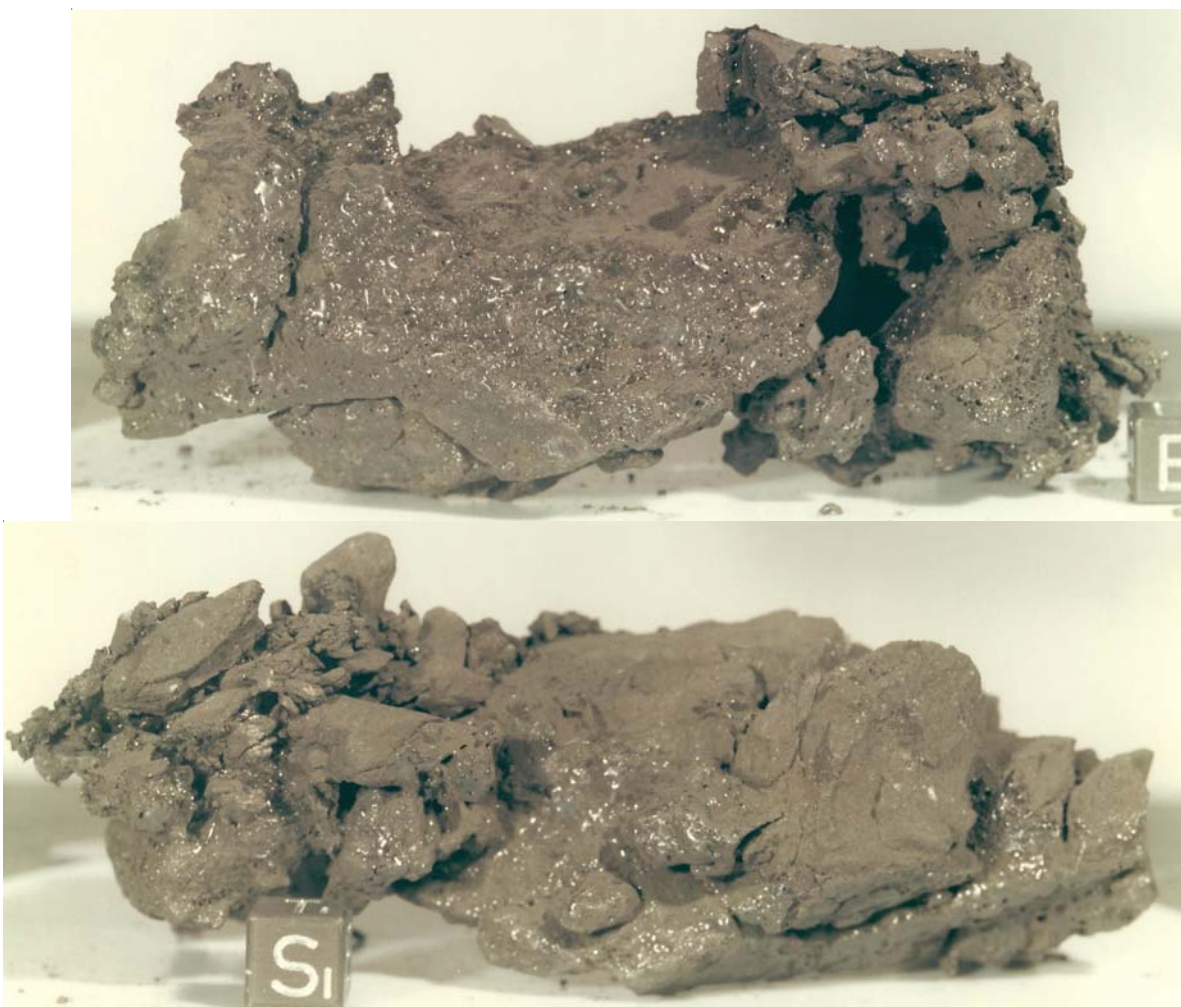


70019
Regolith Breccia
159.9 grams



Figures 1 a,b: Photo of glass-welded mass of soil breccia particles 70019. Cube is 1 cm. S73-15332 and 334.

Introduction

Sample 70019 was collected from within a fresh, 3-meter, glassy-lined crater located near the Lunar Module (figures 2 and 3).

70019 could be considered as an example of a large “agglutinate” made up of pieces of regolith breccia cemented together with black glass (figures 1 a,b and 10).

