

VOLATILE ELEMENTS IN LUNAR SOILS. C.-L. Chou, P.A. Baedecker, R.W. Bild, K.L. Robinson and J.T. Wasson, UCLA, Los Angeles, CA 90024

Suites of soil samples have been investigated in order to search for trends associated with element transport through the lunar atmosphere. Eight elements were analyzed--three highly volatile (Zn, Cd, In), four highly siderophile (Ni, Ge, Ir, Au) and one moderately volatile and siderophile (Ga); analytical techniques are as described earlier (1). We find progressive enrichment of Cd with decreasing grain size in sieve fractions of soil 65500, and a two-fold enrichment in the shaded soil 76240 compared to its unshaded control 76260. Cadmium, like its congener Hg, appears to be highly labile on the lunar surface. In contrast, Zn and In concentration trends in these samples offer little or no evidence of highly labile natures.

Data on the sieve fractions of soil 65500, 4 are listed in Table 1; data on the unsieved soil offer a control on possible contamination during the sieving process. With the exception of Au in the three finest fractions, there is no evidence of contamination. The distributions with grain size of Zn, Cd, Ni and Ir are illustrated in Fig. 1. Whereas Cd concentration increases by a factor of 6 between the largest and smallest size fractions, Zn increases by only a factor of about 1.3. In contrast to data obtained in a previous study of sieve fractions (2) the siderophiles are slightly enriched in the coarser size fractions.

Data on shaded soil 76240 and its control 76260 are tabulated in a companion paper by Baedecker *et al.* (3). The Cd concentration observed in the shaded soil is 1.25 times higher than that of the highest value observed in any of the ten other Apollo-17 soils which we studied, and twice as high as in the control. No other element shows significant enrichments in the shaded soil. A higher value of In in the unshaded control is tentatively attributed to contamination.

Our analyses of four samples from an Apollo-17 trench (3) show no significant change in Zn or Cd content with depth; In shows no variation in the three lowest levels but a significantly increased level in the surficial sample (contamination?). That volatiles are not depleted in the skim sample is evidence against a transport mechanism involving surficial volatilization by solar particles or photons followed by trapping of that material which falls through interstices to lower soil levels.

Two Apollo-17 samples collected from the surface (72461) and to a depth of 4 cm (72441) below a 0.7 m boulder near the South Massif show no significant difference in their Zn, Cd and In concentrations, nor do these differ appreciably from those in other mature soils from this site.

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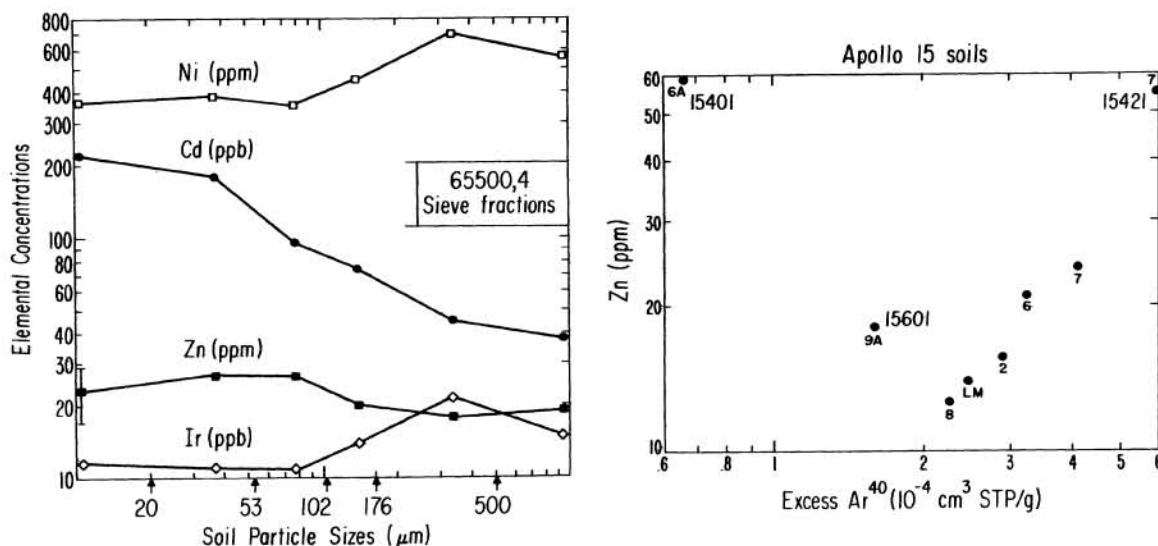
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Fig. 1. Concentrations of two volatiles and two siderophiles in grain-size separates of soil 65500. Fig. 2. Relationship between bulk Zn and excess Ar^{40} contents of Apollo-15 soils.

