Another group of samples was taken by *Alvin* on the Blake Plateau (Table 2). Two of the samples (dive 200) were taken near the axis of the Gulf Stream where the water current was about 50 cm/sec. In contrast, water farther up the column contained less than a tenth of the total suspensate noted in the bottom water. From the viewing ports of *Alvin* we observed soft gelatinous or flocculent particles, sometimes as large as 1 cm in diameter, that characterized the upper 200 m of water, both over the Blake Plateau and in slope waters off Cape Hatteras. The sizes of these particles increased downward, reached a maximum at depths of 20 to 100 m, and then diminished rapidly to an approximately constant size at deeper levels. Similar phenomena have been observed near Japan (*19*).

What is the significance of our results in the context of the long-term movement of sediment on the continental margin? Because 1965 was an exceptionally dry year in the North Atlantic states, our studies north of Cape Hatteras probably reflect minimum contributions of riverborne detritus. In the South Atlantic states, however, 1965 was wetter than average, and we may have sampled concentrations of suspended matter that were a little larger than normal for May and June. On the basis of this, we conclude that the transport of suspended detritus via surface waters across the continental shelf to the regions of the continental slope is minimum during normal or near-normal conditions. Abnormal events such as storms and floods, on the other hand, have a strong but quantitatively unknown effect on the transport of detritus in coastal water. For example, surface water 20 km off Cape Canaveral (Cape Kennedy) contained 7 mg/liter of suspended matter 2 days after Hurricane Betsy traversed the area in September 1965. One month earlier, surface water in the same area contained only 0.25 mg/liter. Similar increases in the concentration of suspended matter following storms have been observed in the Bering Sea (*20*). Evidence on the movement of bottom sediments on the continental shelf and in estuaries of the Atlantic seaboard indicates that the dominant direction of bottom movement is landward rather than seaward (*21*). If sediment transport by storms is limited to the present shelf regions, from which the sediment is subsequently moved inland by bottom currents, we conclude from the information now available that the continent is presently contributing litle detritus to the continental slope and deeper regions of the Atlantic Ocean.

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Chemical Composition of the Lunar Surface in Sinus Medii

Abstract. *More precise and comprehensive analytical results for lunar material in Sinus Medii have been derived from the alpha-scattering experiment on Surveyor VI. The amounts of the principal constituents at this mare are approximately the same as those of constituents at Mare Tranquillitatis. The sodium contents of both maria are lower than those of terrestrial basalts. The titanium content at Sinus Medii is lower than that at Mare Tranquillitatis; this suggests important differences in detailed chemical composition at different mare areas on the moon.*

The alpha-scattering experiment on three of the Surveyor soft landings on the moon made possible the first direct chemical analyses of lunar surface material. Preliminary results of these anal-

Table 1. Chemical analyses at the Surveyor mare sites. Values and errors in columns 2 through 8 are expressed as atom percentages on a hydrogen-free basis.

Element*	Error of the method (1 σ)	Surveyor V (Mare Tranquillitatis)		Survivor VI				
				Standard glass		Sinus Medii surface material		
		Alpha analysis†	Estimated errors‡	Composition	Alpha analysis†	Alpha analysis†	Estimated errors‡	Oxide (% by weight)§
O		61.1 ± 0.6	± 1.0	57.6	55.7 ± 1.3	59.3 ± 1.0	± 1.6	
F		0.05 ± 0.05	± 0.08			0.07 ± 0.08	± 0.13	
Na	± 0.05	0.47 ± 0.08	± 0.15	9.6	9.5 ± 0.2	0.59 ± 0.14	± 0.24	0.8
Mg	± 0.9	2.8 ± 0.2	± 1.5	8.4	9.7 ± 0.5	3.7 ± 0.3	± 1.6	6.6
Al	± 0.2	6.4 ± 0.1	± 0.4	0	0.3 ± 0.2	6.5 ± 0.2	± 0.4	14.7
Si	± 0.7	17.1 ± 0.3	± 1.2	17.2	17.6 ± 0.6	18.5 ± 0.4	± 1.4	49.1
"S"		0.0				0.0		
"Ca"	± 0.3	5.5 ± 0.3	± 0.7	0	0	5.2 ± 0.4	± 0.9	12.9
"Ti"	± 0.1	2.0 ± 0.3	± 0.5			1.0 ± 0.5	± 0.8	3.5
"Fe"	± 0.2	3.8 ± 0.1	± 0.4	7.1	7.3 ± 0.1	3.9 ± 0.2	± 0.6	12.4
"Zn"		< 0.09				< 0.13		
"Sr"		< 0.06				< 0.13		
Zr-In		< 0.06				< 0.16		
Sn-U		< 0.07				< 0.10		

