60135

Glass-coated, high-shocked Anorthosite

137.7 grams

Figure 1: Photo of 60135. Tick marks are 1 cm. NASA S72-37967.

Introduction

60135 is a glass covered, round object with a coarse-grained, highly shocked cumulate interior (figure 1). The glass coating on one side has been eroded off by micrometeorite bombardment, exposing the interior (figure 7). The glass composition is that of a soil and the interior rock is a ferroan anorthosite. It was found sitting perched on the regolith, but may have been kicked up.

Petrography

Warren et al. (1983) find the interior rock fragment is a "coarse grain cumulate – highly shocked but not brecciated". They conclude that it originated as a coarse cumulate, with subhedral cumulus plagioclase crystals up to 4.4 mm across, and anhedral, poikilitic, intercumulus pyroxene crystals in optical continuity up to 5 mm apart. Mineral analyses indicate it is a ferroan anorthosite (figure 4).

Mineralogy

Olivine: not reported

Pyroxene: Pyroxene is pigeonite (Wo_3En_{64}) typical of ferroan anorthosite (Warren et al. 1983). Exsolution lamalae are lacking, but may have been homogenized.

Mineralogical Mode of 60135

	Warren et al. 1983	
Plagioclase:	95 %	75
Pyroxene:	5	25

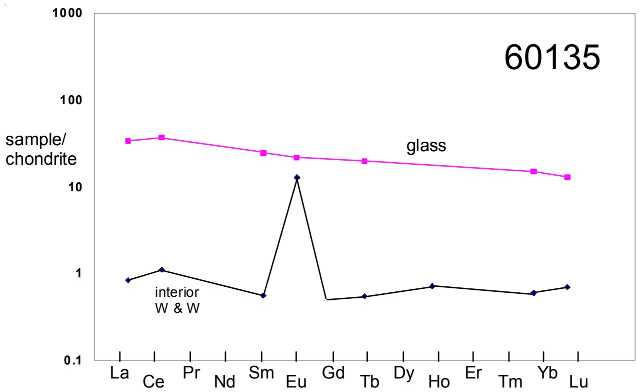


Figure 2: Normalized rare-earth-element diagram for 60135 showing that the glass coating was not made from the interior rocklet (data from Morris et al. 1986 and Warren et al. 1983).

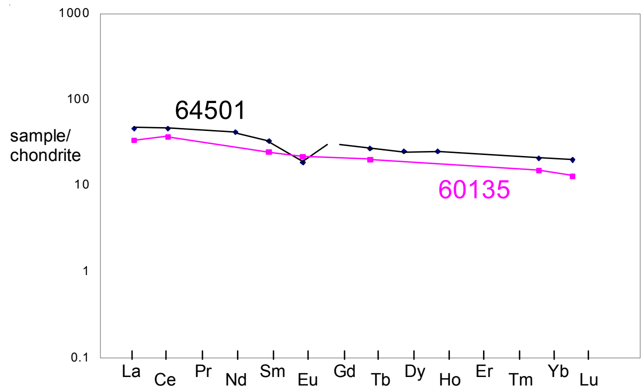


Figure 3: Normalized rare-earth-element pattern for glass on 60135 (Morris et al. 1983) compared with soil 64501 (Papike et al. 1982).

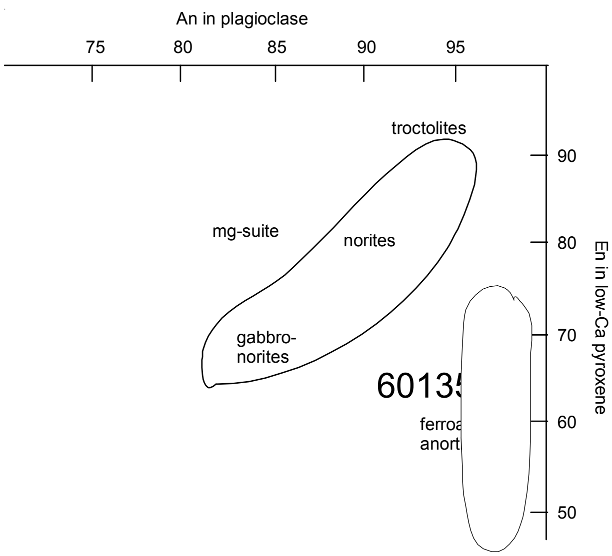


Figure 4: Plagioclase and pyroxene composition of interior of 60135 compared with known lunar rocks.

