

10023
Regolith Breccia
66 grams



Figure 1: Photos of 10023, top and bottom. Sample is about 6 cm across. NASA S69-45394 and S69-45390.

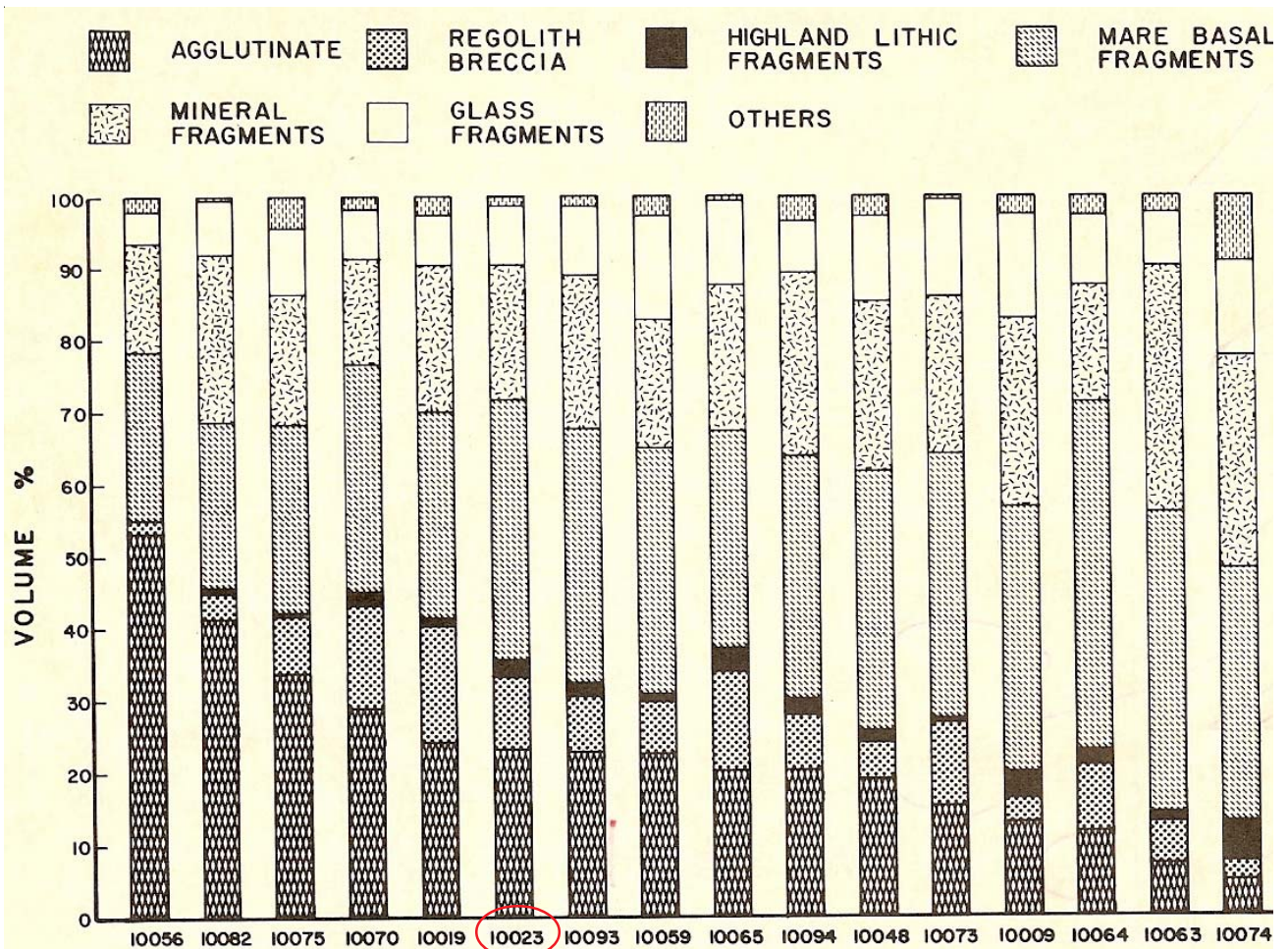


Figure 2: Comparison of lithic components in Apollo 11 breccias (from Simon et al. 1984).

