62235

Poikilitic Impact Melt Breccia

319.6 grams

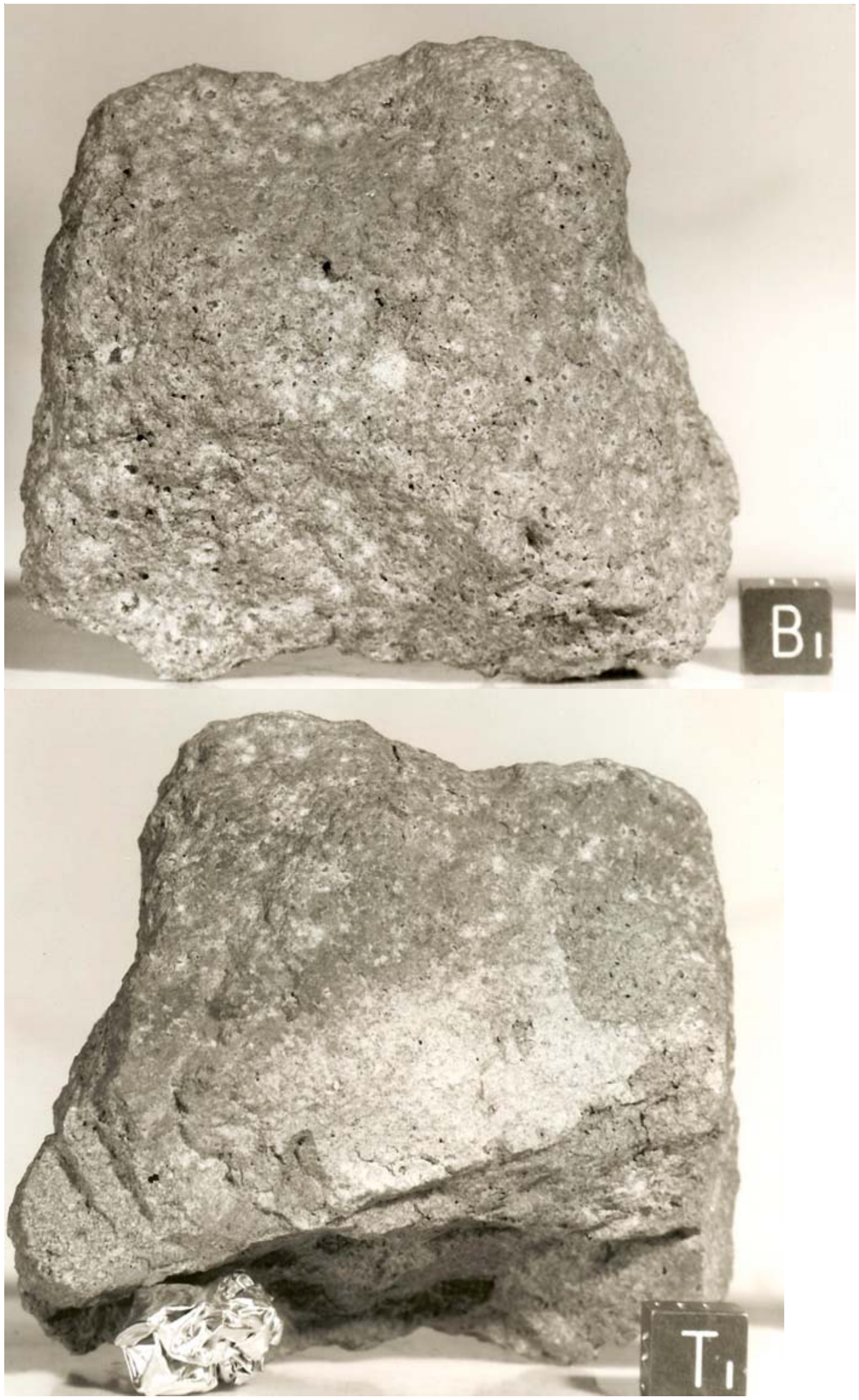
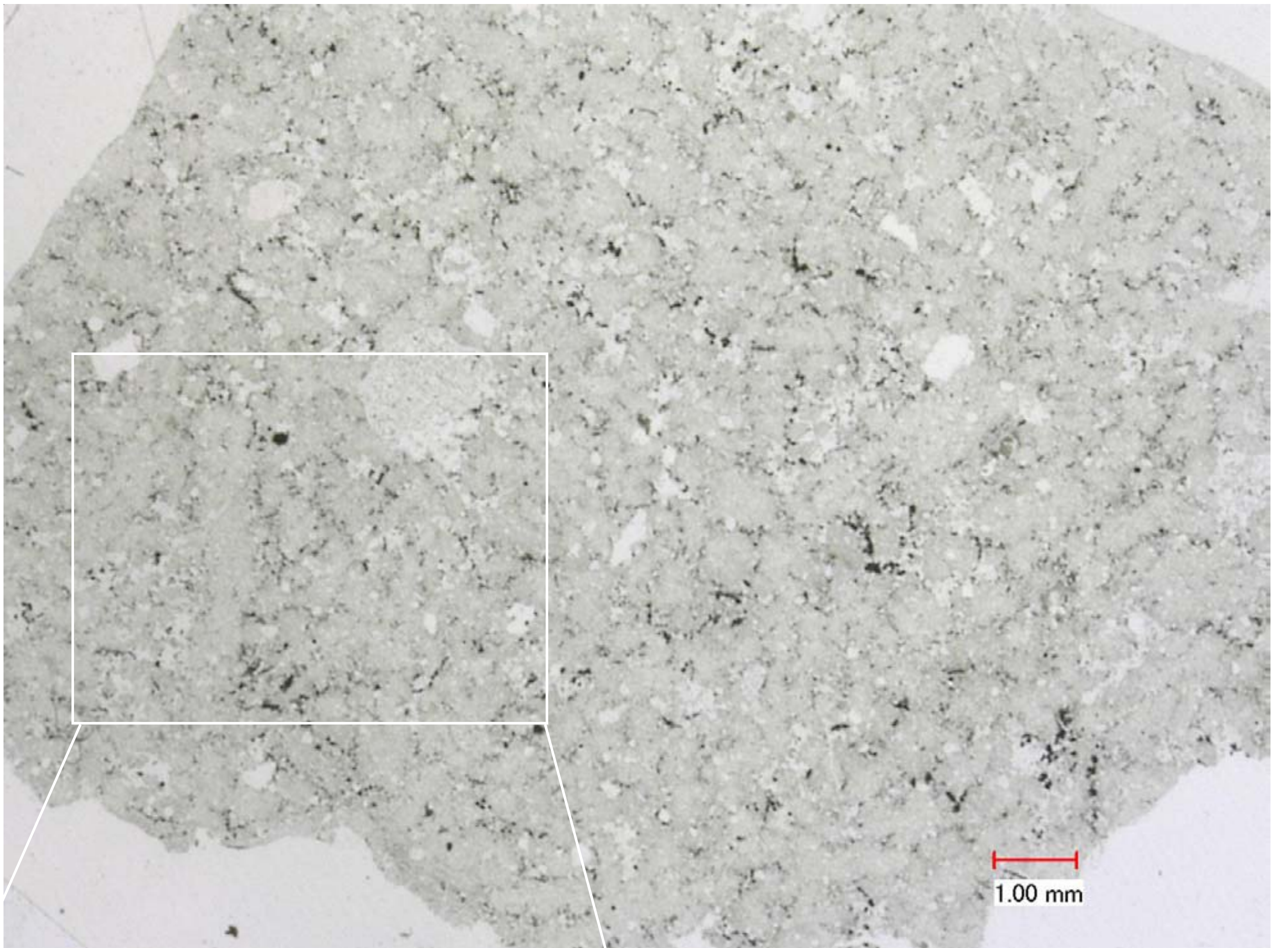


Figure 1: Top and bottom of 62235 (guess which is which). Cube is 1 cm for scale. S72-41280 and 284.