Note: Numerous investigators (e.g. Greenwood and Heiken 1970; Wilshire and Moore 1974; See et al. 1986) have shown an interest in glass from small, fresh craters in the lunar regolith and it is rather disappointing that they haven’t honed their interest by studying this particular large glass object

Mineralogical Mode for 70019

(Simon et al. 1990)

Matrix	59.7 %	
	20-90 micron	90-100 micron
Mare Basalt	1.0	6
KREEP Basalt		
Feld. Basalt		
Plutonic	0.2	0.2
Granulitic	0.2	0.3
Breccia	0.5	1.1
Olivine	0.5	0.1
Pyroxene	10.3	2.5
Plagioclase	3.1	1.0
Opaques	2.1	0.1
Glass	4.1	1.6
Agglutinate	3.8	1.4

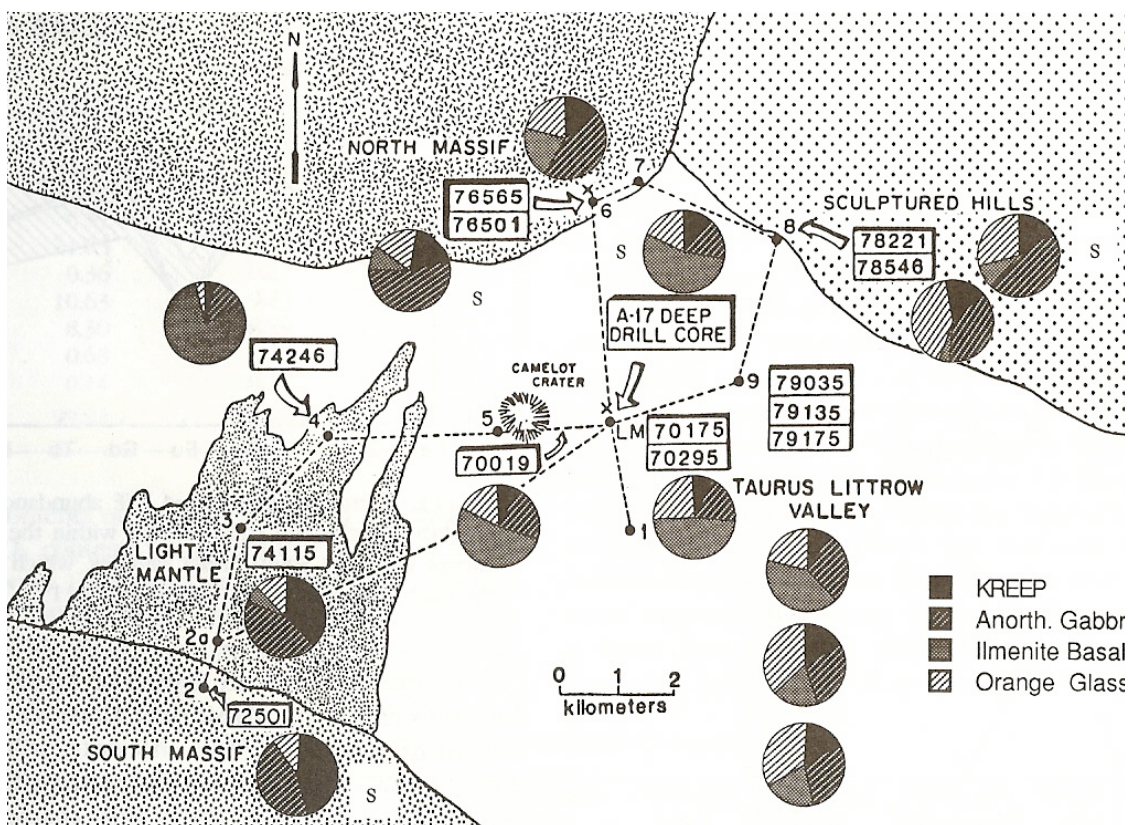


Figure 2: Location of regolith breccias at Apollo 17 site (Simon et al. 1990).



Figure 3: Small (3 m) crater where 70019 was collected. AS17-145-22186.

