

10019 – 297 grams

10066 – 60 grams

Regolith Breccia



Figure 1: Photo of 10019,1. Cube is 1 inch and scale is in cm. NASA S76-23354.

Introduction

Kramer et al. (1977) reported that 10019 and 10066 appeared to be alike and their chemical compositions are found to be alike (figure 1 and 2). Fruland (1983) and Simon et al. (1984) included 10019 in the Regolith Breccia Initiative.

10019 has micrometeorite pits on the top surface (figure 1).

10066 has not been studied.

Simon's Mode for 10019

	S	L
Mare Basalt	4.4	10.8
Highland Component	0.6	
Regolith breccia	5.6	3
Agglutinate	11	1.8
Pyroxene	4.6	1.4
Olivine	0.5	
Plagioclase	2.2	0.2
Ilmenite	1.7	0.1
Orange glass	1.2	
Other glass	3	0.9
Matrix	47 %	



Figure 2: Photo of 10066,1. About 4 cm across. NASA S75-3112.

Petrography

10019 and 10066 are both glass-matrix regolith breccias (figure 3 and 4). Phinney et al. (1976) reported that 10019 was coherent with 10 % porosity. Phinney et al. termed 10019 a “vitric-matrix” breccia with 35 % glass in matrix and SEM evidence of apparent sintering - especially near glass spheres.

Simon et al. (1984) determined the mode for 10019 (see table). They calculated that it had about 25% highland component, but couldn’t directly identify very many clasts of highland rock.

As is the case with other Apollo 11 breccias, Keil et al. (1970), Simon et al. (1984) and others have determined the composition of a wide range of glass particles in 10019. Some have the composition of the “orange glass” 74220, while one particle has the composition of HASP. A subset of the glass composition is different from the glass found in soil 10084, indicating that Apollo 11 breccias are derived from a different regolith (than 10084).

Significant Clasts

Keil et al. (1970) described an anorthosite clast in 10019 and determined the compositions of plagioclase, olivine and Mg-spinel.

Chemistry

Rhodes and Blanchard (1981) found that the composition of 10019 was similar to the other regolith breccias and 10084 (figure 5). The rare earth element patterns (figures 6 and 7) are exactly the same as for the soil. Rose et al. (1970) reported 157 ppm Ni.

Schonfeld and Meyer (1972) calculated that 10019 was a mix of mare basalt with ~19 % gabbroic anorthosite and ~3.5 % KREEP, while Rhodes and Blanchard (1981) found it was a mix of soil and high-K basalt. However, Simon et al. (1984) could not identify such a high percentage of highland component.

Cosmogenic isotopes and exposure ages

The cosmic ray induced activity was reported by LSPET (1969) as $^{26}\text{Al} = 98$ dpm/kg., $^{22}\text{Na} = 47$ dpm/kg., $^{46}\text{Sc} = 10$ dpm/kg., $^{54}\text{Mn} = 27$ dpm/kg. and $^{56}\text{Co} = 35$ dpm/kg.

Other Studies

Kirsten et al. (1970) used a microprobe technique to study the location of ^4He in a thin section of 10019.

Bloch et al. (1971) and Neukum et al. (1972) reported the size distribution of micrometeorite craters on 10019.

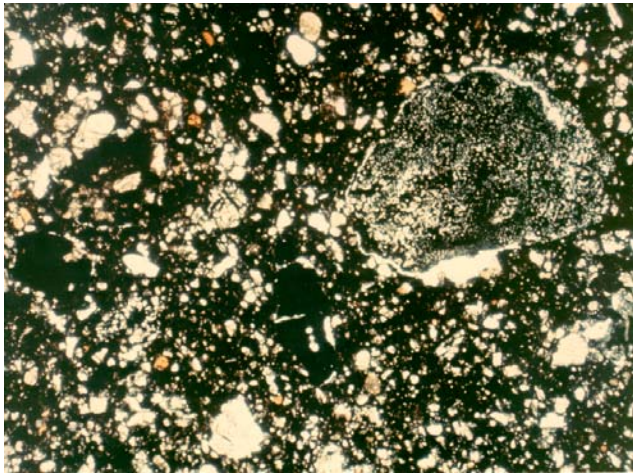


Figure 3: Transmitted light photomicrograph of thin section 10019,2 showing fine matrix with broken orange glass beads and rock clasts. Field of view is 2.5 mm. NASA# S70-19237.