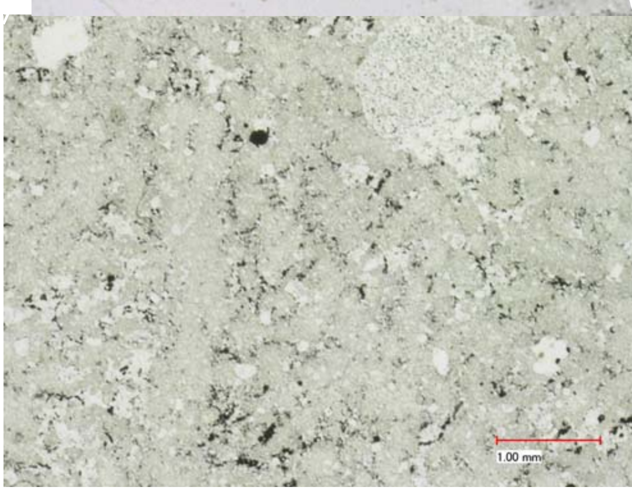


Figure 2: Photomicrographs in plane light of 62235, taken by C. Meyer @20x and 50x.

Mineralogical Mode for 62235

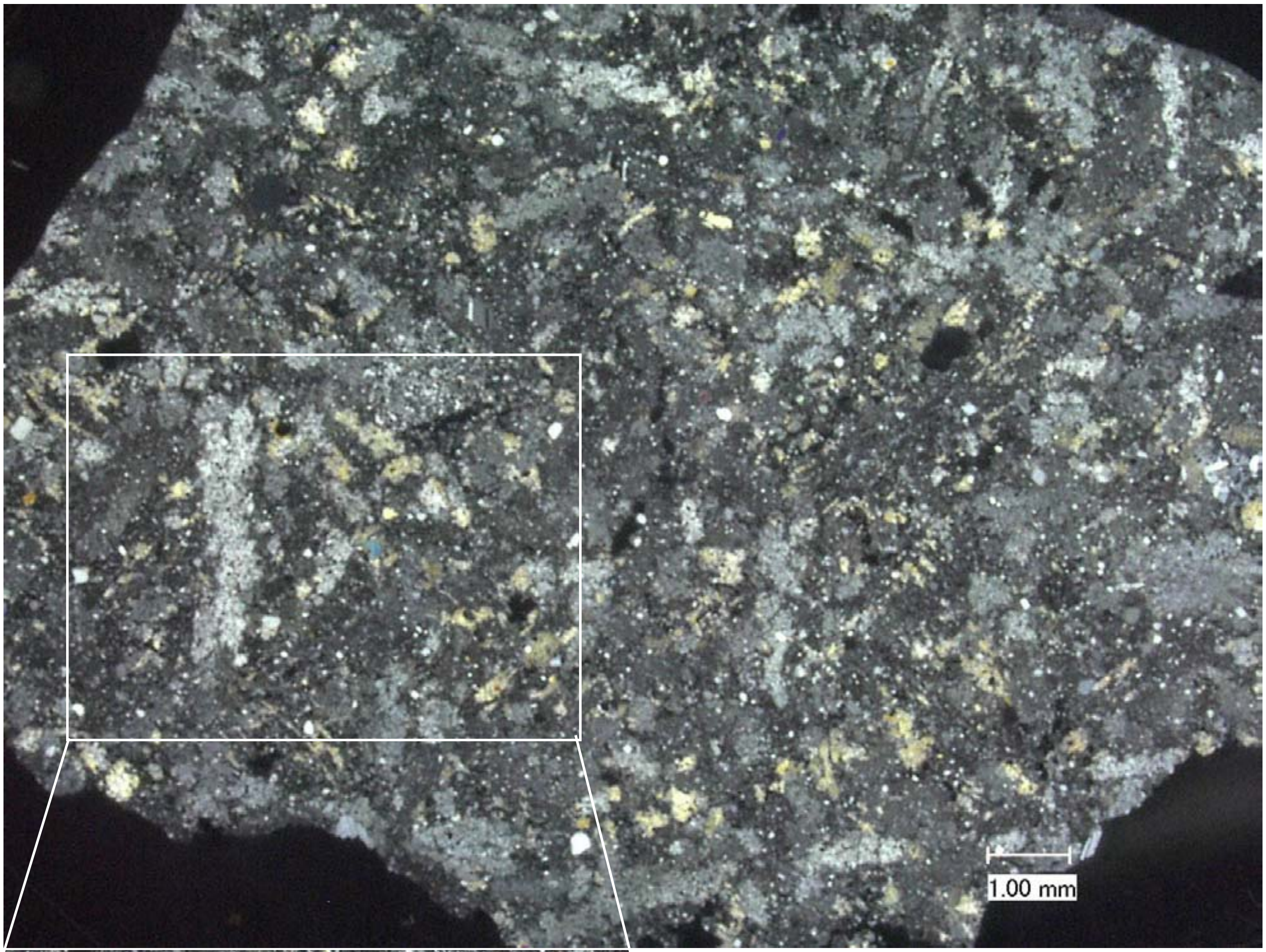
	Crawford and Hollister 1974	Vaniman and Papike 1978
Olivine		6
Pyroxene		42
Plagioclase	57	34
Ilmenite		2.8
Metal/troilite		1.3

