DRIVE TUBE 60009: A CHEMICAL STUDY OF MAGNETIC SEPARATES OF SIZE FRACTIONS FROM FIVE STRATA, D.P. Blanchard[1], J.W. Jacobs[2], and J.C. Brannon[2], [1]NASA Johnson Space Center, Houston, TX 77058; [2]Lockheed Electronics Corp., Houston, TX 77058.

As part of the consortium at Johnson Space Center studying samples from drive tube 60009, we have analyzed by instrumental neutron activation analysis aliquots of unsieved bulk soil and magnetically separated "agglutinitic" and "non-agglutinitic" fractions of the 90-150μm and <20μm size fractions of each of five core samples. Samples were sieved by the JSC-SEM laboratory using the techniques of McKay et al. (1974). Size fractions were subsequently separated magnetically following the methods of Adams and McCord (1973). Results of our analyses are presented in Table 1.

Composition vs depth - As expected from theoretical studies which predict random layering resulting from ejecta from random impacts, we found no systematic correlation of composition and depth. We chose samples to represent the broadest range of layers present in the core and indeed we observed wide compositional variation; for example, FeO ranges from 1.99% in the plagioclase rich white layer (60009,457) to 5.20% in "normal" Apollo 16 soil (60009,458).

Composition vs size fraction - The most striking feature of the data is the consistent enrichment of most of the elements in our analytical suite in the <20μm fraction relative to both the 90-150μm fraction and the bulk soil. Except for Na and Eu which tend to correlate with plagioclase content and Ni and Co which are components in meteoritic metal, the elements in our analytical suite are associated with mafic components (Fe, Sc, Cr) and interstitial residua (REE, Hf, Ta, Th). On fig. 1, which shows data for typical LIL element, Sm, this effect can be seen by comparing the bulk soil compositions with those calculated for the total <20μm size fraction. Apparently disproportionately high fractions of mafic component in these soils reside in the finest size fraction. The more mafic composition of the finer fractions is consistent with the higher proportions of agglutinitic material in these fractions (see fig. 1) in light of the well documented mafic enriched nature of the agglutinitic component in lunar soils (Rhodes et al., 1975; Blanchard et al., 1975; Rhodes et al., 1976). However it is not consistent with data for Apollo 17 mare soils in which the finest fractions are found to contain disproportionately large fractions of plagioclase and highland material (Korotev, 1976). This apparent anticorrelation of bulk soil type with type of component which is enriched in the <20μm fraction, if substantiated by data on more soils, may have important implications for surface transport of materials on the lunar surface.

Discussion - The broken line (a least squares fit) through the compositions of the 90-150μm agglutinitic fractions (Fig 1b) demonstrates their amazingly constant composition. The non-agglutinitic fractions show a regular progression of compositions. The compositions of the total 90-150μm fractions are consistently lower than the bulk composition.

The data strongly suggest that these soils are the results of addition of a very Sm-poor component (z.b. plagioclase) to an agglutinate rich soil (which was also much more mafic and LIL element rich) such that the compositions of the non-agglutinitic fractions are the result of dilution with this component. Because the agglutinate composition does not change, the Sm-poor component

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must have been very agglutinate poor (immature, fresh lithic debris). The Sm concentration of the total 90-150μm fractions are in all cases lower than that of the unsieved bulk soil indicative of "recent" addition to the soils of coarse, Sm-poor material which has not been thoroughly comminuted.

A similar model of mixing is also proposed by Bogard and Hirsch (1976) on the basis of a linear correlation between spallogenic and cosmic ray produced noble gases which is interpreted as the result of mixing variable amounts of gas-poor diluent with a gas-rich soil. McKay et al. (1976) report an inverse correlation between agglutinitic fraction (magnetic) and plagioclase content for these soils. A similar model was proposed for other Apollo 16 soils by Rhodes et al. (1975). Consistent with the proposed model, the total <20μm size splits have higher Sm concentrations than the bulk soils (Fig 1a). Except for the most agglutinate rich soil (458) the <20 agglutinitic component does not have the same constant composition as the 90-150 fraction. The trivial explanation is that the separation techniques are less efficient at this grain size. We must await full petrographic data to evaluate that possibility. However, assuming legitimate separation, the data suggest that the Sm-poor component is being incorporated more rapidly into the agglutinitic fraction of the <20μm fraction than into the 90-150 fraction. This important observation