* The symbols for elements heavier than silicon represent groups of elements whose mass ranges are given in Table 1 of the final Surveyor V report (*4*). † These values are the results (with statistical errors of 1 σ) of the least-squares treatment on the basis of an eight-element library for the standard glass and a 13-element library for the samples from the lunar surface. They have been corrected for the small biases of the method. ‡ The estimated errors were calculated from the error of the method and the statistical errors. They are quoted at the 90 percent confidence level. § We calculated this oxide composition from the values of column 7 (neglecting the apparent deficiency of 2.6 atom percent of oxygen) for the oxides Na_2O, MgO, Al_2O_3, SiO_2, CaO, TiO_2, and FeO.

yses as well as final results for the Surveyor V site in Mare Tranquillitatis have been reported (*1–4*). The data from Surveyor VI, which landed at another mare site (Sinus Medii), have now been processed more completely. As in the final reduction of Surveyor V data (*4*), the results have been derived from more data than were available at the time of the preliminary report and from more detailed and improved data processing. This has led to significantly more comprehensive and precise results for Sinus Medii than were reported earlier (*2*).

The method of chemical analysis by alpha-particle interactions leading to scattered alpha particles and protons has been described (*5*). The accuracy of this method has been examined by analysis of rocks of known composition (*4*). Small biases have been established. After subtraction of these biases, the observed precision is assumed to be determined by two factors: (i) the statistical fluctuations arising from the finite number of events recorded, and (ii) an "error of the method." This treatment of errors has provided better estimates of the reliability of the results of lunar analysis by this technique than were possible earlier.

The Surveyor VI data presented here were taken from recordings made at the tracking stations of the NASA Deep Space Network. After the data were examined for quality, they were used to prepare energy spectra of backscattered alpha particles and protons for each of the phases of the lunar operations. Background subtractions and small corrections to the energy scales of the spectra were made in a manner similar to that in the final Surveyor V report (*4*). The principal difference between the data presented here and those from the Surveyor V mission was the higher background in the alpha mode and its increase with time as a result of the gradual buildup of the scattering of uncollimated alpha particles from the gold-plated interior of the sensor head (*6, 7*).

The data from the lunar mission were analyzed in terms of a library of spectra obtained in the laboratory with a spare flight instrument. This library was essentially the same as that used in the analysis of terrestrial rocks with the spare instrument and in the final treatment of the Surveyor V data (*4*).

The first stage of the alpha-scattering experiment on the moon involves analysis of a standard glass sample. Data from 420 minutes of operation were accumulated in this stage during the Surveyor VI mission. An analysis of these data on the basis of an eight-element library leads to the elemental abundance values and statistical errors (1 σ) shown in column 6 of Table 1. Comparison of these results with the known composition of the glass (column 5 of Table 1) gives further confidence that the instrument was operating satisfactorily on the moon.

One sample of lunar surface material was examined on the Surveyor VI mission. Data from 1722 minutes of operation (approximately 85 percent of the available data) in the alpha mode and 1660 minutes in the proton mode passed tests of reliability and were used in the analysis. Some of the data excluded in the alpha mode appeared to have poor resolution in the energy region between 2.4 and 4 Mev; inclusion of these data would not change the analytical results significantly. The amount of useful data in the proton mode is less than that in the alpha mode primarily because one of the four proton detectors was noisy during a period of high instrument temperatures. Because of mission constraints, the total amount of data obtained from Surveyor VI is less than half of that obtained from Surveyor V.