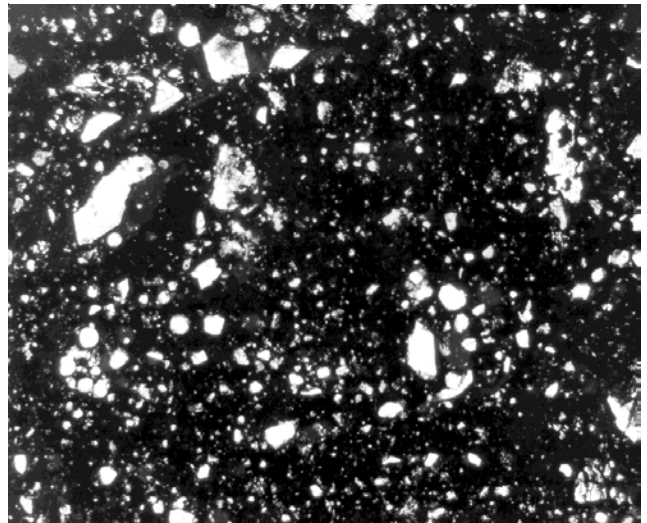


Figure 4: Photomicrograph of thin section 10066,20. NASA S76-26288.

Processing

10019 was one of the rocks in the F-201 at the time of the glove rupture (resulting in exposure to Houston air). Apollo 11 samples were originally described and cataloged in 1969 and “re-cataloged” by Kramer et al. (1977). There are 8 thin sections for 10019 and only 5 for 10066.

List of Photo #s for 10019

- S69-46255 – 46333
- S75-31360 – 31367
- S76-26276 – 26278 TS

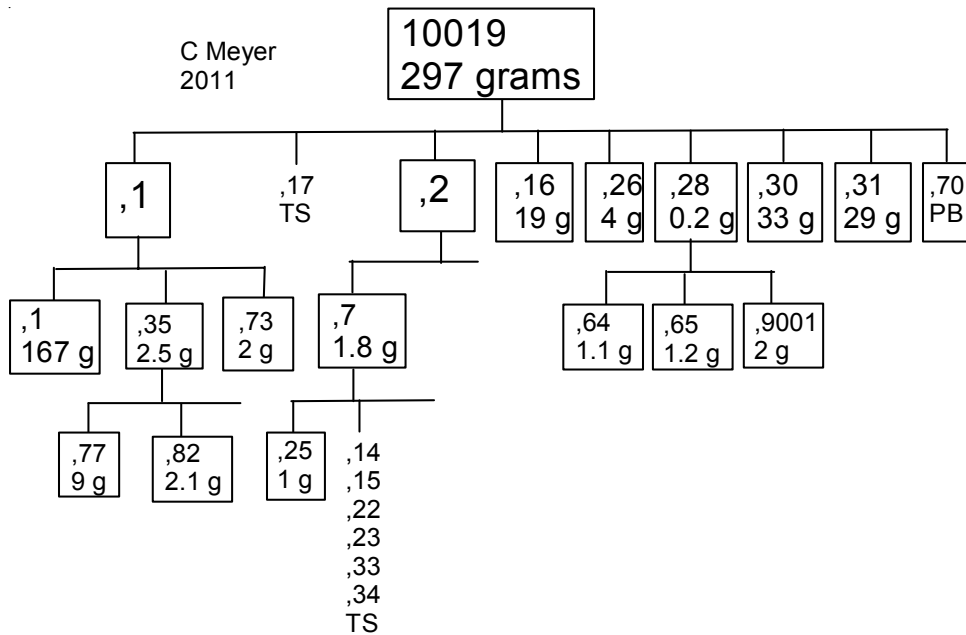
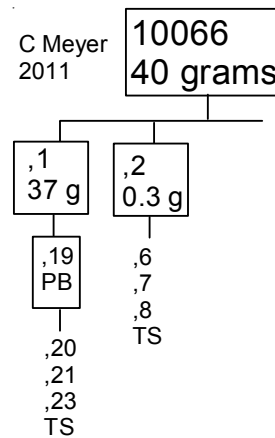


