

CARBON COMPOUNDS IN APOLLO 17 LUNAR SAMPLES: INDICATIONS OF COMETARY CONTRIBUTION TO BRECCIA 78155 ?

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Vacuum pyrolysis-mass spectrometric analyses(1) were carried out on seven samples collected by the Apollo 17 astronauts. The samples analyzed were one breccia (78155), one basaltic rock (71055), the "orange soil" (74220) and other fines (78501, 74240, 71501, 78221). The analyses were concerned mainly with the abundances of the carbonaceous gases: methane, carbon monoxide, and carbon dioxide. The results are listed in Table 1.

The fines are noteworthy not only because of their variable CH_4 , CO and CO_2 contents, but also because of the variable abundances of other volatiles: water, hydrogen sulfide, sulfur dioxide and hydrocarbons, particularly the ethylene and propane ions. Some of these compounds, such as water, may be reaction products which developed during pyrolysis. The "orange soil" contained both the lowest carbon content and volatiles. Microscopic examination in transmitted light revealed that the glass beads varied in size between $10\mu\text{m}$ and $102\mu\text{m}$ and that they were abundant in this sample. The glass beads did not contain inclusions which were commonly seen in other fines. The color of the glass beads varied between orange and yellow color or opaque in the "orange soil". The rest of the material appeared to be glass fragments of irregular shapes and of varying sizes. After pyrolysis at 1000°C the beads and glass fragments appeared opaque; again there were no detectable inclusions. Several small fragments seem to have aggregated and stuck together forming clusters during heating. The 71501 fines sample was particularly rich in sulfur compounds (10 ppm) and low molecular weight hydrocarbons (14 ppm).

Breccia 78155 was the most volatile rich of all samples analyzed. The CH_4 , CO , and CO_2 content represented a total of 267 ppm carbon. Hydrocarbons (exclusive of methane) were present in approximately 60 ppm quantity; the most intense ion was $m/e=43$. This sample contained hydrogen cyanide (~ 5 ppm), hydrogen sulfide (~ 6 ppm), as well as elemental sulfur. Water was the most abundant of all the volatiles, but again, this may have been a reaction product. Sulfur dioxide was absent; this along with the fact that carbon monoxide was three and one-half times as abundant as carbon dioxide indicates that the reduced species of carbon and sulfur were more abundant than the oxidized species. HCN , C_2 , C_3 and C_4 hydro-

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carbons are all reminiscent of the non-metallic species detected in cometary spectra, i. e. CN, C₂ Swan bands and C₃ bands (2). The contrast between breccia 78155 and basalt 71055 regarding their carbon contents and volatiles was striking. The only carbon compound found in the basalt was carbon dioxide, i. e. the oxidized species; whereas the breccia was rich in the more reduced carbon monoxide, methane and the higher molecular weight hydrocarbons together with elemental sulfur and hydrogen sulfide. One may note that cometary spectra typically reveals reduced species of carbon, nitrogen and oxygen. It is not unlikely that this breccia or its components could have been involved in some cometary impact on the lunar surface. (3)

REFERENCES

- (1) NAGY B., MOHAMMED M.A. J., and MODZELESKI V.E., (1972) "An evaluation of pyrolytic techniques with regard to the Apollo 11, 12, and 14 Lunar sample analyses", Space Life Sciences 3, 323-329.
- (2) WHIPPLE F.J. in The Moon, Meteorites and Comets (1963) eds. B. M. Middlehurst and G. P. Kuiper, Univ. of Chicago Press, Chicago, 639-644.
- (3) GIBSON E.K. Jr. and MOORE C.B., (1973) "Volatile-rich lunar soil: evidence of possible cometary impact", Science 179, 69-71.

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Table 1

ANALYSIS OF APOLLO 17 SAMPLES
Expressed in ppm C (10^{-6} g C/g of sample)

	CH ₄	CO	CO ₂
71055 (<u>Basalt</u>)	0	0	6.3
78155 (<u>Breccia</u>)	18.6	193.6	54.5
<u>Fines</u>			
74220	0.8	0	0.7
78501	1.6	28.8	15.7
74240	0.8	51.2	0
71501	0	66.2	2.2
78221	0	22.5	30.8