Introduction

62235 was found sitting half-exposed on the lunar surface at station 2 on the rim of Buster Crater. It was collected along with soils 62230 and 62240 and adjacent samples. The exposed surface of 62235 had numerous micrometeorite craters, while the bottom side did not (figure 1).

62235 is an apparently homogeneous, coherent, hollocrystaline impact melt rock with classic poikilitic texture (figures 2 and 3). It is highly enriched in trace elements and siderophile elements and has been dated at 3.88 b.y., with an exposure history of 153 m.y.

This lunar sample was found by Collinson et al. (1973) to be magnetized in a strong field (1.3oerstad) with consistent directional orientation (confirmed by independent measurements by Sugiura and Strangway 1983).



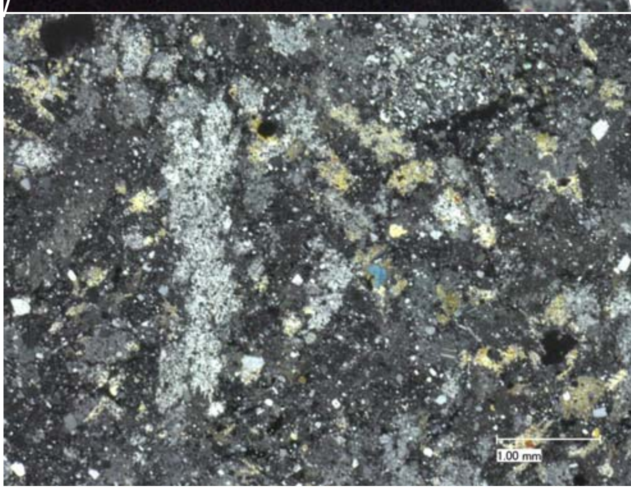


Figure 3: Photomicrographs of 62235, taken by C. Meyer with crossed polarizers @20x and 50x.

Petrography

62235 is a quilt-like patchwork of intergrown pyroxene oikocrysts with olivine cores and enclosing numerous small laths of plagioclase (compare with 60315 and 65015). Ilmenite and accessory phases have been concentrated at the boundaries of the pyroxene patches (figure 2 and 3). Crawford and Hollister (1974) discussed the petrography of 62235 and presented a two-stage crystallization sequence from detailed analysis of the mineral chemistry. They reported olivine cores, rimed by orthopyroxene and finally high-Ca pyroxene.