Plagioclase: Plagioclase is maskleynite with composition An_{96-98} (Warren et al. 1983).

Ilmenite: not reported

Chemistry

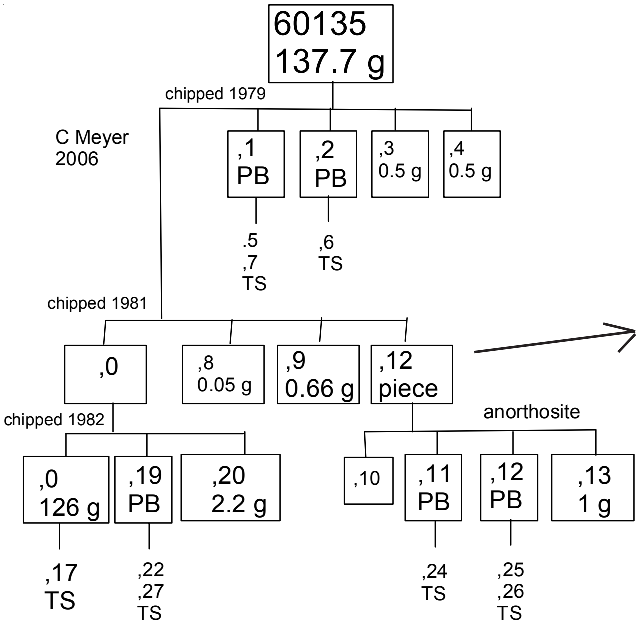
Warren et al. (1983) found that the interior of this glass "egg" was highly aluminous as did See et al. (1986). Warren et al. analyzed two splits and found different results do to sampling error of such a coarse grained sample (average is given in table 1). See et al. (1986) and Morris et al. (1986) analyzed the glass and found it was rather like the soil and very unlike the interior (figures 2 and 3). Eldridge et al. (1973) analyzed the whole egg.

Figure 5: Lunar Sample 60135 on display. NASA S94-39619.

Table 1. Chemical composition of 60135.

								rock	
reference	Eldridge 73		See 86			Morris 86		Warren 83	
weight	bulk		glass	anor		glass		*(ave)*	
SiO2 %			43.69	43.91	(a)	43.69	(a)	44.9	(b)
TiO2			0.17	0.02	(a)	0.17	(a)	0.006	(b)
Al2O3			3.77	35.24	(a)	30.77	(a)	32.7	(b)
FeO			3.55	0.55	(a)	4.77	(b)	2.3	(b)
MnO								0.04	(b)
MgO			3.82	0.5	(a)	3.82	(a)	2.8	(b)
CaO			17.2	19.26	(a)	17.2	(a)	17.6	(b)
Na2O			0.33	0.35	(a)	0.35	(b)	0.32	(b)
K2O	0.018	(c)	0.05	0.04	(a)	0.05	(a)	0.004	(b)
P2O5									
S %									
sum									
Sc ppm						5.21		4.6	(b)
V									
Cr						706	(b)	399	(b)
Co						43	(b)	4.8	(b)
Ni						632	(b)	11	(b)
Cu									
Zn								5	(b)
Ga								3.1	(b)
Ge ppb								93	(d)
As									
Se									
Rb									
Sr								157	(b)
Y									
Zr								10	(b)
Nb									
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb									
Cd ppb								14	(d)
In ppb									
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm									
Ba						87	(b)	9	(b)
La						7.88	(b)	0.2	(b)
Ce						22.4	(b)	0.67	(b)
Pr									
Nd									
Sm						3.61	(b)	0.083	(b)
Eu						1.21	(b)	0.72	(b)
Gd									
Tb						0.72	(b)	0.02	(b)
Dy									
Ho								0.04	(b)
Er									
Tm									
Yb						2.39	(b)	0.098	(b)
Lu						0.31	(b)	0.017	(b)
Hf						2.3	(b)	0.06	(b)
Ta						0.27	(b)	0.0057	(b)
W ppb									
Re ppb								0.11	(d)
Os ppb									
Ir ppb								3.13	(d)
Pt ppb									
Au ppb								1.07	(d)
Th ppm	0.27	(c)				1.64	(b)	0.018	(b)
U ppm	0.068	(c)				0.46	(b)		(b)