Using a 13-component library, we analyzed these alpha and proton data from the lunar sample by a least-squares treatment. The results are given in column 7 of Table 1. The value for each element is shown, together with its associated statistical error (1 σ), as determined from the least-squares reduction. The small biases of the method have been subtracted, as in the final Surveyor V analyses (*4*). In the next to last column of Table 1 are estimates of the errors at the 90 percent confidence level. These have been calculated from the statistical errors and the errors of the method but do not include possible contributions from nonhomogeneities or special geometries of the lunar surface. The values of the concentrations of the more abundant elements are not affected appreciably if the number of components in the library is increased from 13 to 21. For example, spectra of boron, nitrogen, phosphorus, and chlorine were included in the 21-element library for analysis, but these elements made no significant contributions to the lunar sample spectra. Limits are given in Table 1 for groups of elements heavier than nickel.

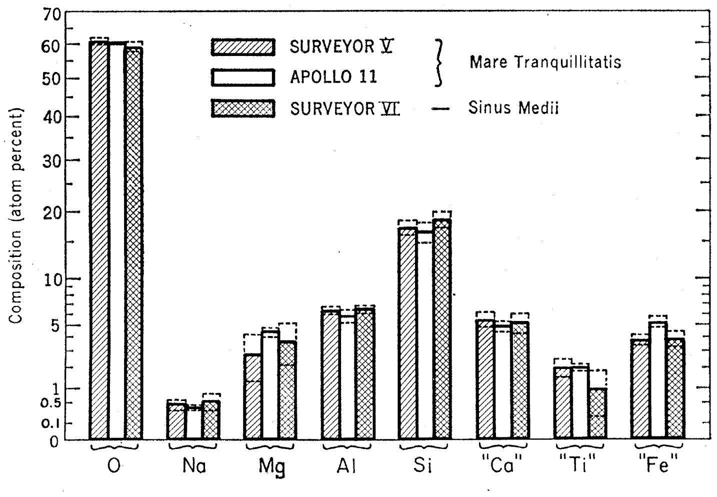
The values presented in Table 1 for the composition of lunar surface material at Sinus Medii are within the ranges given in the preliminary reports for this site (*2, 6*). The estimated errors, however, are now smaller, and results are reported for a larger number of elements. No result is listed for carbon. Although the least-squares analysis gives a value of 1.2 percent, the experience with rock analyses (which gave a relatively large scatter and positive bias for carbon) lends confidence only in the conclusion that the amount of carbon, if this element is present at all, does not exceed 2 atom percent. The abundance of sodium, reported earlier only as an upper limit of 2 percent, is now set at a value of 0.6 percent. As in earlier reports, the abundances of potassium and calcium are combined as "Ca."

Although the value determined for oxygen in the Sinus Medii material is 2.6 percent less than that required to oxidize the metals, this deficiency is still within the estimated errors of analysis. The relative values determined for sodium, magnesium, aluminum, silicon, calcium, titanium, and iron have been used to calculate the oxide weight composition shown in the last column of Table 1.

In the preliminary Surveyor VI reports, it was established that there was a close similarity in composition between surface material from Sinus Medii and that from Mare Tranquillitatis. In order to facilitate this comparison, the data from the two samples examined on the Surveyor V mission have been appropriately combined and are shown with corresponding estimates of error in columns 3 and 4 of Table 1. Figure 1 shows a comparison of the chemical composition of material in Sinus Medii (Surveyor VI) with that in Mare Tranquillitatis [Surveyor V and Apollo 11 (*8*)]. In general, the correspondence between the results derived by the alpha-scattering technique at the two sites is well within the 90 percent confidence limits. The agreement of the Surveyor V data with results of the preliminary examination of the Apollo 11 samples (*8*) is also generally satisfactory. Significant differences in detail, however, merit consideration.