Table 1. Chemical composition of 10019.

reference weight	Rhodes81	Rose70	Wiesmann75 50 mg	Wakita70 532 mg	497 mg	Goles70	LSPET69	O'Kelley70	Gopalan70 Lovering71
SiO2 %	41.6	(a) 41.1	(b)	41.1	33.6	(d) 40.4			
TiO2	7.6	(a) 8.25	(b)		8.8	(d) 8.2			
Al2O3	12.6	(a) 13.7	(b)	12.7	13.2	(d) 13			
FeO	15.78	(a) 15.7	(b)	17.1	16.6	(d) 16.3			
MnO	0.21	(a) 0.22	(b)	0.22	0.25	(d) 0.19	(d)		
MgO	7.74	(a) 7.86	(b)	8.8	7.1	(d) 6.3			
CaO	11.74	(a) 11.9	(b)		12.5	(d) 12.6			
Na2O	0.47	(a) 0.93	(b)	0.47	0.46	(d) 0.47	(d)		
K2O	0.15	(a) 0.14	(b) 0.16	(c) 0.11	0.13	(e)	0.145	(f) 0.145	(f) 0.17
P2O5	0.11	(a)							
S %									
sum									
Sc ppm				64	64	(d) 60.9	(d)		
V				86	98	(d) 63	(d)		
Cr	2050	(a) 2190	(b)	2110	1990	(d) 1870	(d)		
Co				36	34	(d) 34.5	(d)		
Ni		tr.							
Cu									
Zn									
Ga									
Ge ppb									
As									
Se									
Rb			3.25	(c) 3.4		(e)			3.31
Sr			167	(c)					166.4
Y				91		(e)			
Zr		tr.	326	(c) 490	220	(d) 580	(d)		
Nb									
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb									
Cd ppb									
In ppb				5.2		(e)			
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm				0.41		(e)			
Ba			174	(c) 340	130	(d)			
La			16.6	(c) 15.1	14.1	(e) 15.5	(d)		
Ce			47.2	(c) 56		(e) 54	(d)		
Pr						(e)			
Nd			37.7	(c) 42		(e)			
Sm			13.1	(c) 13.8	14.2	(e) 12.7	(d)		
Eu			1.77	(c) 1.9	2	(e) 1.78	(d)		
Gd			18.6	(c) 20.5		(e)			
Tb				3.8		(e)			
Dy			20.6	(c) 18		(e)			
Ho				5.9		(e) 5	(d)		
Er			12.1	(c) 14.1		(e)			
Tm				2		(e)			
Yb			11.1	(c) 12.4	12	(e) 11.7	(d)		
Lu				1.6	1.6	(e) 1.84	(d)		
Hf				13	14	(d) 10.8	(d)		
Ta						1.7	(d)		
W ppb									
Re ppb									0.73
Os ppb									7.8
Ir ppb									
Pt ppb									
Au ppb									
Th ppm			2.16	(c) 2.7	3.2	(d)	1.9	(f) 1.9	(f)
U ppm			0.58	(c)		0.49	(d) 0.43	(f) 0.43	(f)

technique: (a) XRF, (b) semimicro XRF, (c) IDMS, (d) INAA, (e) RNAA, (f) rad. Counting

Table 2. Chemical composition of 10066.