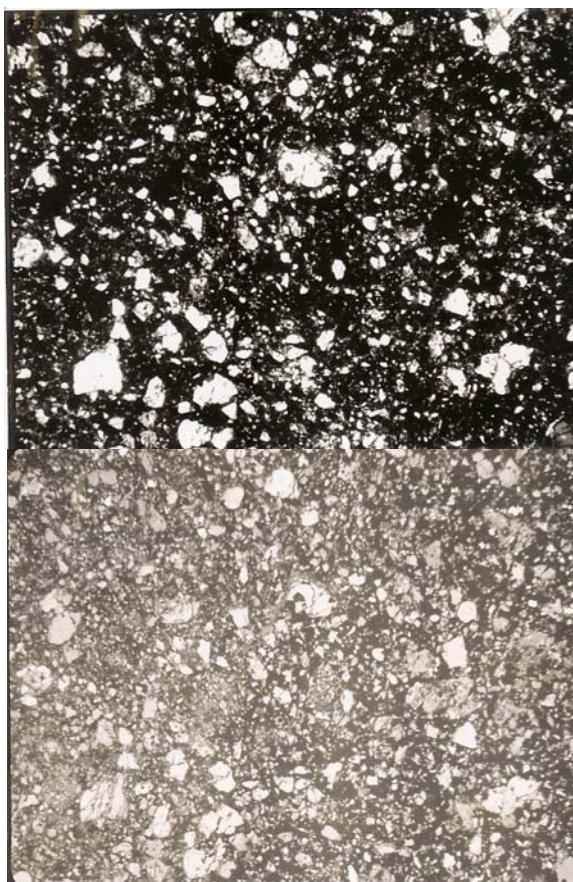


Figure 4: Transmitted and reflected light photomicrographs of thin section 70019,94.

Petrography

Fruland (1983) and Simon et al. (1990) included 70019 in their study of regolith breccias from Apollo. It is made of two major components – dark, coherent microbreccia fragment and black shiny glass. The microbreccia has a seriate grain size distribution with glass matrix and glass inclusions (figure 4 a,b). Simon et al. (1990) found that the matrix was 60% (figure 5) and that agglutinates were abundant (figure 6). Typical orange glass is also abundant. Pearce and Chou (1977) also described 70019.

Glass

The glass in 70019 has been the object of several studies. Fredriksson et al. (1974) and Mao et al. (1975) reported analyses, while Klein and Uhlmann (1976) and Uhlmann et al (1979) used the glass in 70019 to discuss viscosity of molten glass on the Moon. Sato (1976) and Mao et al. (1975) discussed the reduction of iron in glass in 70019.

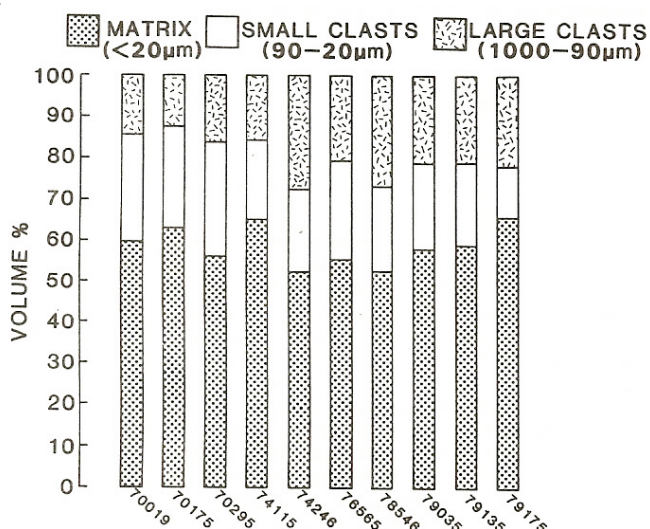


Figure 5: Proportions of clasts and matrix in Apollo 17 regolith breccia (Simon et al. 1990).

Chemistry

Rhodes et al. (1974), Wiesmann and Hubbard (1976), Pearce and Chou (1977), Wanke et al. (1976) and Simon et al. (1990) all obtained similar results (table 1). It has the composition of the soil in the area of the LM (figure 8, 9). Jovanovic and Reed (1975) also reported P, Cl, F and other elements.

Petrowski et al. (1974) determined 142 ppm C, 70 ppm N and 999 ppm S, Norris et al. (1983) reported 116 ppm C and 70 ppm N and Becker and Clayton (1975) reported 60 ppm N (figure 9). Filleux et al. (1977, 1978) reported surface abundances of carbon of ~ 170 ppm. Liech et al. (1974) studied H and F on the surface. It all depends on what part of the sample you study (figure 10)!