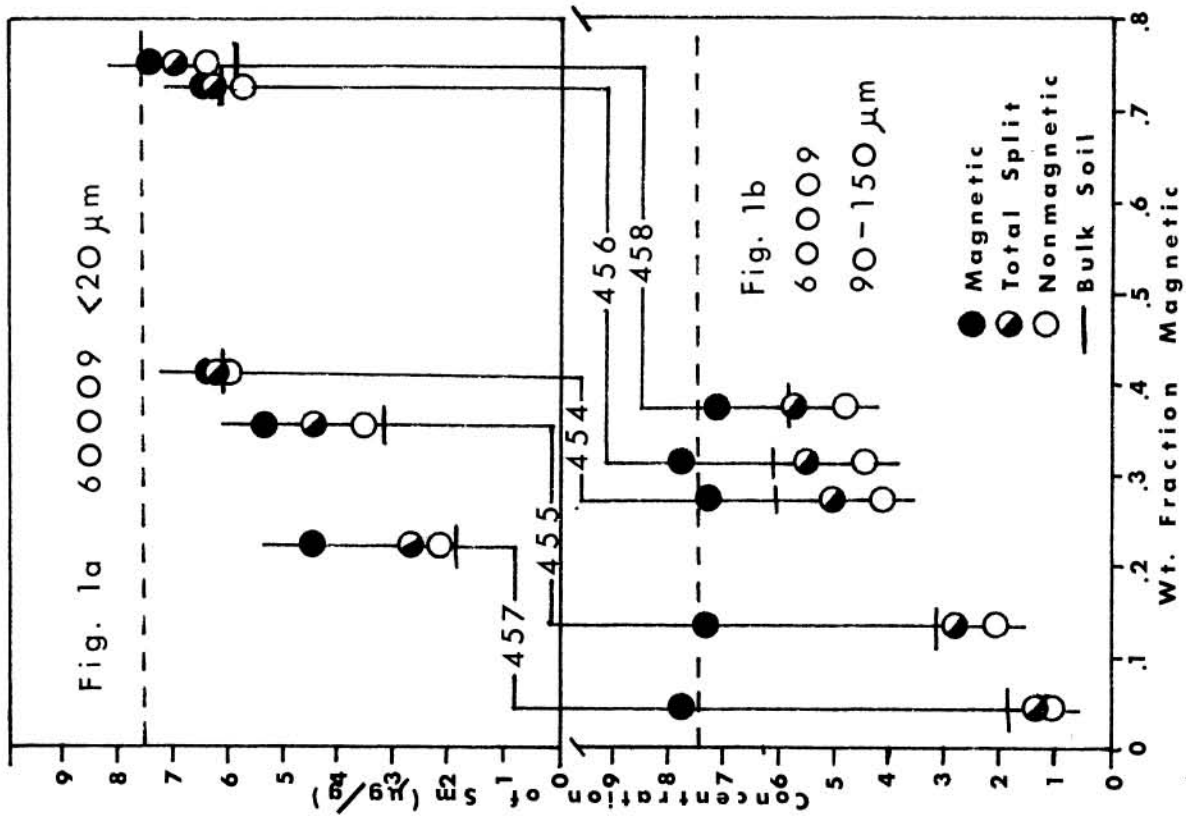

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Table 1. Compositions of samples from drive tube 60009.

