10021

Regolith Breccia

255 grams

Figure 1: Photo of 10021,36. Middle piece is 2 cm across. NASA S75-31372.

Introduction

10021 is a rather friable soil breccia. It breaks into rounded pieces (figures 1 and 6). It was collected as part of the contingency sample from the area immediately in front of the Lunar Module (LM). The sample container (bag?) used for the contingency sample also contained other rather friable samples 10023, 10025, 10026, 10027, 10028 – some or all of which may be pieces of the same. The E1 surface of 10021 had numerous zap pits.

10021 is very mature regolith and was found to have more He than any other lunar breccia.

Fruland (1983) chose 10021 as one of the regolith breccias to be studied by the Regolith Breccia Initiative of LAPST.

Petrography

Fruland (1983) and Kramer et al. (1977) give the only petrographic descriptions. The matrix is made up of brown-black glass (figure 2) and does not appear to be very porous. Several large accretionary structures and relict agglutinates were observed in the matrix (Fruland 1985). Glass spheres and fragments are common, with a wide range of color and composition.

Chemistry

The composition of 12021 was determined by Goles et al. (1970) and others. It is not greatly different from that of soil sample 10084 (figures 3 and 4).

Schonfeld and Meyer (1972) calculated that 10021 was a mix of mare basalt with ~18 % gabboic anorthosite and ~2 % 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}Al = 81 dpm/kg., ^{22}Na = 41 dpm/kg., ^{46}Sc = 10 dpm/kg., ^{54}Mn = 15 dpm/kg. and ^{56}Co = 38 dpm/kg.

Other Studies

The total organic carbon content of 10021 was determined by hydrogen flame ionization pyrolysis (Ponnamperuma et al. 1970).

Funkhouser et al. (1970) and Hintenberger et al. (1971, 1975) determined the rare gas abundance and isotopic ratios (figure 5).

Robie and Hemingway (1971) determined calorimetric data (specific heat) for 10021.

Processing

Apollo 11 samples were originally described and cataloged in 1969 and "re-cataloged" by Kramer et al. (1977). It was returned in the contingency sample bag (see also 10023). There are 29 thin sections of 10021.