Cosmogenic isotopes and exposure ages

Keith et al. (1974) determined the cosmic-ray-induced activity of ^{22}Na = 110 dpm/kg, ^{26}Al = 45 dpm/kg, ^{54}Mn = 166 dpm/kg, ^{56}Co = 240 dpm/kg and ^{46}Sc = 59 dpm/kg. Fruchter et al. (1978) determined ^{26}Al = 52 dpm/kg and ^{54}Mn = 245 dpm/kg. and calculated that this was about 85% saturated.

Other Studies

Nunes et al. (1975) and Church and Tilton (1975) determined U, Th, Pb and Pb isotopes in 70019.

Grossman et al. (1974) showed that the isotopic composition of oxygen in 70019 was on the fractionation line for the Earth and Moon.

Becker and Clayton (1975) and Petrowski et al. (1974) reported an abundance of ^4He , but other rare gas studies that could give us the exposure age are lacking.

Sugiura et al. (1979, 1980) studied the magnetic properties of 70019. Pearce and Chou (1977) tried to obtain the direction of magnetic field using the glass, but the orientation of the sample on the lunar surface was not documented. They found that the magnetic

properties of the glass were similar to those of the breccias (figure 11).

Processing

There are 12 thin sections of 70019. Most of the thin sections were from only one lithology (figure 10). 70019 was chipped, not sawn.

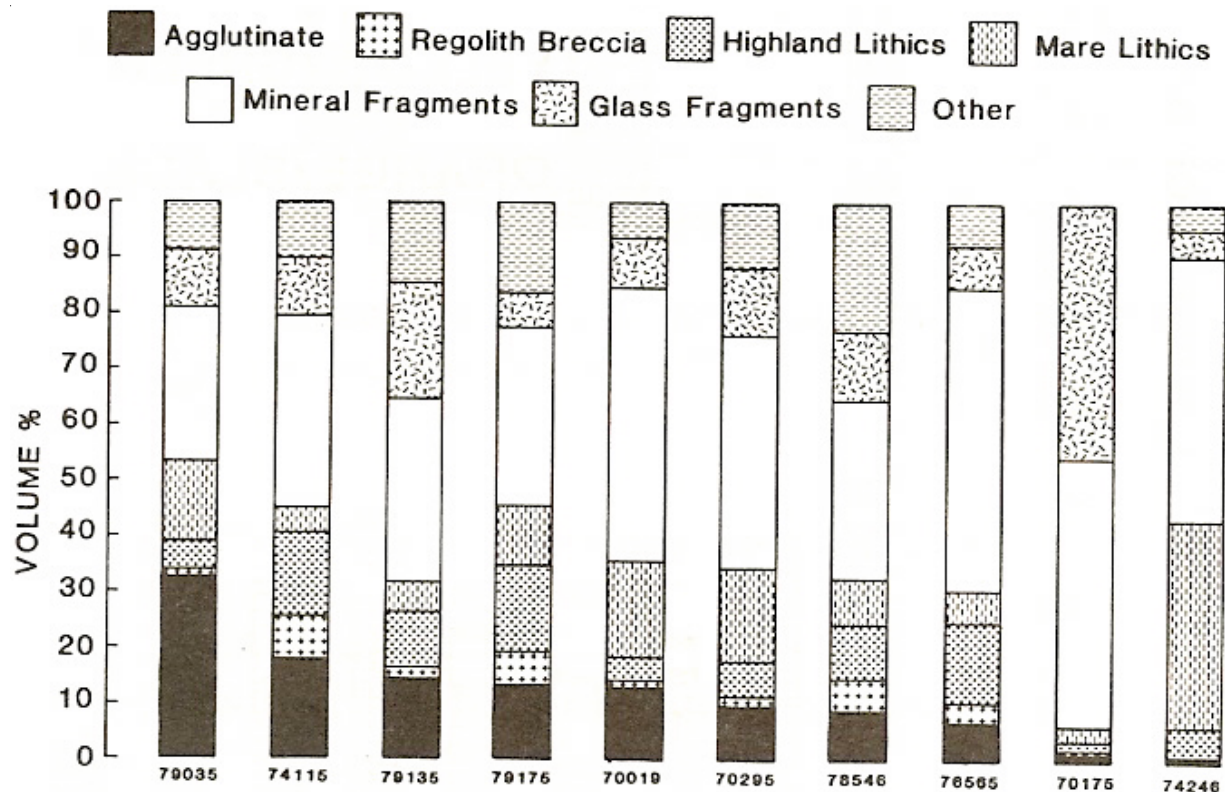


Figure 6: Proportions of lithic clasts in Apollo 17 regolith breccias (Simon et al. 1990).