McGee et al. (1979) provided an elegant interpretive description: "Sample 62235 is a clast-bearing impact-melt breccia characterized predominantly by coalescing oikocrysts of orthopyroxene enclosing laths of plagioclase. Poikilitic ilmenite (with included plagioclase tablets) and small amounts of phosphate, Fe-Ni metal, troilite and K-spar are concentrated between the oikocrysts. Mineral clasts, dominantly plagioclase, together with less commonly occurring lithic clasts are scattered randomly throughout the sample. Irregularly shaped vugs (up to 0.6 mm) are relatively common; spherical vesicles (typically 0.25 mm and less) are also present but are less dominant." "Orthopyroxene oikocrysts typically display rectangular outlines (up to 2 mm in length) although round and irregular shapes are also present. Oikocrysts are commonly observed to have grown around spherical

vesicles. Plagioclase is present as anhedral or tablet-shaped crystals (0.01-0.05 mm) and as lath-shaped crystals (both enclosed within orthopyroxene oikocrysts and located between the oikocrysts."
"Ilmenite is the dominant opaque phase, occurring as poikilitic crystals (up to 0.4 mm), typically with silicate inclusions, which occur interstitial to orthopyroxene oikocrysts. Rare, needle-like laths of ilmenite (0.025-0.05 mm) are present and occur in association with poikilitic ilmenite grains. Troilite and Fe-Ni metal occur as micron size blebs or irregularly shaped crystals also in association with poikilitic ilmenite. Irregularly shaped troilite grains may be as large as 0.25 mm."
"Plagioclase clasts are present as subangular to subrounded grains (up to 0.6 mm) enclosed within and interstitial to orthopyroxene oikocrysts. The clasts are typically unfractured and rarely display twinning. Lithic clasts constitute a small percentage (typically <10%) of the total clast population in samples 62235. Basaltic clasts are present and typically display ophitic textures. One small anorthosite clast was observed in section 62235,39; no breccias clasts were observed."

Mineralogy

Plagioclase: Meyer et al. (1974) determined that the Ba content of plagioclase clasts in 62235 was too low for them to have reached equilibrium with the high Ba melt.

Pyroxene: The majority of the abundant pyroxene is low-Ca (figure 4).

Ilmenite: von Englehardt (1979) determined the crystallization history of ilmenite.

Metal: Metal grains are large and abundant in 62235. Pearce et al. (1974) determined the Ni and Co contents (figure 5). Hunter and Taylor (1981) found little rust nor schreibersite.

Chemistry

Clark and Keith (1973), Brunfeldt et al. (1973), Hubbard et al. (1973), Laul et al. (1974) and Wanke et al. (1976) all reported chemical analyses for 62235 (table). In fact, the broad agreement of their analyses on this homogeneous rock, shows that the chemical analyses on rather small amounts of lunar material, in the 1970s, were of high accuracy. What they found was that this sample had lots of KREEP (figure 6). It also has very high Ni, Ir, Au, Re and W.

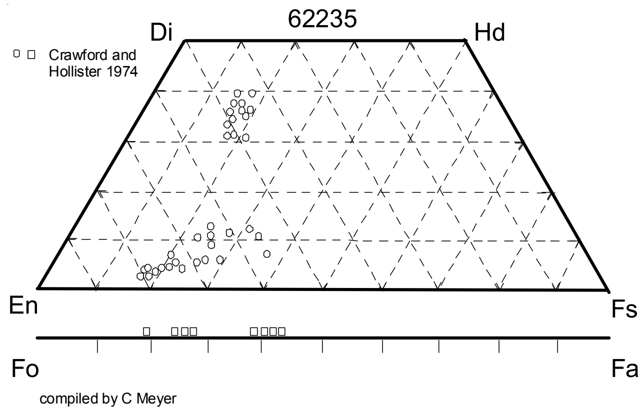


Figure 4: Composition ofolivine and pyroxene in 62235 (Crawford and Hollister 1974).