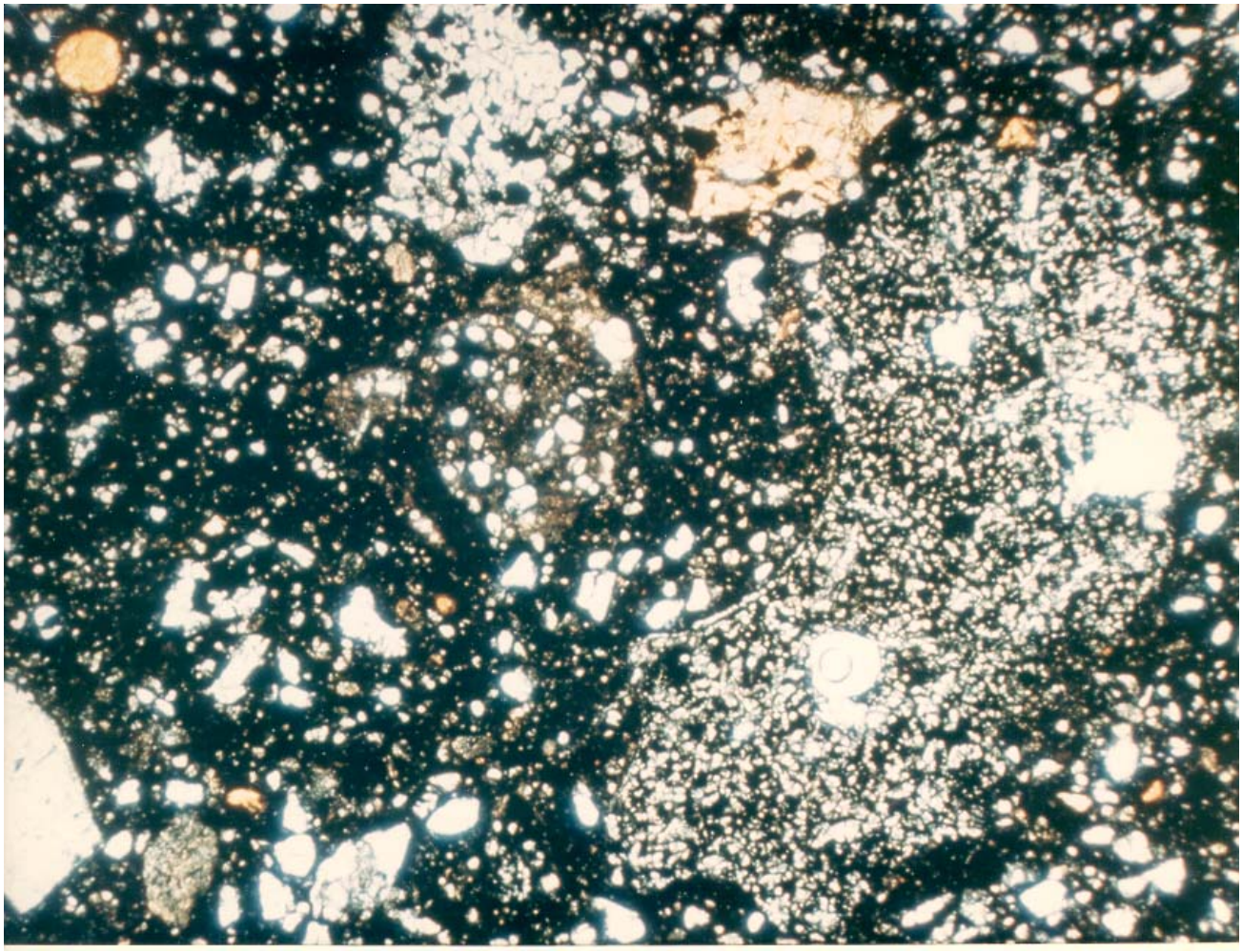

Figure 2: Thin section photomicrograph of 10021,28 showing orange fine-grained matrix with glass bead and rock clasts. Scale is 2.5 mm. NASA S70-49481.

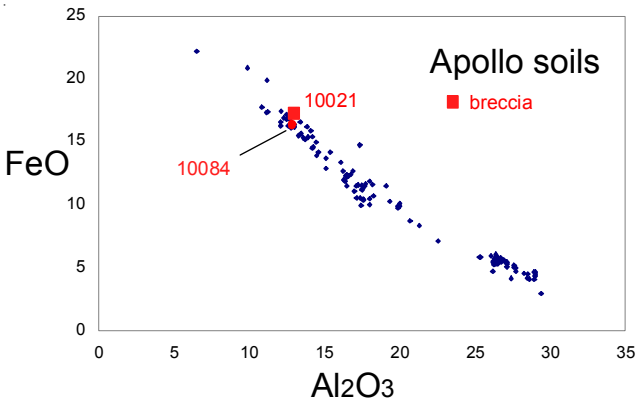

Figure 3: Composition of 10021 compared with that of Apollo soil samples.

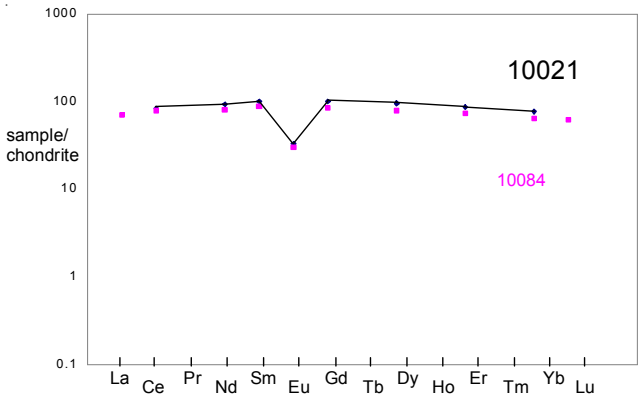

Figure 4: Normalized rare earth element diagram for breccia 10021 compared with soil 10084 (data from Rhodes et al. 1981).