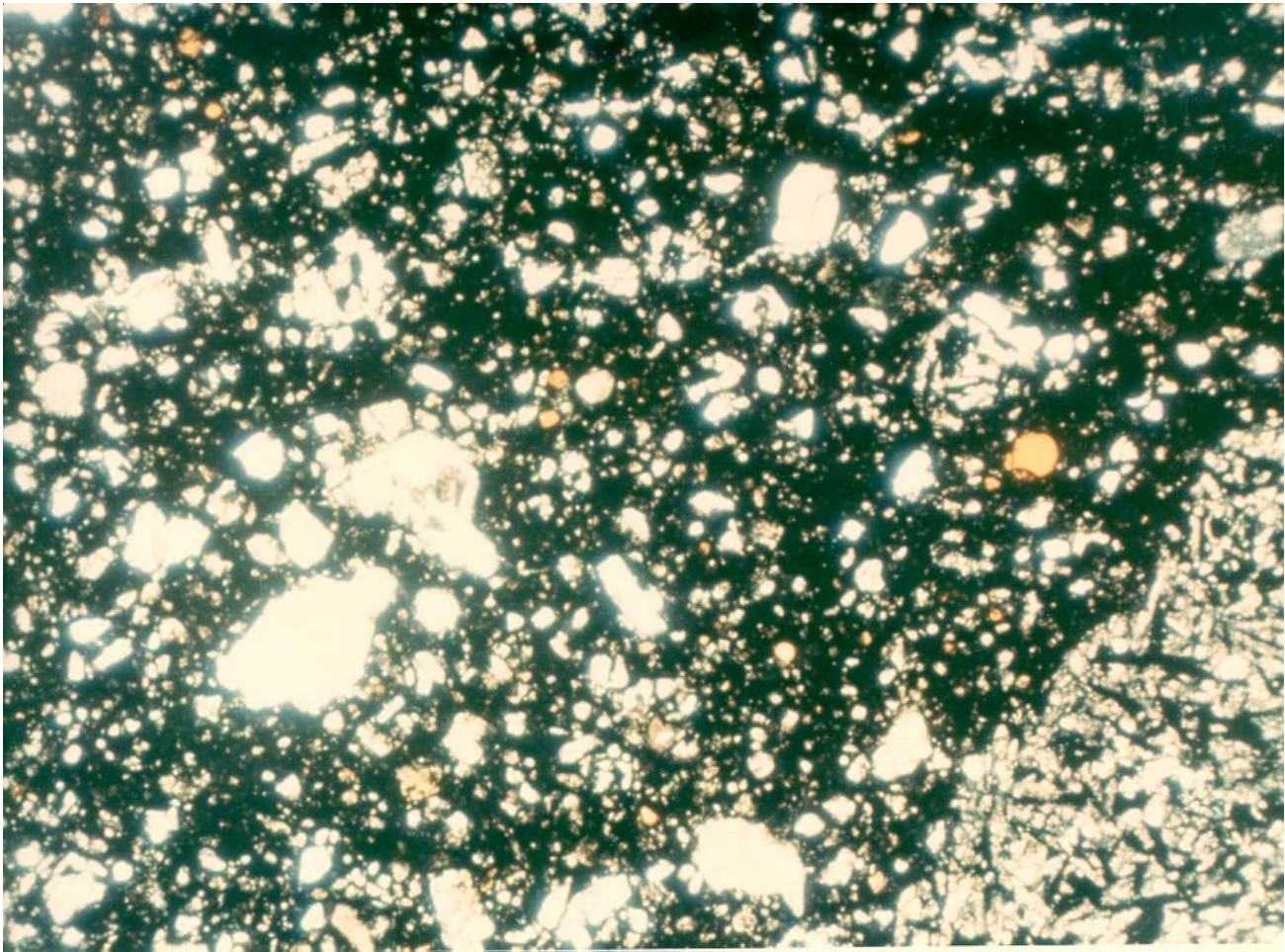


Figure 3: Photomicrograph of 10023,11 showing fine-grained matrix with orange glass bead and rock fragment. Thin section is 2.5 mm across and 30 microns thick. NASA S70-19245.

Introduction

10023 is a coherent regolith breccias with numerous micrometeorite pits on the top, rounded surface (figure 1). It was collected as part of the contingency sample and returned in air with the crew to the lunar receiving laboratory JSC. It was photographed before collection on the lunar surface and the lunar orientation is known (see Schmitt et al. 1970).