reference	Goles70	
weight		
SiO ₂ %	43.2	
TiO ₂	8.2	
Al ₂ O ₃	12.2	
FeO	16.5	
MnO	0.2	(a)
MgO	7.6	
CaO	12	
Na ₂ O	0.46	(a)
K ₂ O		
P ₂ O ₅		
S %		
sum		
Sc ppm	60.3	(a)
V	59	(a)
Cr	1910	(a)
Co	33.8	(a)
Ni		
Cu		
Zn		
Ga		
Ge ppb		
As		
Se		
Rb		
Sr		
Y		
Zr		
Nb		
Mo		
Ru		
Rh		
Pd ppb		
Ag ppb		
Cd ppb		
In ppb		
Sn ppb		
Sb ppb		
Te ppb		
Cs ppm		
Ba		
La	17.4	(a)
Ce	62	(a)
Pr		
Nd		
Sm	15.1	(a)
Eu	1.7	(a)
Gd		
Tb	2.8	(a)
Dy		
Ho	6.5	(a)
Er		
Tm		
Yb	11.8	(a)
Lu	1.9	(a)
Hf	10.6	(a)
Ta	2.1	(a)
W ppb		
Re ppb		
Os ppb		
Ir ppb		
Pt ppb		
Au ppb		
Th ppm		
U ppm	0.56	(a)
technique:	(a) INAA	

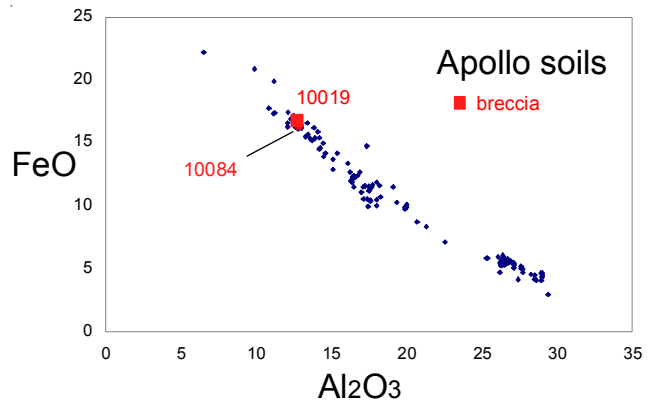


Figure 5: Composition of 10019 compared with Apollo soil samples.

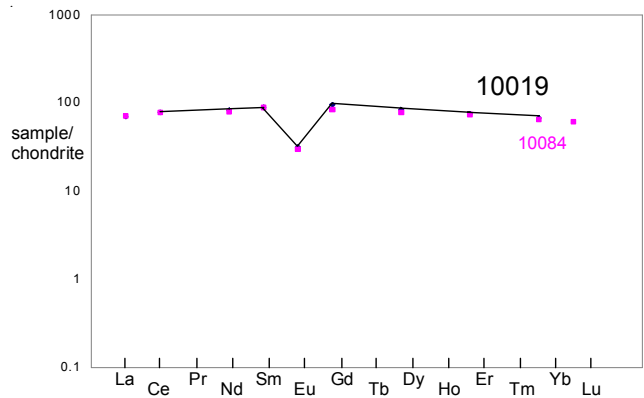


Figure 6: Normalized rare earth element diagram for breccia 10019 compared with soil 10084 (data from Wiesmann et al. 1970).

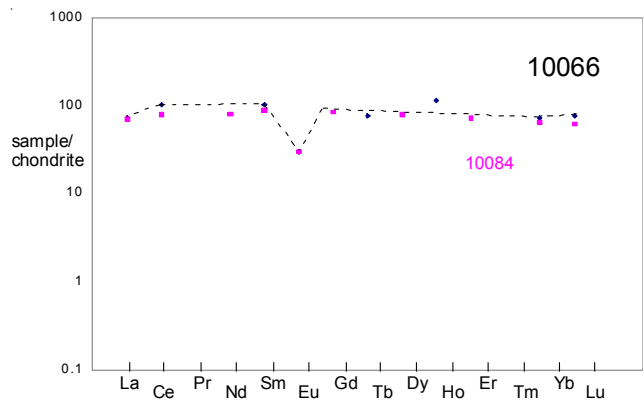


Figure 7: Normalized rare earth element diagram for breccia 10066 compared with soil 10084 (data from Goles et al. 1970).

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