technique: (a) emp, (b) INAA, (c) rad. Counting, (d) RNAA



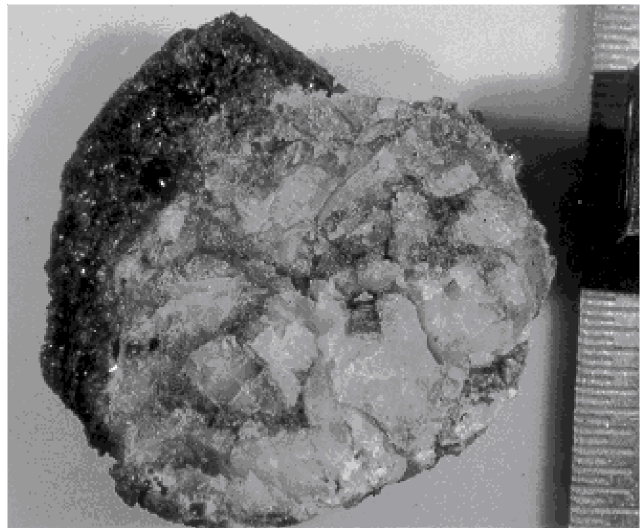


Figure 6: The piece (,12) that was chipped in 1981 (see diagram).

Cosmogenic isotopes and exposure ages

Eldridge et al. (1973) determined the cosmic-ray-induced activity of ^{22}Na = 40 dpm/kg. and ^{26}Al = 160 dpm/kg.

Processing

One end of this glass "egg" has been sampled carefully, several times, to preserve the majority of it (figures 6 and 7). It is now used as a display sample for very special occasions (figure 5).

