DISTRIBUTION OF TI IN GLASS AND MINERAL COMPONENTS OF LUNAR SOILS 10084 AND 71501; GRAIN SIZE FRACTION 100 TO 210 μm. D. Johnson, B. Jolliff, R. Zeigler, and P. Carpenter; Department of Earth and Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University in St. Louis, One Brookings Drive, St. Louis, MO 63130 (djohnson@levee.wustl.edu).

Introduction: In this abstract, we compare the Ti-bearing components in two Ti-rich Apollo soils, one from Apollo 11 (10084) and one from Apollo 17 (71501). The objective is to better understand quantitatively how Ti is hosted in lunar soil and the implications for mineralogic remote sensing and assessment of resource potential related to Fe-Ti oxide contents. Specifically, we seek to address the following questions:

- How closely correlated are the ilmenite content and the Ti concentration in lunar soil?
- How does ilmenite in soil vary in terms of grain size, habit, and assemblage (e.g., monomineralic vs. lithic fragments)?
- How much Ti is in coarse vs. fine-grained ilmenite?
- What other components in regolith carry Ti and how much (e.g., impact, volcanic, and agglutinitic glass)?
- What are the effects of exposure (regolith maturity)?

Lunar soil 10084 is mature (I_S/FeO = 78) [1] with a bulk soil TiO_2 concentration of 7.3 wt% [2]. Lunar soil 71501 is submature (I_S/FeO = 35) [1] with a bulk TiO_2 concentration of 9.5 wt% [3].

Concentrations of TiO_2 in 10084 and 71501 have been shown to decrease in the finest grain-size fractions [4,5]. In addition, concentrations of TiO_2 in the agglutinitic glasses are lower than in bulk soil [4,5]. The depletion of TiO_2 in agglutinitic glass may simply indicate that coarse ilmenite does not comminute to the finest grains sizes involved in the formation of agglutinitic melt or that ilmenite does not melt as completely as the silicate minerals [4,5].

Here we present results on the grain size (area) and shape of ilmenite grains, and we present a mass balance model of how much Ti (wt%) is carried in different soil components. We focus on the 100 to 210 μm grain size fraction because in this size range, the lithology of regolith grains can be readily determined.

Methods: A 100 mg sample of 10084 and 71501 was sieved into five different size fractions: >210 μm, 100-210 μm, 48-100 μm, 20-48 μm, and <20 μm. Polished thick sections of the 100-210 μm size fraction were prepared to collect chemical data.

A JEOL 8200 electron microprobe (EMP) was used to determine major-element concentrations of soil components (glass, mineral and lithic fragments). Back-scattered electron (BSE) and major element x-ray maps were also acquired by EMP (Figure 1). The BSE and x-ray maps were subsequently used to classify individual soil grains.

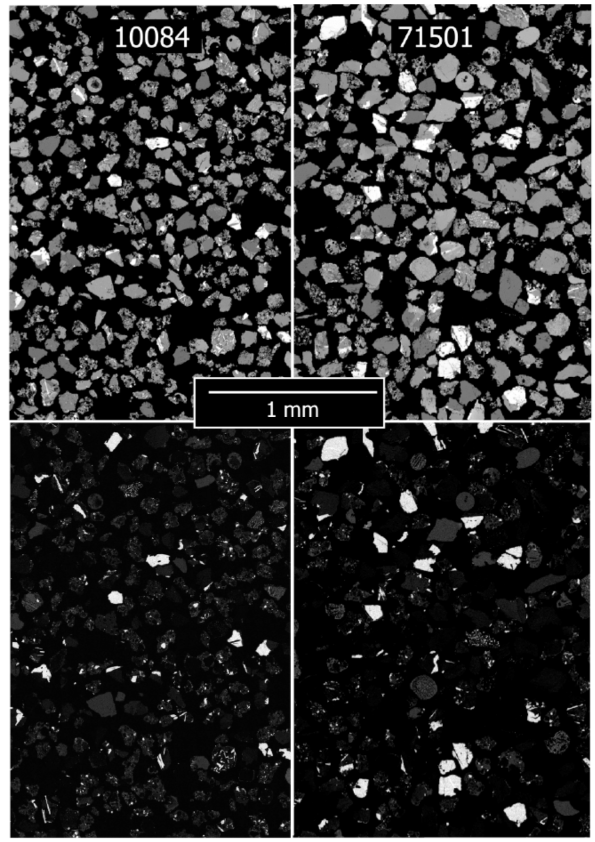

Figure 1. BSE images (top) and Ti X-ray images (bottom) of lunar soils. Bright areas in X-ray image reflect Ti concentration. White is ilmenite and shades of gray are mostly Ti-bearing glasses.

Major components used in the mass-balance modeling include; basalt, regolith breccia, fragmental breccia, crystalline melt breccia, glassy melt breccia, agglutinates, plagioclase, ilmenite, pyroxene, olivine, and glass. Glasses were subdivided into high Ti (>8.0 wt% Ti), low Ti (>1.5 to ≤8.0 wt% Ti) and very low Ti (≤ 1.5 wt% Ti) [6].

