60095

Glass Sphere

46.6 grams

Figure 1: Photo of 60095. Cube is 1 cm. NASA S72-39425.

Introduction

Lunar sample 60095 was observed sitting on the lunar surface while placing the heat flow probe in the deep drill hole at Apollo 16 (Sutton 1981). It is a glass sphere that measures about 2.6 cm in diameter and is partly broken showing large vesicles inside (figure 1). Part of the surface is covered with micrometeorite craters.

Petrography

Schaal et al. (1979abs), Mehta and Goldstein (1979) and Ryder and Norman (1980) describe 60095 as a broken sphere made of yellow-green to light brown glass with numerous internal vesicles. The outer surface is smooth, having formed by cooling in a vacuum, but with some cooling cracks and micrometeorite pits.

The internal glass is generally not devitrified except where there are residual inclusions of plagioclase that act as nucleation sites for devitrification. Small rounded bleb of metal with associated troilite and schreibersite are abundant, ranging in size from ~ 50 microns down to a few angstroms. Strings of metal particles are sometimes aligned in flow planes (schlieren).

Mineralogy

Glass: The sphere is almost entirely homogeneous glass with only minor schlieren.

Metallic Iron: Two types of metal particles were found in 60095 glass (Mehta and Goldstein 1979). Finely divided metal/sulfide particles as small as 150 angstroms were observed in ion-thinned foils of 60095 glass. They range in Ni content 17 to 57%. Tiny cubes of Fe metal about <500 microns were found to be Ni free.

Chemistry

See et al. (1986) and Morris et al. (1986) determined the composition of 60095 (table 1). Ganapathy et al. (1974) determined trace elements. It is similar in composition to other glass thought to be ejecta from South Ray Crater and similar to bulk soil composition (figure 2).

Cosmogenic isotopes and exposure ages

Using a depth profiling technique Warhaut et al. (1979) found high ^{22}Ne <50 angstroms below the surface, but little or no ^{4}He.

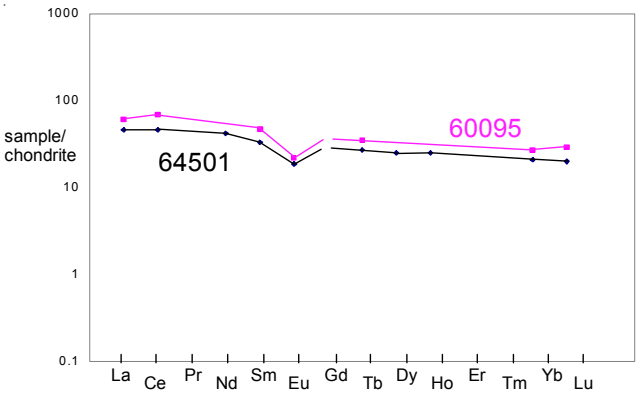


Figure 2: Normalized rare-earth-element pattern for 60095 glass compared with that of Apollo 16 soil (64501). Data from Morris et al. (1983) and Papike et al. (soil).

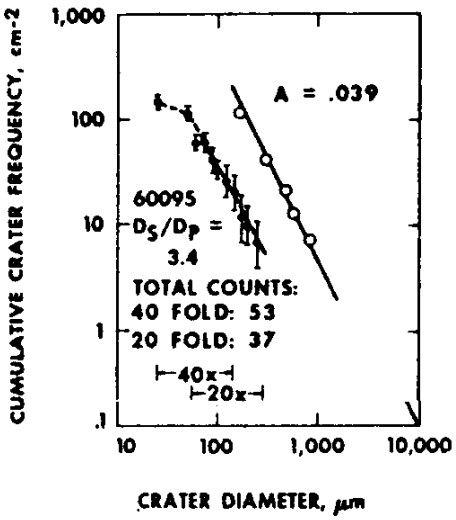


Figure 3: Crater count vrs. size for 60095 (Neukum et al. 1973).

Other Studies

Neukum et al. (1973) and Brownlee et al. (1975) studied the micrometeorite craters that populate the top surface of 60095 (figures 3 and 4).

Processing

Sample 60095 was cut with a wire saw (figures 5 and 6). Various pieces broke off because of the pressure of the vise during sawing. These pieces were where the greatest density of micrometeorite pits were located and studied.