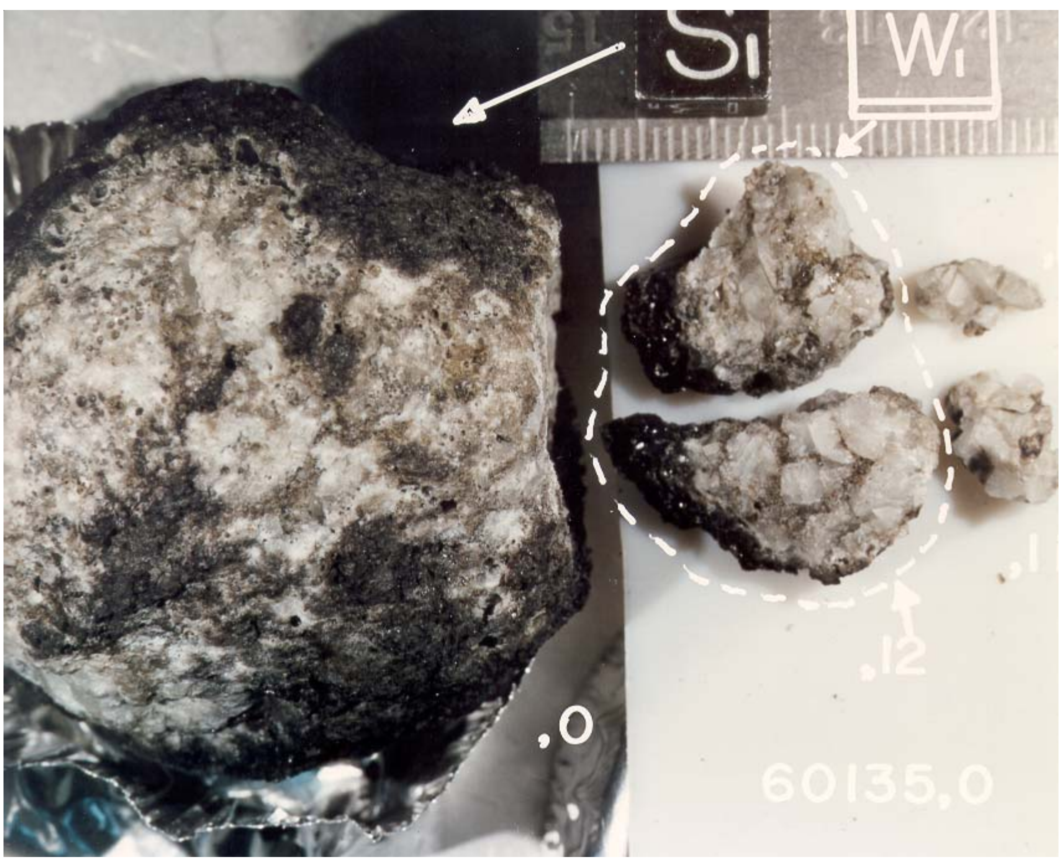


Figure 7: Chipping of 60135 in 1981. NASA S81-41552. Cube is 1 cm.