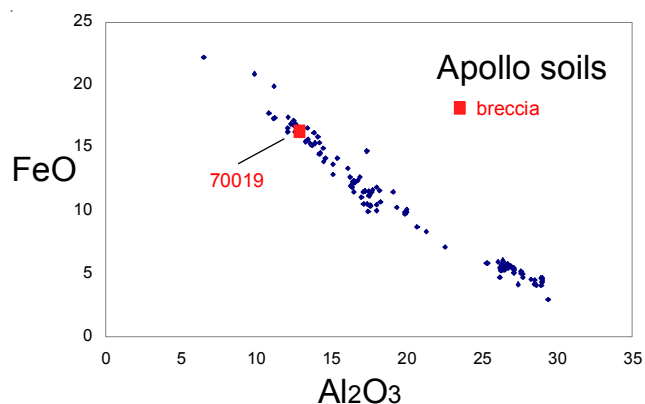


Figure 7: Composition of 70019 compared with Apollo soil samples.

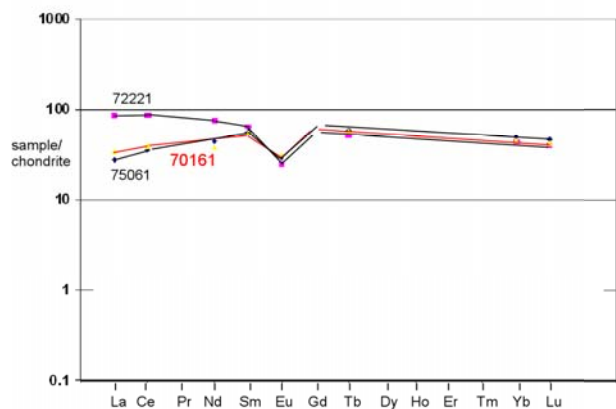


Figure 8: The composition of 70019 is very similar to that of 71061.

Table 1. Chemical composition of 70019.

reference weight	Rhodes74	Keith74	Simon90	Pearce77 interior	Wiesmann75	Wanke75
SiO2 %	40.66	(a)				
TiO2	8.26	(a)	7.91	(c)	8.48	(c)
Al2O3	12.38	(a)	12.7	(c)		
FeO	16.38	(a)	15.9	(c)	16.7	(c)
MnO	0.24	(a)	0.219	(c)	0.24	(c)
MgO	9.5	(a)	9	(c)		
CaO	11.03	(a)	11.8	(c)	11.1	(c)
Na2O	0.47	(a)	0.41	(c)	0.43	(c)
K2O	0.09	(a)	0.083	(c)	0.09	(c)
P2O5	0.07	(a)				
S %	0.1	(a)				
sum						
Sc ppm			59.6	(c)	59	(c)
V			87	(c)	90	(c)
Cr	2942	(a)	2870	(c)	3220	(c)
Co			33	(c)	33	(c)
Ni	154	(a)	140	(c)	141	(c)
Cu						
Zn	42	(a)	15	(c)		
Ga						
Ge ppb						
As						
Se						
Rb			2.9	(c)	1.42	(d)
Sr			170	(c)	170	(d)
Y						200
Zr			135	(c)	290	(c)
Nb					193	(d)
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb						
In ppb						
Sn ppb						
Sb ppb						
Te ppb						
Cs ppm			0.42	(c)		
Ba			97	(c)	105	(c)
La			7.9	(c)	8.3	(c)
Ce			23	(c)	23.8	(c)
Pr						
Nd			18.2	(c)	19.9	(c)
Sm			7.61	(c)	8.1	(c)
Eu			1.6	(c)	1.66	(c)
Gd			12	(c)		11.5
Tb			2	(c)	1.92	(c)
Dy			12.7	(c)	12.4	(c)
Ho						13
Er						7.61
Tm			1	(c)		
Yb			6.12	(c)	7.3	(c)
Lu			0.89	(c)	1.05	(c)
Hf			6.4	(c)	6.9	(c)
Ta			1.2	(c)	1.3	(c)
W ppb						
Re ppb						
Os ppb						
Ir ppb			4.7	(c)		
Pt ppb			3.3	(c)		
Au ppb						
Th ppm		1.03	0.8	(c)	0.89	(c)
U ppm		0.23	(b) 0.2	(c)		
technique: (a) XRF, (b) radiation count., (c) INAA, (d) IDMS						