The Apollo 11 results indicate a slightly larger amount (5.3 atom percent) of iron at Mare Tranquillitatis than does the alpha-scattering experiment at either the Surveyor V or the Surveyor VI sites (3.9 atom percent). This difference could be a local variation; it may, however, reflect an additional small bias of the alpha-scattering technique in the analysis of nonhomogeneous samples. The differences in the case of the mean values for magnesium are not considered significant in view of the observed large scatter of results in the rock analyses by the alpha-scattering technique.

In the case of titanium, however, as mentioned in the final Surveyor V report (*4*), the lower abundance found in Sinus Medii, as compared with that at Mare Tranquillitatis, is considered real. Figure 2 presents a comparison of the scattered alpha spectra from the Surveyor V and VI missions in an energy region sensitive to elements heavier than silicon. These data show that material analyzed at the Surveyor VI site (Sinus Medii) contains less of those elements heavier than silicon than material at Mare Tranquillitatis: the Surveyor VI spectrum contains 10 ± 2



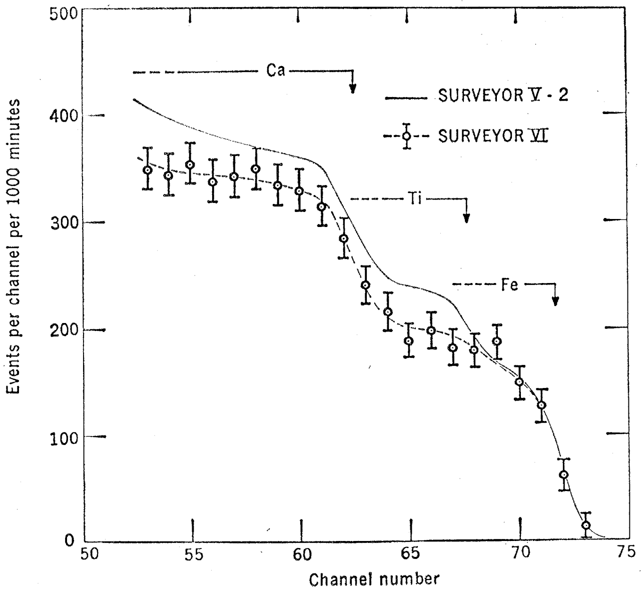


Fig. 1 (left). Comparison of the composition of lunar surface material in Sinus Medii (Surveyor VI) with that in Mare Tranquillitatis (Surveyor V and Apollo 11), plotted on a square root scale. The Surveyor V data are the mean values obtained on two samples; the Apollo 11 data are derived from the preliminary analyses of two samples of fine-grained bulk material (*8*). The dotted lines indicate estimates of error (90 percent confidence limits in the case of the alpha-scattering results). Oxygen was not determined directly in the Apollo analyses. Fig. 2 (right). Comparison of the Surveyor V (sample 2) and Surveyor VI alpha-mode spectra in the energy region sensitive to elements of mass number $30 < A < 60$. The abscissa (channel number) is a measure of the energy of the backscattered alpha particles. The smooth curves are the computer fits of the least-squares analysis to the data. The experimental points are shown only for the Surveyor VI data; the statistical errors were smaller in the case of Surveyor V. The element symbols with arrows show the theoretical high-energy limits of scattering from calcium, titanium, and iron.

percent fewer alpha events in this energy region than does that of Surveyor V. Furthermore, the difference in the spectra appears to be mainly due to a difference in the titanium region (scattering from titanium extends to lower energies, thus also affecting the intensity in the calcium region). These qualitative differences are borne out by comparison of the least-squares results which show that the calcium abundances at the Surveyor V and VI sites are approximately the same, but that the Surveyor VI value for elements heavier than calcium is 4.9 instead of the 5.8 percent found by Surveyor V. This difference is ascribed to a lower value of titanium, with the value for iron remaining the same. Statistical analysis of the data from the two missions indicates that the titanium concentration at Sinus Medii is 0.48 ± 0.26 ($1\ \sigma$) of that at Mare Tranquillitatis.