We have followed up on our previous study of atmophilic elements at the Apollo 15 site (4) by studying soil 15421 with unusually high and soil 15601 with unusually low content of orphan Ar^{40} (5). Data on these and on breccia 15015 are listed in Table 2. Sample 15421 has remarkably high Zn, Cd and In contents, and extends the previously observed trends between these elements and excess Ar^{40} upwards about a factor of 2 (Fig. 2). The high Zn and Cd values in 15601 cause it to fall away from the trends, whereas the In value follows the trend. Soil 15401 plots far away from the trends. There is no correlation between Zn, Cd, or In and solar rare-gas isotopes. We interpret these data to indicate the mixing of normal, mature mare-type Apollo-15 soil with an ancient lunar component enriched in Ar^{40} and magmatically released volatiles. The situation is complicated by indications that Zn and Cd are enriched (6) and excess Ar^{40} depleted (7) in the pyroxenitic green glass from the Apollo 15 site. The high Zn and Cd content of the low excess- Ar^{40} soil 15401 is almost certainly related to its extremely high green-glass content (6,8). Sample 15421 deserves thorough study to determine the siting of its Zn, Cd, In and excess Ar^{40} .

In Table 3 are listed data for Apollo 16 soils. Particularly intriguing is North Crater soil 67031 which has a low content of all siderophiles except Au, for which duplicate determinations gave 361 and 313 ng/g. Since we have no reason to suspect terrestrial contamination, and since the Au/Ni ratio exceeds by a factor of 200 the highest values known in meteorites, it appears that processes leading to Au-rich components must be reexamined (9).

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Table 1. Concentrations of eight trace elements in bulk soil 65500,4 and in six sieve fractions. Table 2. Mean trace-element concentrations in Apollo 15 soils and a breccia. Table 3. Mean concentrations of eight trace elements in Apollo 16 soils.

	Ni ($\mu\text{g/g}$)	Zn ($\mu\text{g/g}$)	Ga ($\mu\text{g/g}$)	Ge (ng/g)	Cd (ng/g)	In (ng/g)	Ir (ng/g)	Au (ng/g)
bulk	491	25.8	5.58	1080	101	16.1	14.4	8.1
>500 μm	554	18.9	5.06	810	37.7	29.9	15.0	6.1
176-500 μm	697	17.1	5.11	1450	46.6	13.7	21.5	11.1
102-176 μm	456	19.9	5.06	910	73.9	12.9	13.8	5.3
53-102 μm	358	26.3	4.84	780	94.9	13.3	10.9	(464)†
20-53 μm	384	26.6	5.40	780	178	14.2	11.0	(22)†
<20 μm	364	23*	6.64	950	219	8.5	11.5	(71)†
15421,29	215	55.0	4.44	263	240	58	2.5	3.0
15601,183	157	19.5	3.41	184	102	3.4	3.0	1.15
15015,40	236	13.1	4.20	378	40.7	3.0	7.3	3.1
60501,32	494	22.6	5.24	1110	96	13	16.3	9.4
61281,6	474	26.2	5.62	1080*	104	19	13.0	8.0
61501,21	504	35.3	6.23	1165	126	18	19.8	8.4
66041,24	466	24.4	4.98	958	83	19	16.3	5.9*
66081,21	689	22.3	5.19	1560	82	14	21.5	10.6
67031,15	48	3.96	4.10	44	15.4	1.6	2.6	337
67601,18	204	7.26	4.18	310	19.6	4.9	6.8	3.6

*Lower than average accuracy. †Data of poor quality and should be disregarded.

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