technique: (a) XRF, (b) radiation count., (c) INAA, (d) IDMS

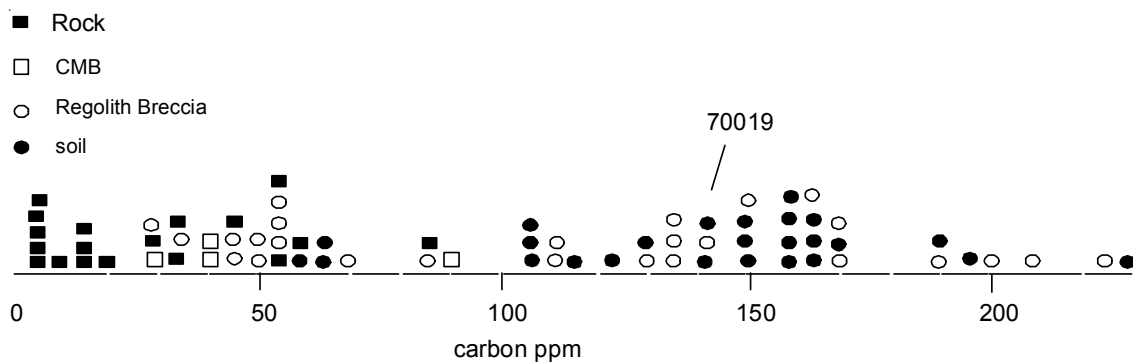


Figure 9: Carbon content of 70019 put in context of other Apollo samples.