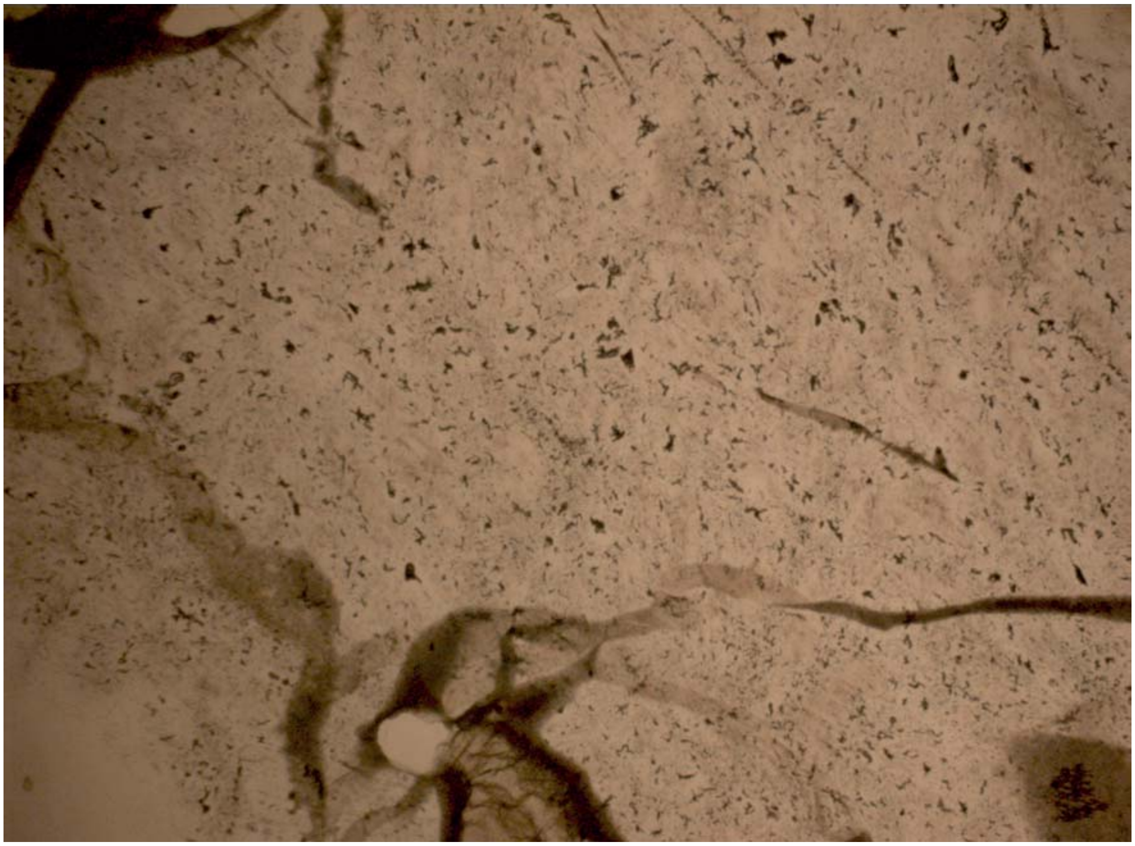


Figure 8: Thin section 60135,17.

References for 60135

Butler P. (1972a) Lunar Sample Information Catalog Apollo 16. Lunar Receiving Laboratory. MSC 03210 Curator's Catalog. pp. 370.

Eldridge J.S., O'Kelley G.D. and Northcutt K.J. (1973) Radionuclide concentrations in Apollo 16 lunar samples determined by nondestructive gamma-ray spectrometry. *Proc. 4th Lunar Sci. Conf.* 2115-2122.

LSPET (1973b) The Apollo 16 lunar samples: Petrographic and chemical description. *Science* **179**, 23-34.

LSPET (1972c) Preliminary examination of lunar samples. *In* Apollo 16 Preliminary Science Report. NASA SP-315, 7-1—7-58.

Moore C.B. and Lewis C.F. (1976) Total nitrogen contents of Apollo 15, 16 and 17 lunar rocks and breccias (abs). *Lunar Sci.* VII, 571-573. Lunar Planetary Institute, Houston.

Morris R.V., See T.H. and Horz F. (1986) Composition of the Cayley Formation at Apollo 16 as inferred from impact melt splashes. *Proc. 17th Lunar Planet. Sci. Conf.* in J. Geophys. Res. **90**, E21-E42.

Morrison D.A., McKay D.S., Fruland R.M. and Moore H.J. (1973) Microcraters on Apollo 15 and 16 rocks. *Proc. 4th Lunar Sci. Conf.* 3235-3253.

Morrison G.H., Nadkarni R.A., Jaworski J., Botto R.I. and Roth J.R. (1973) Elemental abundances of Apollo 16 samples. *Proc. 4th Lunar Sci. Conf.* 1399-1405.

Neukum G., Horz F., Morrison D.A. and Hartung J.B. (1973) Crater populations on lunar rocks. *Proc. 4th Lunar Sci. Conf.* 3255-3276.

Ryder G. and Norman M.D. (1980) Catalog of Apollo 16 rocks (3 vol.). Curator's Office pub. #52, JSC #16904

See T.H., Horz F. and Morris R.V. (1986) Apollo 16 impact-melt splashes: Petrography and major-element composition. *Proc. 17th Lunar Planet. Sci. Conf.* in J. Geophys. Res. **91**, E3-E20.

Sutton R.L. (1981) Documentation of Apollo 16 samples. In Geology of the Apollo 16 area, central lunar highlands. (Ulrich et al.) U.S.G.S. Prof. Paper 1048.

Warren P.H., Taylor G.J., Keil K., Kallemeyn G.W., Shirley D. and Wasson J.T. (1983d) Seventh foray: Whitlockite-rich lithologies, a diopside-bearing troctolitic anorthosite, ferroan anorthosite and KREEP. *Proc. 14th Lunar Planet. Sci. Conf.* in J. Geophys. Res. **88**, B151-B164.