Table 1. Chemical composition of 10021.

reference	*LSPET69*	Wiesmann75		Philpotts70		Goles70		Annell70		Kharkar71	Wasson70		O'Kelley70	
weight		51 mg		137 mg									157 g	
SiO2 %	43					41.8								
TiO2	8.6	8.17	(a)			8.2				8.84				
Al2O3	11					13								
FeO	19					16.8				15.7				
MnO	0.22					0.2	(b)	0.23	(c)					
MgO	7.4					8.3								
CaO	11					10.8				13.4				
Na2O	0.2	0.5				0.46	(b)			0.47				
K2O	0.15	0.19	(a)	0.19	(a)								0.193	(d)
P2O5														
S %														
sum														
Sc ppm	68					61.8	(b)	72	(c)	72				
V	22					73	(b)	60	(c)					
Cr	2500					1950	(b)	2480	(c)	2100				
Co	13					30.7	(b)	33	(c)	27				
Ni	215							184	(c)					
Cu								12	(c)					
Zn								24	(c)					
Ga								4.6	(c)					
Ge ppb											410	(e)		
As														
Se														
Rb		3.96	(a)	4.03	(a)			4	(c)					
Sr	150			165	(a)			130	(c)					
Y	300							113	(c)					
Zr	1500					250	(b)	424	(c)					
Nb								28	(c)					
Mo														
Ru														
Rh														
Pd ppb														
Ag ppb														
Cd ppb														
In ppb											22	(e)		
Sn ppb														
Sb ppb														
Te ppb														
Cs ppm														
Ba	105	202	(a)	211	(a)	350	(b)	270	(c)					
La						17.5	(b)	22	(c)	17.8				
Ce		50.7	(a)	57.2	(a)	61	(b)			48.3				
Pr														
Nd		42.5	(a)	48.9	(a)									
Sm		14.7	(a)	17.2	(a)	15	(b)			11.2				
Eu		1.84	(a)	1.91	(a)	1.8	(b)			1.9				
Gd		19.9	(a)											
Tb						4.2	(b)			3.1				
Dy		23.3	(a)	25.2	(a)					20.9				
Ho						6.9	(b)							
Er		13.7	(a)	13	(a)									
Tm														
Yb		12.5	(a)	12.7	(a)	14.5	(b)			9.9				
Lu				1.99	(a)	2.25	(b)			2.2				
Hf						12.2	(b)			13.4				
Ta						1.6	(b)			1.8				
W ppb														
Re ppb														
Os ppb														
Ir ppb											7.5	(e)		
Pt ppb														
Au ppb											2.4	(e)		
Th ppm	1.8	(d)											2.5	(d)
U ppm	0.39	(d)	0.72	(a)		0.56	(b)						0.54	(d)

technique: (a) IDMS, (b) INAA, (c) emission spec., (d) radiation counting, (e) RNAA