This is the rock where Strangway et al. (1969) originally reported finding a strong magnetization: *“If this rock was not magnetized by local fields in the spacecraft or in the lunar receiving laboratory, it must have been magnetized on the moon.”*

Mineralogical Mode

	Chao et al. 1971
Basaltic rock	23.4
Anorthositic rock	0.4
Mineral fragments	6.3
Glass-welded aggregate	9.2
Devitrified glass	4.9
Heterogeneous glass	3
Homogeneous glass	2.3
Basaltic microbreccia	0.5
Anorthositic breccia	0.1
Shocked	0.1
Less than 25 microns	22.5
Pore space	27.3

Simon’s Mode for 10023

	S	L
Mare Basalt	6.5	14.2
Highland Component	1	0.3
Regolith breccia	5.2	0.6
Agglutinate	11.9	1.3
Pyroxene	5.5	1.1
Olivine	0.1	
Plagioclase	2.6	
Ilmenite	1.5	
Orange glass	1.9	0.8
Other glass	2	0.6
Matrix	42.9 %	

Petrography

10023 is a rather typical regolith breccia from Apollo 11 (figure 2). Chao et al. (1971) reported that it had a glass matrix with 27 % pore space (figure 3). The mode has about 25 % mare basalt.

Simon et al. (1984) included breccia 10023 in their comprehensive study of Apollo 11 regolith breccias – their mode is given in the table. They calculated that it had about 19% highland component, but couldn't directly identify that many clasts of highland rock. Quaide and Bunch (1970) determined the size distribution of grains in 10023 (figure 7).

Chao et al. (1971) illustrate a cross section thru a micrometeorite crater in 10023.

Chemistry

Rhodes and Blanchard (1981) found that the composition of 10023 was different from the other regolith breccias and 10084 (figure 5). The rare earth element concentration of this breccia sample is slightly higher than for the soil 10084 (figure 6).

Other Studies

Funkhouser et al. (1970) determined rare gases (figure 8).

Processing

Apollo 11 samples were originally described and cataloged in 1969 and "recataloged" by Kramer et al. (1977). There are 6 thin sections.

References for 10023

Chao E.C.T., James O.B., Minkin J.A., Boreman J.A., Jackson E.D. and Raleigh C.B. (1970) Petrology of unshocked crystalline rocks and evidence of impact metamorphism in Apollo 11 returned lunar samples. *Proc. Apollo 11 Lunar Sci. Conf.* 287-314.

Chao E.C.T., Boreman J.A., Minkin J.A. and James O.B. (1970) Lunar glasses of impact origin: Physical and chemical characteristics and geologic implications. *J. Geophys. Res.* 75, 7445-7479.

Chao E.C.T., Boreman J.A. and Desborough G.A. (1971) The petrology of unshocked and shocked Apollo 11 and Apollo 12 microbreccias. *Proc. Second Lunar Sci. Conf.* 791-816.

Funkhouser J.G., Schaeffer O.A., Bogard D.D. and Zahringer J. (1970) Gas analysis of the lunar surface. *Proc. Apollo 11 Lunar Sci. Conf.* 1111-1116.

King E.A. *and a cast of thousands* (1969) Lunar Sample Information Catalog, Apollo 11. Lunar Receiving Laboratory, MSC 412 pp

Kramer F.E., Twedell D.B. and Walton W.J.A. (1977) Apollo 11 Lunar Sample Information Catalogue (revised). Curator's Office, JSC 12522

LSPET (1969) Preliminary examination of lunar samples from Apollo 11. *Science* 165, 1211-1227.

