A REEXAMINATION OF AMINO ACIDS IN LUNAR SOIL; K. L. F. Brinton and J. L. Bada, The Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0212
J. R. Arnold, Department of Chemistry, University of California, San Diego, La Jolla, CA 92093-0317

Amino acids in lunar soils provide an important indicator of the level of prebiotic organic compounds on the moon. The results provide insight into the chemistry of amino acid precursors, and furthermore, given the flux of carbonaceous material to the moon, we can evaluate the survival of organics upon impact. The amino acid contents of both hydrolyzed and unhydrolyzed hot-water extracts of Apollo 17 lunar soil were determined using o-phthaldialdehyde/N-acetyl cysteine (OPA/NAC) derivatization followed by HPLC analysis [1]. Previous studies of lunar amino acids were inconclusive, as the technique used (derivatization with ninhydrin followed by HPLC analysis) was unable to discriminate between cosmogenic amino acids and terrestrial contaminants [2]. Cosmogenic amino acids are racemic, and many of the amino acids found in carbonaceous meteorites such as Murchison, i.e. α-amino-i-butyric acid (aib), are extremely rare on Earth. The ninhydrin method does not distinguish amino acid enantiomers, nor does it detect α-alkyl amino acids such as aib, whereas the OPA/NAC technique does both.

The sample 78421,16 was collected during the Apollo 17 mission. Two 1 g portions were hot-water extracted for 24 h. The extract of one sample was directly analyzed, while the other was acid-hydrolyzed for 23 h in 6 N HCl prior to analysis. Control blanks were processed and analyzed concurrently with both samples. The samples were derivatized with OPA/NAC for 15 minutes in order to maximize the detectability of aib, and then analyzed by HPLC [2]. See Table 1 for the results.

Table 1: Amino acid analysis results, blank corrected and reported in ng/g, with an estimated error of ±20%. All determinations are based on retention time only. Sample 78421 was analyzed in this study, while the 72501 results are reported by Fox et al. [1].

	78421		72501	
	unhydrolyzed	hydrolyzed	unhydrolyzed	hydrolyzed
D,L-Aspartate	0.0	0.0	0.1	0.7
D,L-Serine	0.5	0.9	0.1	0.3
D,L-Glutamate	0.0	0.2	0.0	0.7
Glycine	3.5	10.6	1.7	7.1
D-Alanine	0.0	0.2		
L-Alanine	1.1	1.2	0.3*	1.1*
Aib	0.3	0.2	0.0	0.0

*Fox et al. did not distinguish between alanine enantiomers [1].

The excess of L-alanine over D-alanine and the high abundance of serine indicate the presence of terrestrial contamination. However, in this study we

did not attempt to resolve the serine enantiomers as we were specifically looking for aib, which has never before been detected in lunar soils. The peaks corresponding to aib and D-alanine in the hydrolyzed fraction are indicative of indigenous lunar amino acid precursors.

Previous investigations have shown that aqueous solutions of HCN, upon hydrolysis, yield glycine and small amounts of other amino acids [1, 3]. In our work, the large increase in glycine upon hydrolysis supports the surmise that the precursor responsible for the amino acids is HCN indigenous to lunar soil.

Using the value of 12.1 μg/g (hydrolyzed) for aib in the Murchison meteorite [4], and 1-2% for carbonaceous chondritic debris in lunar soil, we have estimated the aib content of lunar soil to be 0.1-0.2 μg/g, assuming 100% survivability. (We obtain a similar value, to within an order of magnitude, by examining the long term accumulation of IDP's.) Since our results show the actual aib content of lunar soil to be <0.3 ng/g, we calculate the impact survivability of aib on the lunar surface to be approximately 10^{-3}. This is likely to be an overestimate, since aib may also be a product of the acid hydrolysis of HCN [3].

Studies of amino acids on the moon are important in evaluating whether organic compounds required for the origin of life on Earth may have been supplied from extraterrestrial sources. Our results suggest that, although amino acids may be present on the moon, they are more likely derived from precursor molecules, rather than being components of extraterrestrial debris [5].

REFERENCES

[1] Zhao M. and Bada J. L. (1989) *Nature, 339* , 463.
[2] Fox S. W., Harada K., and Hare P. E. (1976) *GCA, 40* , 1069.
[3] Yuasa S., Flory D., Basile B., and Oró J. (1984) *J. Mol. Evol., 20* , 52.
[4] Cronin J. R. and Pizzarello S. (1983) *Adv. Space Res., 3* , 5.
[5] Chyba C. and Sagan C. (1992) *Nature, 355* , 125.