The Development of CAS-1 Lunar Soil Simulant

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Lunar soil simulants are geochemical copycats of lunar sample (McKay et al., 1993; McKay et al., 1994). They have similar chemical composition, mineralogy, particle size distribution, and engineering properties with lunar sample. Simulants of lunar rocks and soils have been developed to satisfy the requirements of a variety of scientific and engineering investigations. They are essential to meeting the system requirements for lunar exploration and in support of future human activities on the Moon. Such studies include material handling, construction, excavation, and transportation. The simulants is also appropriate for research on dust control, spacesuit durability, and agriculture.

China will actualize the first lunar exploration project up to the end of 2007. It is an essential and pressing task to develop new lunar soil simulants. The development of new lunar soil simulant is one of the basic infrastructure items of Chang'E Project of China.

Regolith is the name given to the layer of unconsolidated material at the surface of a planet - the loose materials that overlies the solid rock. On Earth, soil is part of the regolith, and lunar regolith is consequently often called “soil.” Lunar regolith is composed a variety of lithic clasts, mineral fragments set, and minor impact melt that were broken apart from underlying bedrock by the impact of meteorites. The special compositions in the lunar regolith are breccia, agglutinates, glass spherules, meteorite fragments, and etc.

Through Apollo, Luna, Surveyor, Clementine, Lunar Prospector and other lunar exploration projects, the mineral and chemical compositions of lunar regolith, the surface material are almost known clearly. The average mineral and chemical compositions of lunar regolith at Apollo and Luna landing sites were presented by Basu et al and others (Basu and Riegsecker, 1998; McKay et al., 1991; Riegsecker et al., 1998). It is the only and good ground truth for us to develop lunar soil simulants.

As we know, the composition of mare basaltic lunar regolith is similar terrestrial volcanic ash (Zheng et al., 2005a). According to the survey of Chinese volcano and their eruption, we can select the volcanic scoria or ash materials which chemical and mineral compositions are similar with real lunar samples, and develop lunar soil simulants. In the paper, CAS-1 Lunar Soil Simulant was developed successfully.

GEOLOGICAL OCCURRENCE

The Longgang volcanic cluster belongs to one of the active volcanic regions, located in 42.33°N~42°20'0"N, 126.50°E~126°30'0"E, Jilin Province of northeast China, west of Changbaishan volcano. It has been active in modem times, and is a typical cinder cones volcano. Basaltic and trachy-basaltic lava flows cover a 1700 sq km broad area dotted by more than 150 Quaternary cinder cones, 8 tuff rings, tephra sheet, lava flow, maar and so on.

There is only one known cinder cone of Holocene age, Jinlongdingzi (Gold Dragon Peak). The eruption that formed the large Jinlongdingzi scoria cone and deposited tephra over a broad area to the east was radiocarbon dated at about 1600-1700 years ago (Fan et al., 1999; Liu et al., 2000; Liu and Xiang, 1997; Liu and Zhang, 1997). The starting materials of CAS-1 (Figure.1) was mined from volcanic clastic sheet (Sihai volcanic cinder layer) of Jinlongdingzi modern active volcano (Zheng et al., 2005b). Then, the volcanic scoria of alkaline basaltic composition has been ground, sized, and placed into storage (Figure 2).

FIGURE 1. THE STARTING MATERIALS OF CAS-1

FIGURE 2. PHOTOGRAPH OF CAS-1 LUNAR SOIL SIMULANT

CHEMICAL AND MINERAL COMPOSITION OF CAS-1

The petrological, mineralogical, and geochemical composition of CAS-1 was analysed and compared to lunar sample. The results show that CAS-1 has similar composition with the average lunar materials sampled at Apollo 14 landing site (Table 1 and Figure 3).

TABLE 1. CHEMICAL COMPOSITION OF CAS-1 LUNAR SOIL SIMULANT (WT.%).

	CAS-1	**14163**	**A 14**	**JSC-1**	**FJS-1**	**MKS-1**
	Chinese lunar simulant	lunar sample	Apollo14 landing site	American lunar simulant	Japanese lunar simulant	Japanese lunar simulant
SiO_2	49.24	47.3	48.1	47.71	49.14	52.69
TiO_2	1.87	1.6	1.7	1.59	1.91	1.01
Al_2O_3	18.52	17.8	17.4	15.02	16.23	15.91
Fe_2O_3	3.09	-	-	3.44	4.77	4.78

FeO	8.26	10.5	10.4	7.35	8.3	7.5
MnO	0.19	0.1	0.14	0.18	0.19	0.22
MgO	7.32	9.6	9.4	9.01	3.84	5.41
CaO	4.11	11.4	10.7	10.42	9.13	9.36
Na_2O	3.69	0.7	0.7	2.7	2.75	1.9
K_2O	1.38	0.6	0.55	0.82	1.01	0.58
SO_3	0.03					
LOI	1.02	-	-	0.111	0.43	0.5
P_2O_5	1.28	-	0.51	0.66	0.44	0.14
Cr_2O_3	0.01	0.2	0.23	-	-	-
Total	99.97	99.8	99.83	99.65	98.14	100

LOI: Loss on ignition. Except CAS-1, the other chemical data are cited from(Basu and Riegsecker, 1998; Haskin and Warren, 1991; McKay et al., 1991; McKay et al., 1994; Weiblen et al., 1990)

The mineral composition of CAS-1 was analysed using SEM with SE imaging. Figure 3 shows the SEM-backscattered electron image of CAS-1. The majority of CAS-1 is glass, plagioclase and olivine.

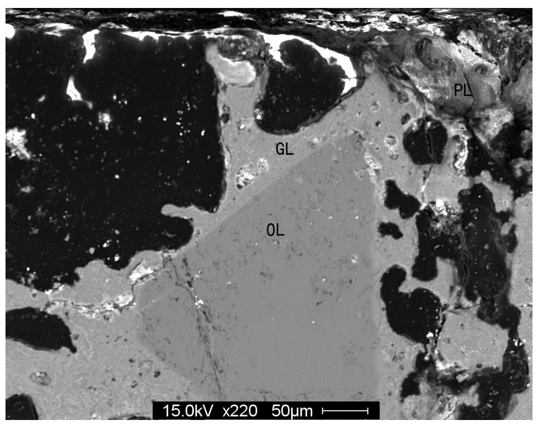

FIGURE 3. THE MINERAL COMPOSITION OF CAS-1 (SEM-BACKSCATTERED ELECTRON IMAGE)

GL: glass; PL: plagioclase; OL: olivine.

CONCLUSION

The basic mechanical parameters of CAS-1, such as particle size distribution, specific gravity, angle of internal friction, and cohesion, have been characterized and fall within the ranges of lunar mare soil samples(Zheng et al., 2004). CAS-1 is also a good complement for five existed lunar soil simulants, JSC-1 (McKay et al., 1993; McKay et al., 1994), MLS-1, MLS-2 (Weiblen and Gordon, 1988; Weiblen et al., 1990), MKS-1, FJS-1 (Kanamori, 2000; Kanamori et al., 1998).

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