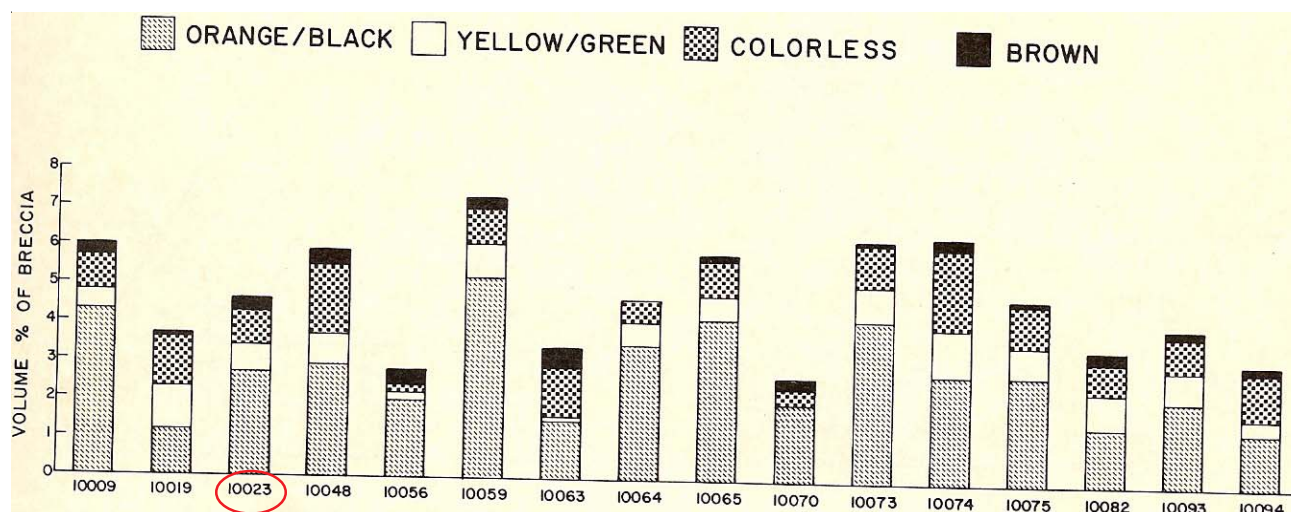


Figure 4: Percentage of glass particles in Apollo 11 soil breccias (Simon et al. 1984).

Table 1. Chemical composition of 10023.

reference	Wiesmann75	Rhodes81	
weight	54 mg		
SiO ₂ %		41.4	(b)
TiO ₂		8.4	(b)
Al ₂ O ₃		11.67	(b)
FeO		16.65	(b)
MnO		0.22	(b)
MgO		7.76	(b)
CaO		11.62	(b)
Na ₂ O		0.47	(b)
K ₂ O	0.19	(a) 0.2	(b)
P ₂ O ₅		0.13	
S %			
sum			
Sc ppm			
V			
Cr		2121	(b)
Co			
Ni			
Cu			
Zn			
Ga			
Ge ppb			
As			
Se			
Rb	4	(a)	
Sr	169	(a)	
Y			
Zr	380	(a)	
Nb			
Mo			
Ru			
Rh			
Pd ppb			
Ag ppb			
Cd ppb			
In ppb			
Sn ppb			
Sb ppb			
Te ppb			
Cs ppm			
Ba	206	(a)	
La	18.5	(a)	
Ce	55.3	(a)	
Pr			
Nd	45.5	(a)	
Sm	15.1	(a)	
Eu	1.85	(a)	
Gd	23.5	(a)	
Tb			
Dy	24.3	(a)	
Ho			
Er	14	(a)	
Tm			
Yb	13.1	(a)	
Lu			
Hf			
Ta			
W ppb			
Re ppb			
Os ppb			
Ir ppb			
Pt ppb			
Au ppb			
Th ppm	2.7	(a)	
U ppm	0.74	(a)	

technique: (a) IDMS, (b) XRF

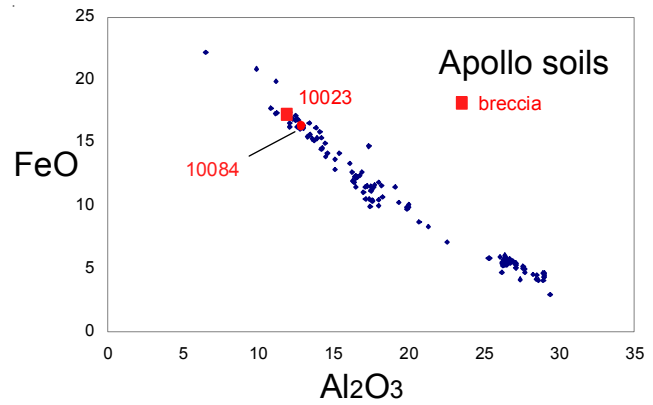


Figure 5: Composition of 10023 compared with that of Apollo soil samples.

