composition.

It is unfortunate that the alpha backscattering technique cannot resolve the heavy elements in more detail. Some additional information may be gained if we add to the observations two rather plausible assumptions: (i) those elements above P in atomic number consist primarily of Ca and Fe with minor amounts of K, Ti, and Ni (to make a comparison, I lump Ca plus K, and Ti, Fe, and Ni); and (ii) the atom ratio of Ca to Al on the lunar surface is similar to that in terrestrial basalts or in eucrites. Significant chemical differences between the terrestrial basalts and eucrites (*2*), in particular the high iron and low sodium content of the latter, are evident in the comparison given in Table 1. My assumptions regarding the lunar material require that the iron, nickel, and titanium content of the mare material is even higher than that of the eucrites. If the second assumption is not made, the calcium and potassium content inferred for lunar material must be increased if the iron content is reduced. Thus, either the Ca and K content or the Fe, Ti, and Ni content of lunar mare material is significantly greater than that of terrestrial basalts. Any significant reduction in the limit for the Na content given by Turkevich *et al.* (*3*) results in a ratio of Na to Si (for the lunar material) that is more like that observed in eucrites than in basalts.

The similarities of the eucrites and mare material support the suggestion (*4*) that these meteorites originate on the moon. If the origin of mare material is related to the origin of material with a similar chemical composition, the textures and chemical compositions of the eucrites rather than those of terrestrial basalts should be considered.

If the origin of mare material cannot be inferred as a priori consequence of its chemical composition, the wide-scale differentiation of the moon that is implied by Gault *et al.* (*1*) must rest on the presumed ultrabasic or peridotitic composition of the moon. Thus, an answer to one of the most interesting questions raised by planetary exploration, that is, whether or not there are major differences in the bulk chemical composition of planetary bodies, is assumed by Gault *et al.* (*1*) to arrive at the conclusion that the moon is probably differentiated.

The chemical fractionation processes that have operated during the formation of planetary bodies and meteorites may have resulted in planetary bodies and meteorites with varying chemical compositions (*5, 6*). Enrichment in Ca and Al is expected in any material enriched in iron for solid matter formed by condensation from a gaseous nebula with solar composition (*6*). The possibility that the entire moon, or a substantial fraction of it, is characterized by high contents of Al, Ca, and Fe should be considered before these chemical characteristics of surface materials are used to infer earthlike magmatic differentiation processes on the moon.

The chemical analysis resulting from the analysis of alpha backscattering also suggests an important geophysical result. If the material analyzed is representative of the lunar surface, the density of compacted material with the composition in Table 1 is very significant. The large uncertainties make it meaningless to calculate the mineral composition of this material from the chemical composition. However, it is clear that the higher Fe content will result in a significantly higher density than that of terrestrial basalt. The measured density of eucrites at atmospheric pressure ranges from 3.00 to 3.30 (*7*). The density of a mixture consisting of pyroxene, plagioclase, and metallic iron in the proportions found in average eucrites is 3.25. The chemical result from Surveyor V thus suggests that the density of compacted surface material is rather similar to the mean density of the moon, 3.35. If the observed chemical composition is typical, the density contrast between the surface of the moon and interior of the moon may be relatively small.

Table 1. Comparison of chemical elements in lunar mare material, oceanic tholeiites (abyssal basalts), and eucritic meteorites.

Elements	Lunar mare material	Oceanic tholeiite (*8*)	Eucrite Pasamonte (*7*)
O	56 $\pm$ 5	60.4	59.8
Na	$<$2	1.9	0.23
Mg	3 $\pm$ 3	3.9	3.7
Al	6.5 $\pm$ 2	7.4	6.3
Si	18.5 $\pm$ 3	18.2	18.5
$>$P	13 $\pm$ 3		
FeCoNi	$>$3		
(Ca + K)*	3.9	4.6	4.2
(Fe + Ti + Ni)*	9.1	3.0	6.4

* Assume that the ratio of Ca to Al is the same as in basalts and that $>$P is predominantly Fe and Ca.

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References and Notes

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