Size Split (μm)	60009,454					60009,455					60009,456				
Fraction	Unsieved Bulk	90-150 Magnetic	90-150 Non-Magnetic	<20 Magnetic	<20 Non-Magnetic	Unsieved Bulk	90-150 Magnetic	90-150 Non-Magnetic	<20 Magnetic	<20 Non-Magnetic	Unsieved Bulk	90-150 Magnetic	90-150 Non-Magnetic	<20 Magnetic	<20 Non-Magnetic
wt. fraction	1.0	0.279	0.721	0.412	0.588	1.0	0.134	0.866	0.953	0.047	1.0	0.316	0.684	0.722	0.278
Major Elements (wt %)															
FeO	5.17	6.80	3.70	6.73	4.01	3.54	7.83	2.65	6.67	3.51	5.06	7.20	4.26	5.83	3.58
Na_2O	0.52	0.51	0.48	0.90	0.56	0.41	0.49	0.41	0.44	0.43	0.49	0.51	0.47	0.50	0.52
Trace Elements (μg/g)															
Sc	8.32	11.1	6.96	10.7	7.44	5.58	10.9	4.63	10.5	6.22	9.39	11.6	8.78	9.93	7.18
Cr	740	940	550	1190	660	470	920	350	1040	570	770	990	710	940	620
Co	32	49	7.1	39	13	14	80	4.2	34	7.6	19	56	8.2	27	8.9
Ni	450	730	50	750	190	200	1120	28	530	96	220	770	60	450	120
Hf	4.9	5.6	3.1	5.3	4.1	2.4	5.9	1.5	4.5	2.5	4.5	5.4	4.3	4.8	4.2
Ta	0.7	0.8	0.5	0.9	0.5	0.4	0.9	0.2	0.7	0.4	0.5	0.8	0.3	0.7	0.3
Th	2.0	2.3	1.2	2.3	2.3	1.1	2.3	0.65	1.8	1.2	2.3	2.8	1.5	2.2	2.2
La	13.4	15.6	8.87	13.6	13.6	7.09	16.2	4.61	13.3	7.94	12.8	16.2	9.5	14.1	12.6
Ce	35	42	23	36	35	18.4	44	12.4	34	21	33	42	26	37	33
Sm	6.11	7.36	4.23	6.39	6.24	3.16	7.37	2.13	5.38	3.57	6.09	7.82	4.50	6.48	5.87
Eu	1.19	1.24	1.08	1.20	1.23	0.94	1.23	0.91	1.03	0.98	1.16	1.25	1.15	1.15	1.22
Tb	1.4	1.7	1.0	1.5	1.4	.75	1.6	.45	1.2	.81	1.4	1.8	1.1	1.5	1.4
Yb	4.5	5.5	3.2	4.8	4.2	2.3	5.8	1.5	4.3	2.6	4.5	5.8	3.7	4.7	4.1
Lu	0.59	0.73	0.44	0.64	0.58	0.31	0.77	0.21	0.59	0.34	0.63	0.81	0.50	0.63	0.56

Size Split (μm)	60009,457					60009,458				
Fraction	Unsieved Bulk	90-150 Magnetic	90-150 Non-Magnetic	<20 Magnetic	<20 Non-Magnetic	Unsieved Bulk	90-150 Magnetic	90-150 Non-Magnetic	<20 Magnetic	<20 Non-Magnetic
wt. fraction	1.0	0.041	0.959	0.223	0.777	1.0	.373	.627	0.743	0.257
Major Elements (wt %)										
FeO	1.99	7.42	1.33	5.44	1.83	5.20	7.81	4.85	6.26	4.09
Na_2O	0.42	0.52	0.41	0.44	0.44	0.50	0.50	0.50	0.52	0.54
Trace Elements (μg/g)										
Sc	3.24	11.2	2.23	8.38	3.23	9.46	11.5	9.47	10.5	7.85
Cr	270	890	160	890	280	760	930	750	950	700
Co	6.8	56	2.5	31	4.8	22	85	9.2	33	12.2
Ni	90	850	10	540	70	280	1210	70	560	160
Hf	1.4	5.8	3.6	3.6	1.5	4.7	5.6	6.6	5.0	4.2
Ta	0.2	1.0	0.1	0.5	0.2	0.6	0.7	0.6	0.8	0.6
Th	0.5	2.5	0.3	1.4	0.67	1.9	2.3	1.5	2.7	2.3
La	4.08	16.3	2.37	10.5	4.92	12.7	15.7	10.3	14.9	14.2
Ce	11	42	6.1	29	14	35	42	27	40	37
Sm	1.85	7.71	1.12	4.51	2.19	5.83	7.22	4.84	7.12	6.42
Eu	0.92	1.24	0.88	1.03	0.97	1.19	1.23	1.15	1.24	1.28
Tb	.42	1.6	.26	1.0	.48	1.3	1.7	1.2	1.5	1.3
Yb	1.4	5.7	1.0	3.6	1.6	4.4	5.7	4.1	5.1	4.4
Lu	0.19	0.75	0.14	0.50	0.20	0.59	0.77	0.56	0.70	0.56

gives us the opportunity to evaluate the relative rates of soil processes such as lithic comminution and agglutinate formation and comminution.

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