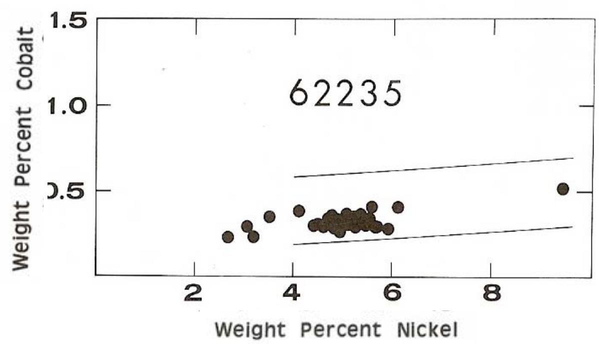


Figure 5: Ni and Co in metal grains in 62235 (Pearce et al. 1976).

Moore et al. (1973) reported that 62235 had very low carbon content (2 ppm). Garg and Ehmann (1976) precisely determined Zr and Hf in 62235 and other Apollo samples.

Radiogenic age dating

Norman et al. (2006) determined the age (figure 7). Nyquist et al. (1973) and Tera et al. (1974) determined the Rb and Sr isotopic composition. Kleine et al. (2005) and Touboul et al. (2007) reported on the isotopic composition of tungsten.

Cosmogenic isotopes and exposure ages

Drozd et al. (1974) and Pepin et al. (1974) give the exposure age (^{38}Ar = 153 m.y., ^{81}Kr = 153.3 m.y.). Clark and Keith (1973) determined the cosmic-ray-induced activity of ^{22}Na = 50 dpm/kg, ^{26}Al = 137 dpm/kg, ^{56}Co = 13 ± 13 dpm/kg. and ^{46}Sc = 3 dpm/kg.

Other Studies

Collinson et al. (1973) originally found 62235 to be magnetized in a strong field (1.3oerstad) with consistent directional orientation (confirmed by independent

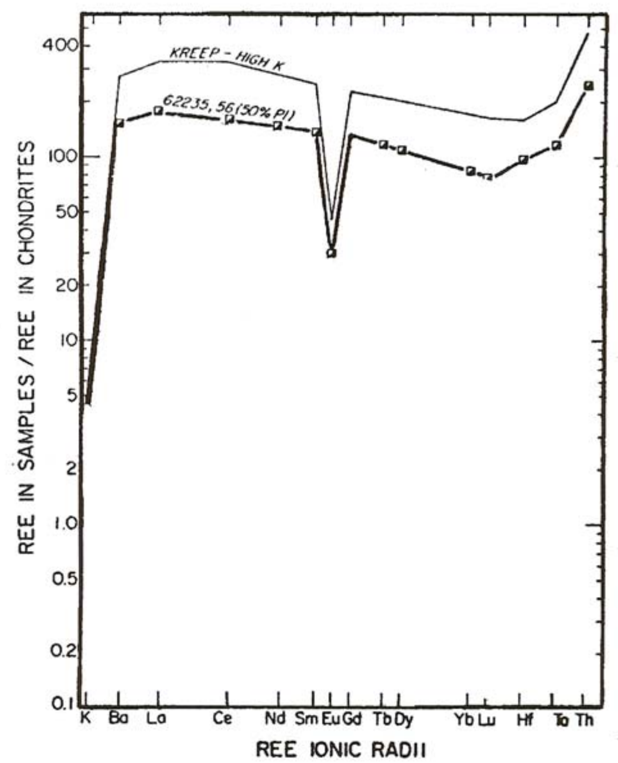


Figure 6: Normalized rare-earth-element diagram for 62235 compared with KREEP (Laul et al. 1974).

measurements by Sugiura and Strangway 1983). Chung and Westphal (1973) determined "dielectric spectra" and other physical parameters.