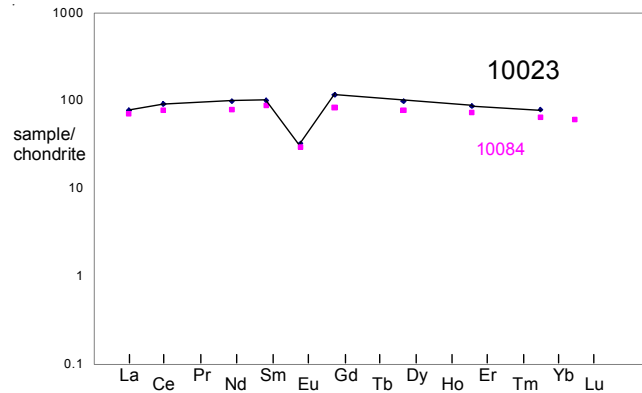


Figure 6: Normalized rare earth element diagram for breccia 10023 compared with soil 10084 (data from Wiesmann et al. 1975).

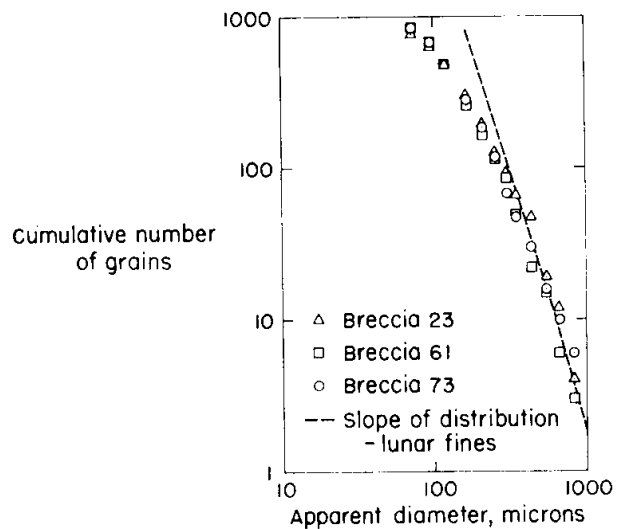


Figure 7: Size distribution for 10023 (Quaide and Bunch 1970).

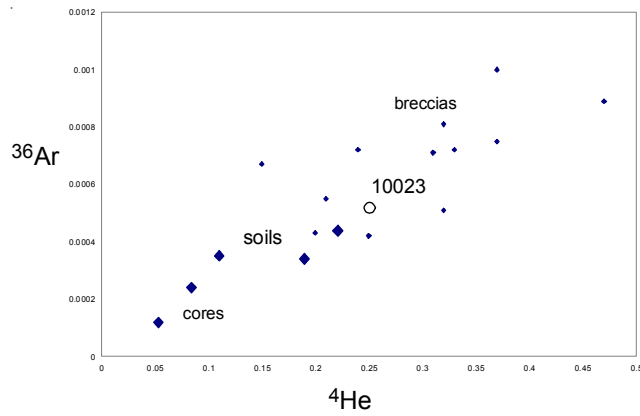


Figure 8: Implanted solar wind in 10023 compared with Apollo 11 soils and breccias (Funkhouser et al. 1070 and Hintenberger et al. 1976). Units STP cc/g.

Phinney W.C., McKay D.S., Simonds C.H. and Warner J.L. (1976a) Lithification of vitric- and clastic-matrix breccias: SEM photography. *Proc. 7th Lunar Sci. Conf.* 2469-2492.

Quaide W. and Bunch Ted (1970) Impact metamorphism of lunar surface materials. *Proc. Apollo 11 Lunar Sci. Conf.* 711-729.

Rhodes J.M. and Blanchard D.P. (1981) Apollo 11 breccias and soils: Aluminous mare basalts or multi-component mixtures? *Proc. 12th Lunar Planet. Sci. Conf.* 607-620.

Schmitt H.H., Lofgren G., Swann G.A. and Simmons G. (1970) The Apollo 11 samples: Introduction. *Proc. Apollo 11 Lunar Science Conf.* 1-54.

Simon S.B., Papike J.J. and Shearer C.K. (1984) Petrology of Apollo 11 regolith breccias. *Proc. 15th Lunar Planet. Sci. Conf.* in *J. Geophys. Res.* 89, C109-132.

Strangway D.W., Pearce G.W., Gose W.A. and Timme R.W. (1971) Remanent magnetization of lunar samples. *Earth Planet. Sci. Lett.* **13**, 43-52.