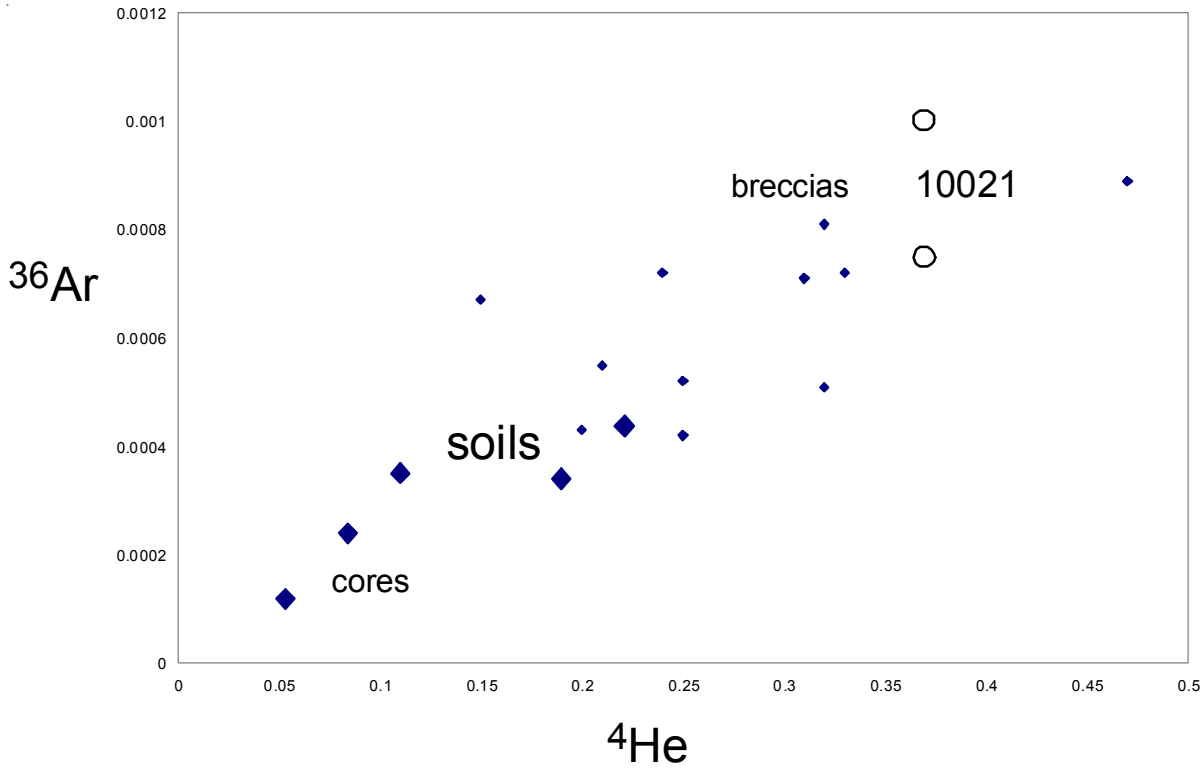

Figure 5: Implanted solar wind rare gas in 10021 compared with Apollo 11 soils and breccias (Funkhouser et al. 1070 and Hintenberger et al. 1976). Units STP cc/g.

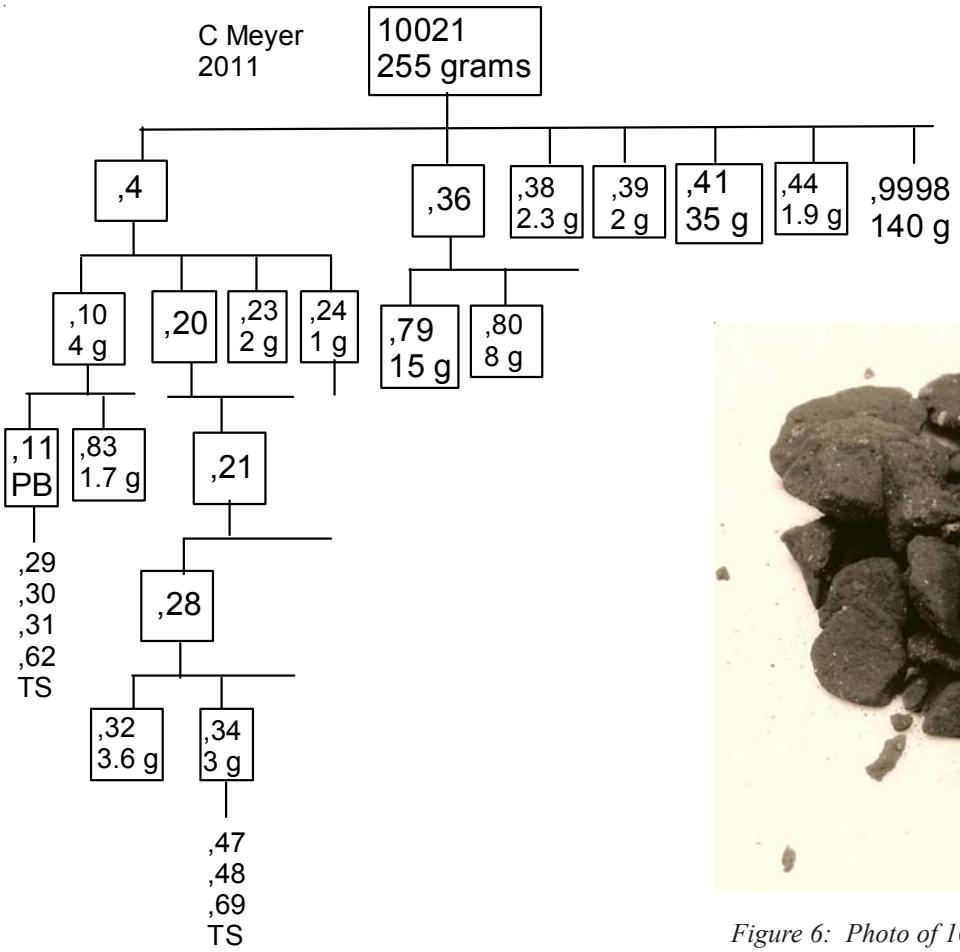

Figure 6: Photo of 10021,41. S72-33021

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Figure 7: Photo of 10021 taken during Apollo 11 PET. S69-45421.