The conclusions to be drawn from the results of Table 1 are similar to those given in preliminary reports on the Surveyor VI analyses: the relative amounts of the six most abundant elements (O, Si, Al, Ca, Fe, and Mg) are the same, within our error limits, at the two mare sites. This suggests that the composition of other lunar maria may be much the same with respect to these common elements. The composition at the two mare sites is different from that of the less volatile components of the solar atmosphere and that of terrestrial ultrabasic rocks or chondritic meteorites. The overall composition of the sample from Sinus Medii is more like that of common basalts than were the final Surveyor V results for Mare Tranquillitatis (*4*); this is due mainly to the lower Surveyor VI value for titanium. A basaltic composition for lunar surface material has been suggested on the basis of earth-based optical observations (*9*). However, the low sodium abundance, as in Surveyor V, is more consistent with that in eucritic meteorites (*10*) than with that in terrestrial basalts. The comparison made by Olsen (*11*) of the gross chemical composition at Mare Tranquillitatis with that of a rock whose composition is similar to that of the terrestrial anorthosites would seem valid also in the case of material from Sinus Medii. As we suggested in the preliminary reports, the principal minerals would appear to be feldspars and pyroxenes. The results from the examination of the Apollo 11 samples (*8*) suggest that the titanium in Sinus Medii may also be in the form of ilmenite. On the basis of the methods of Gault *et al.* (*12*), the estimated density of void-free lunar material at Sinus Medii is 3.09 g/cm^3.

Results from the Surveyor VII mission (*3*) showed that compositional differences occur across the face of the moon: the abundance of elements heavier than calcium at that highland site was lower by more than a factor of 2 than that found at the mare sites of Surveyors V and VI. The results reported here give evidence that differences in titanium concentrations occur from one mare site to another. Moreover, differences in some of the minor constituents can be inferred from these results on the major elements, now that preliminary analyses of returned lunar samples from the Apollo 11 mission are available (*8*). The Apollo results, which show good agreement with the Surveyor V analyses for Mare Tranquillitatis (Fig. 1), indicate that refractory elements such as titanium, zirconium, and yttrium are enriched, whereas alkali and volatile elements (including sodium, potassium, and rubidium) are depleted relative to terrestrial igneous rocks. Thus, the lower value of titanium at the Surveyor VI site suggests that other refractory elements, such as Zr, may be less abundant at Sinus Medii than at Mare Tranquillitatis. The Surveyor VI value for Na, which is nearly as low as that for Surveyor V, implies that other alkali metals are also depleted in the surface material of Sinus Medii.

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Lepidoptera in Cretaceous Amber

Abstract. *The discovery of the head capsule of a lepidopterous larva in Canadian amber of the Cretaceous period is the first fossil evidence of Lepidoptera before the Tertiary period.*

The head capsule of a lepidopterous larva has been discovered in Canadian amber of the Cretaceous period. Its presence there is evidence of the hitherto unrecorded existence of Lepidoptera before the Tertiary period (*1*). The find is neither surprising nor unexpected because Baltic amber has yielded not only adults of several families but larvae (*2*) that closely resemble larvae of extant species.

The amber examined was collected from the tailings of an open-pit coal mine near Medicine Hat, Alberta (*3*). It came from deposits that are at least 72 million years old (*4*). The piece containing the fossil (Fig. 1a) is about 10 by 11 by 3 mm. In addition to the head capsule, it appears to have webbing within it, also some frass in an area that might have been a skeletonized part of the host plant, and more frass in what might be the remains of a tunnel in crumpled leaves. In other words, the larva that shed the head capsule apparently fed in a concealed habitat typical of that of many present-day Microlepidoptera.

The head capsule (Fig. 1, b and c) is about 0.58 mm long, and is not