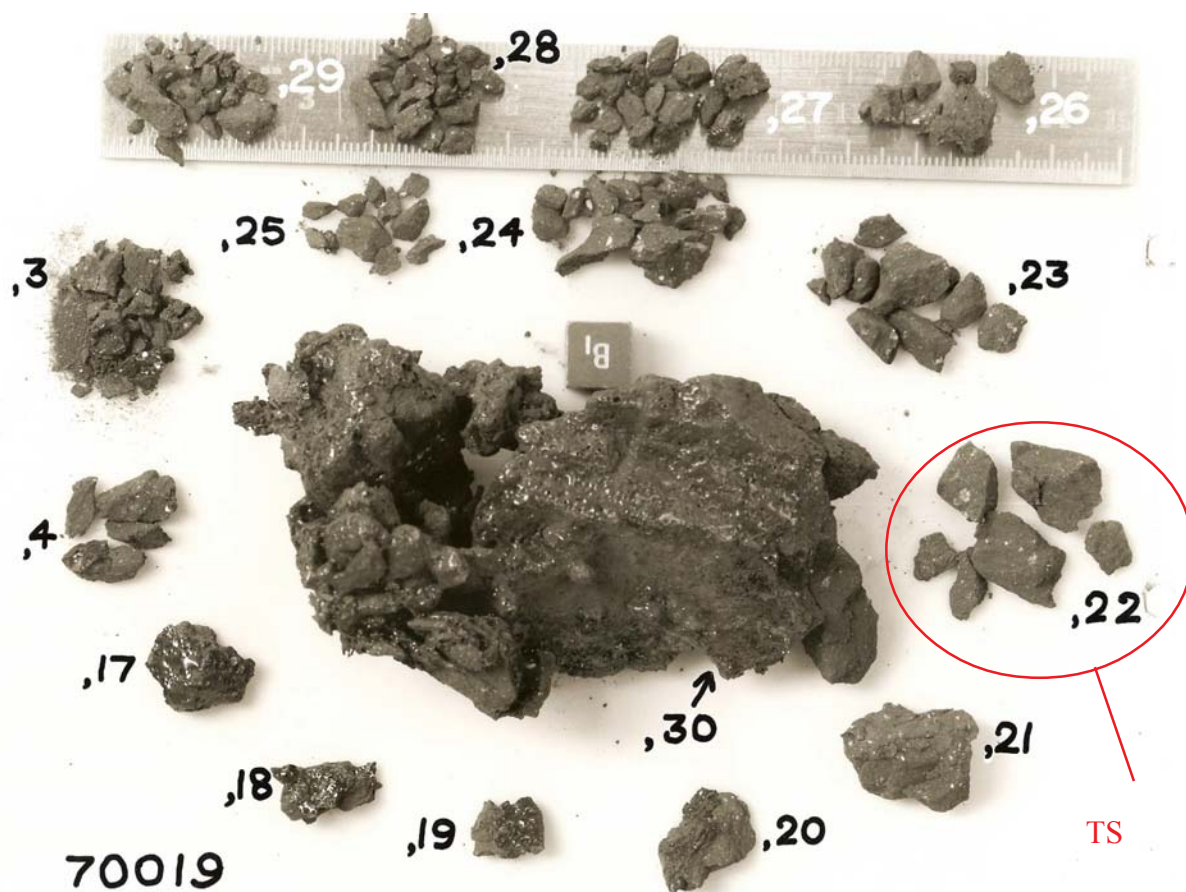


Figure 10: Processing photo of 70019. Cube is 1 cm. S73-37008.

C Meyer
2011

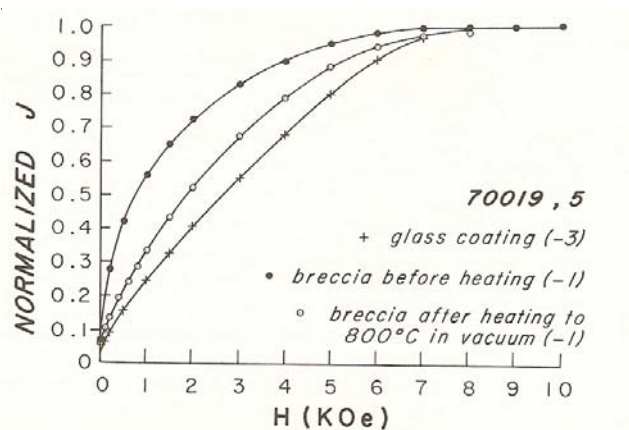
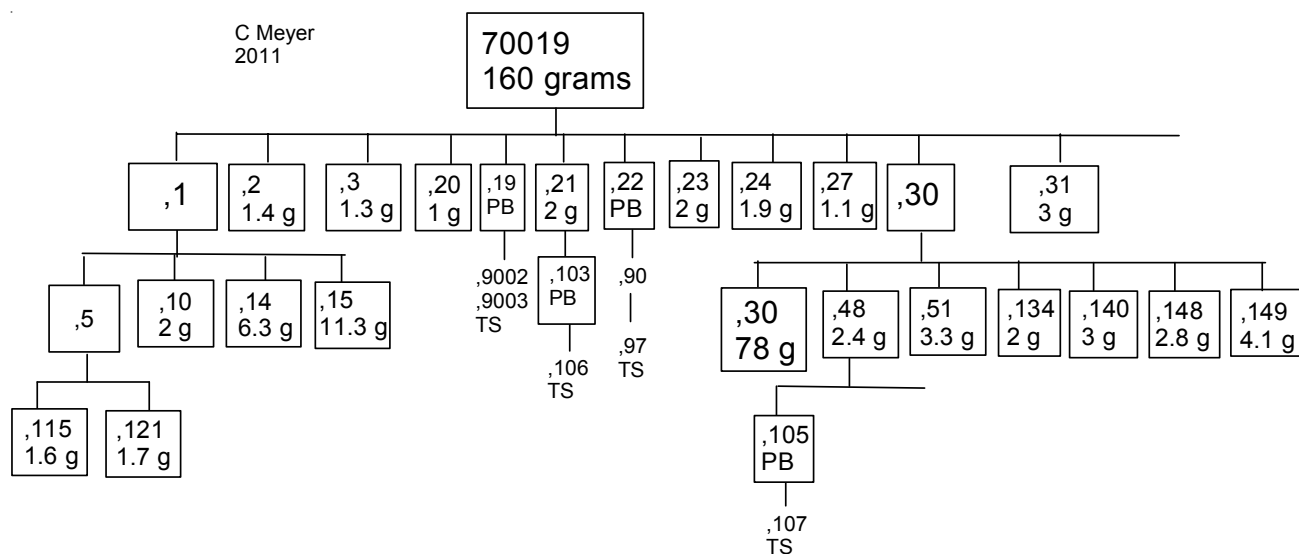


Figure 11: Magnetization curves for glass and breccia in 70019 (from Pearce and Chou 1977).

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