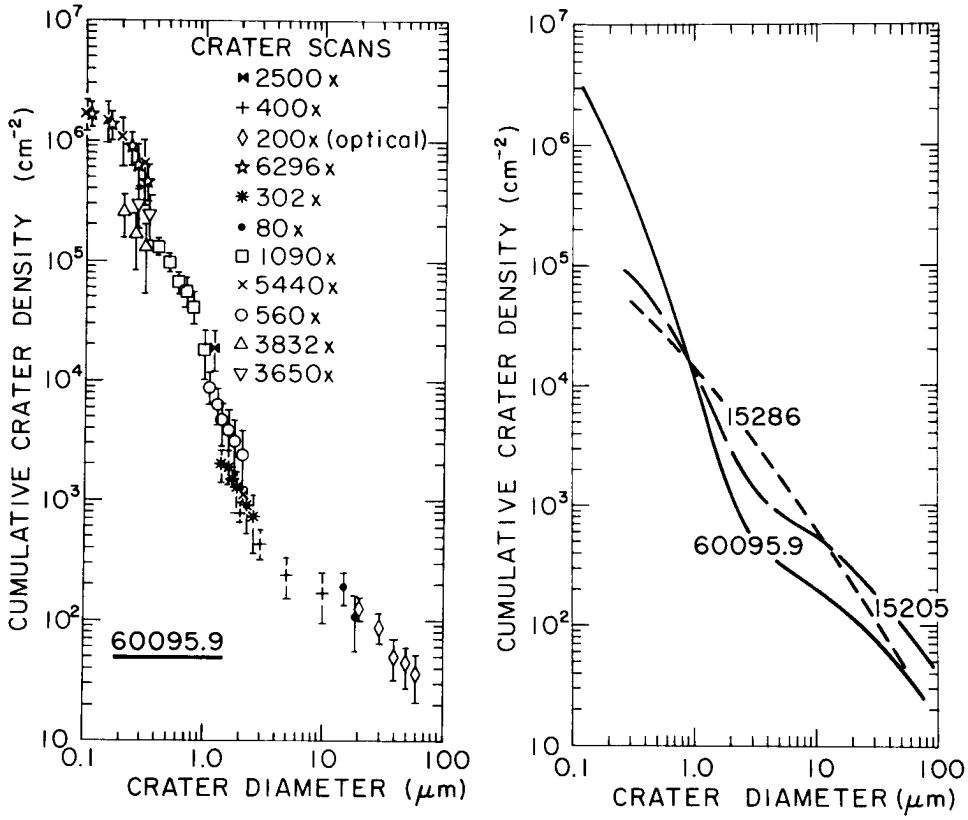
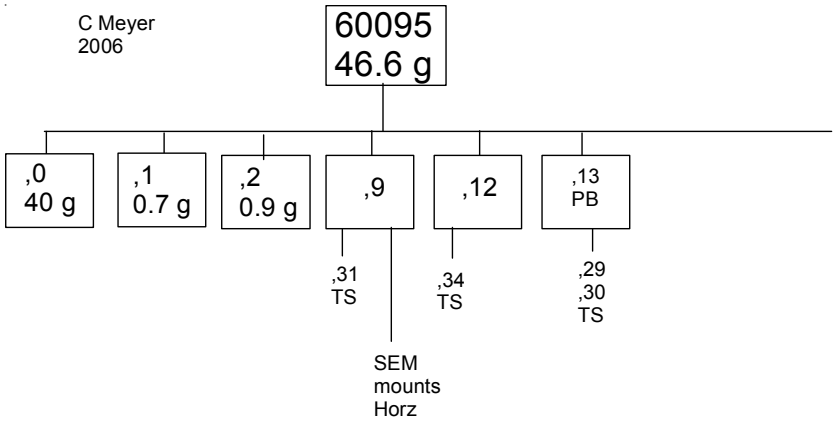


Figure 4: Crater frequencey plot for 60095 compared with other lunar samples (Brownlee et al. 1975).