Area and shape of the ilmenite grains were determined by analyzing the Ti x-ray images using ImageJ software. The shape of the grains is defined by the aspect ratio (AR) as follows: AR of 1:1, equant; AR of 2:1 to 1:1, blocky; 5:1 to 2:1, tabular; and >5:1, acicular.

Results: Grain-size analyses are presented in Table 1. Ilmenite grains from 10084 in the 100 to 210 μm size fraction have a bimodal distribution. Approximately 35% of the total area of the grains is represented by grains less than or equal to 250 $μm^2$. A similar amount of ~32% of the total area of the grains have areas greater than 2500 μm^2. Bimodality is also observed in 71501 but, not as strong. Only about 11% of the total area is due to grains less than or equal to 250 μm^2. Almost 68% of the total area is represented by grains having areas greater than 2500 μm^2. The dominant grain shapes for both 10084 and 71501 are equant to tabular (Table 2).

Mass Balance Model. The mass balance models for 10084 and 71501 are shown in Table 3. Most of the Ti in 10084 is in basalt and ilmenite. Together they account for ~65 % of the Ti. Agglutinates and high-Ti glass contain a significant proportion of the Ti and account for an additional ~20% of the total Ti in 10084.

In 71501, approximately 77% of the Ti is in basalt and ilmenite with over half (55%) of the Ti contained in basalt fragments. Agglutinates and high-Ti glass contain ~14% of the Ti. Pyroxene contains 6.3% of the Ti in 71501, which is almost double the 3.3% contained in 10084 pyroxenes.

Table 1. 10084 and 71501 ilmenite grain size analysis

	10084		71501	
Area (_m^2)	Count	% of total area	Count	% of total area
<=250	3726	34.71	1264	10.47
251 - 500	88	9.85	63	3.85
501 - 750	17	3.40	34	3.52
751 - 1000	18	5.04	18	2.65
1001 - 1250	15	5.14	7	1.34
1251 - 1500	3	1.27	12	2.81
1501 - 1750	5	2.56	6	1.62
1751 - 2000	3	1.81	5	1.62
2001 - 2250	2	1.31	2	0.69
2251 - 2500	4	3.04	9	3.61
>2500	20	31.88	60	67.82
Total	3901	100	1480	100

Table 2. 10084 and 71501 ilmenite grain shape analysis

	10084		71501	
Shape	Count	% of total	Count	% of total
Equant	1792	45.94	563	38.04
Blocky	1389	35.61	376	25.41
Tabular	678	17.38	502	33.92
Acicular	42	1.08	39	2.64
Total	3901	100	1480	100

Table 3. 10084 and 71501 mass balance models

	10084			71501		
Component	Vol. %	Mass %	% Ti	Vol %	Mass %	% Ti
Basalt	18.98	24.57	34.83	32.04	37.50	55.09
Reg. Brec.	3.45	3.44	3.72	2.89	2.60	0.91
Frag. Brec.	3.09	3.07	1.26	1.91	1.72	0.47
Agglutinates	39.78	25.35	16.47	25.61	14.76	11.84
Plagioclase	7.38	7.94	0.09	9.45	9.19	0.27
Ilmenite	2.27	4.20	30.15	2.03	3.40	21.63
Pyroxene	9.06	12.27	3.34	18.18	22.00	6.31
Olivine	0.21	0.29	0.01	1.71	2.04	0.03
High Ti Glass	3.59	4.44	5.93	1.83	2.05	2.46
Low Ti Glass	0.32	0.35	0.31	0.06	0.06	0.03
Very Low Ti Glass	1.38	1.43	0.12	0.13	0.13	0.01
Cryst. Brec.	2.96	3.66	0.10	1.91	2.14	0.05
Glassy Brec.	7.53	9.00	3.68	2.24	2.42	0.89
Totals	100	100	100	100	100	100

Conclusions: In 10084 and 71501 the dominant Fe-Ti oxide mineral is ilmenite. Armalcolite and ulvöspinel are scarce. The ilmenite grains in 10084 show a bimodal distribution of fine, equant to blocky grains and very coarse, equant to blocky grains. Most of the ilmenite grains in 71501 are very coarse equant to tabular grains. Mature soils have been exposed to space weathering for a longer period of time allowing for the ilmenite to be comminuted to smaller grain sizes. Soil 10084 is a mature soil and this would explain the significant amount of ilmenite that ocurs as fine grained crystals. A similar argument could be made for 71501. It is a sub-mature soil and most of the ilmenite still exists as course grains. Much of the Ti in both 10084 and 71501 are contained in ilmenite crystals (mineral fragments and basalt fragments). An obvious point, but one worth making, is that ilmenite in basaltic lithic fragments is commonly very fine grained and significantly finer than the grain-size separate. In both 10084 and 71501 a relatively significant amount of Ti is contained in agglutinates and high Ti glass.

Analysis of agglutinitic glass show that the Ti concentrations in agglutinitic glass for both soils are lower than the bulk Ti content of the soils. We are investigating the cause of this and any relationship to ilmenite grain size variations.

Future work will investigate a set of soils that cover a range of Ti concentrations and levels of maturity, as well as the finer size fractions. Subsequently, we plan to correlate variations of Ti content and distribution, and ilmenite petrographic parameters in the different soils and size fractions to UV-VIS spectral variations.

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