Table 1. Chemical composition of 60095.

reference	Ganapathy74		See 86		Morris 86		*Uhlmann74*	
weight			glass		glass			
SiO2 %			44.82	(a)	44.82	(a)	*46.4*	(d)
TiO2			0.48	(a)	0.48	(a)		
Al2O3			25.94	(a)	25.94	(a)	*23.5*	(d)
FeO			5.72	(a)	5.53	(b)	*6.9*	(d)
MnO								
MgO			7.89	(a)	7.89	(a)	*10.5*	(d)
CaO			14.61	(a)	14.61	(a)	*12.1*	(d)
Na2O			0.32	(a)	0.32			
K2O			0.12	(a)	0.31	(b)	*0.8*	(d)
P2O5								
S %								
sum								
Sc ppm					7.08	(b)		
V								
Cr					780	(b)		
Co					40	(b)		
Ni	560	(c)			412	(b)		
Cu								
Zn	1.55	(c)						
Ga								
Ge ppb	306	(c)						
As								
Se								
Rb	1.67	(c)						
Sr								
Y								
Zr								
Nb								
Mo								
Ru								
Rh								
Pd ppb								
Ag ppb	1.2	(c)						
Cd ppb	1.8	(c)						
In ppb								
Sn ppb								
Sb ppb	2.62	(c)						
Te ppb	26	(c)						
Cs ppm	0.064	(c)						
Ba					200	(b)		
La					14.4	(b)		
Ce					41.7	(b)		
Pr								
Nd								
Sm					6.98	(b)		
Eu					1.22	(b)		
Gd								
Tb					1.27	(b)		
Dy								
Ho								
Er								
Tm								
Yb					4.27	(b)		
Lu					0.71	(b)		
Hf					4.9	(b)		
Ta					0.68	(b)		
W ppb								
Re ppb	2.17	(c)						
Os ppb								
Ir ppb	25.4	(c)						
Pt ppb								
Au ppb	7.11	(c)						
Th ppm					2.6	(b)		
U ppm	0.67	(c)			0.99	(b)		

technique: (a) emp, (b) INAA, (c) RNAA, (d) ???



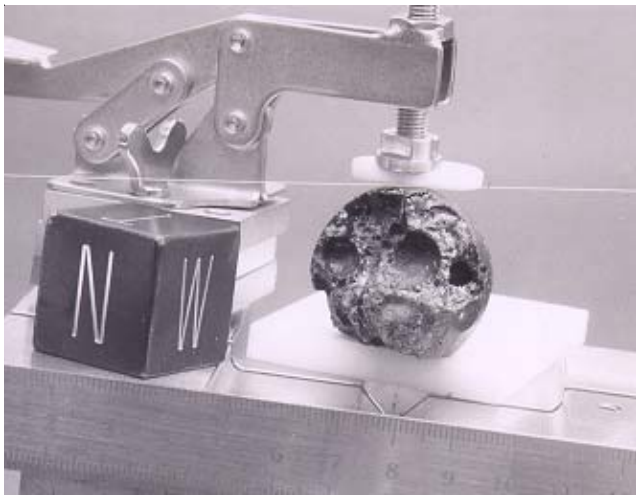


Figure 5: Wiresaw ready to cut 60095.

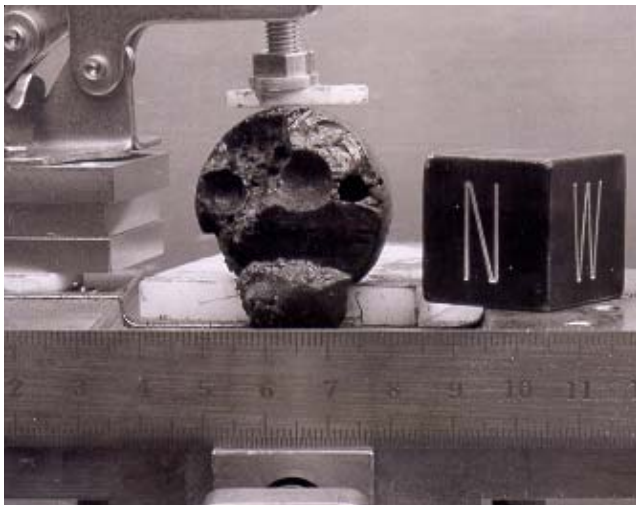


Figure 6: After wiresaw cut.

Figure 7: Numbering the splits of 60095. Splits ,1 and ,2 were from the large piece in figure 6. Other pieces broke off due to pressure of vise.

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