The size-frequency distribution of microcraters was determined by Morrison et al. (1973) and Neukum et al. (1973)(figure 8). McDonnell et al. (1976) used 62235 for experiments with secondary crater production.

Processing

The section on 62235 in Ryder and Norman (1980) contains additional information.

A thin slab (0.5 cm) was cut through the middle of 62235 (figures 9-11). There are 9 thin sections of 62235 (perhaps not enough). *Please be aware that rocks with abundant saw marks may have been substantially heated at the area near the saw cut.*

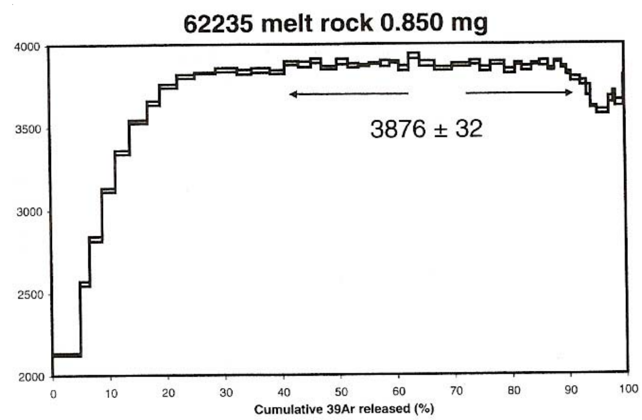


Figure 7: Ar/Ar age plateau for 62235 (Norman et al. 2006).

Summary of Age Data for 62235

Ar/Ar

Norman et al. 2006 3.876 ± 0.032 b.y.

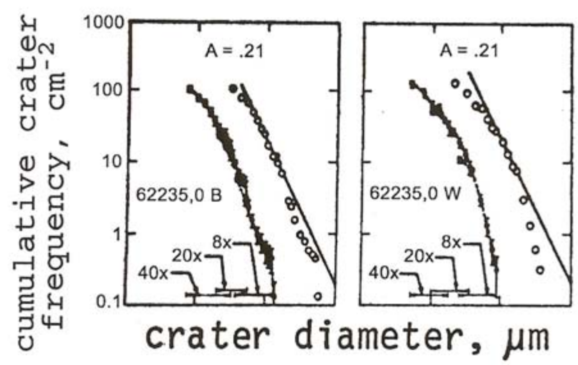


Figure 8: Size distribution of micrometeorite craters on 62235 (Morrison et al. 1973; Neukum et al. 1973).

Table 1. Chemical composition of 62235.

reference	Wiesmann75		McKinley84		Brunfelt73		Wanke76		Hubbard73		LSPET73		Laul74		Clark73	
weight	Hubbard73														Garg76	
SiO2 %			47.1	(b)			47		47.05	(d)	47.04	(d)				
TiO2	1.18	(c)	1.2	(b)	0.85	(a)	1.18		1.19	(d)	1.21	(d)	1.3	(a)		
Al2O3	18.5	(c)	18.7	(b)	21.35	(a)	18.95		18.88	(d)	18.69	(d)	18.6	(a)		
FeO	9.4	(c)	9.55	(b)	10.3	(a)	9.1		9.45	(d)	9.45	(d)	9.5	(a)		
MnO			0.11	(b)	0.11	(a)	0.11		0.13	(d)	0.11	(d)	0.106	(a)		
MgO	10	(c)	10.3	(b)	14.1	(a)	10.3		10.16	(d)	10.14	(d)	12	(a)		
CaO	11.5	(c)	11.5	(b)	12.3	(a)	11.65		11.6	(d)	11.52	(d)	12	(a)		
Na2O	0.46	(c)	0.48	(b)	0.54	(a)	0.51		0.42	(d)	0.48	(d)	0.62	(a)		
K2O	0.35	(c)	0.34	(b)	0.27	(a)	0.32		0.33	(d)	0.34	(d)	0.39	(a)	0.34	(e)
P2O5			0.41	(b)			0.41		0.39	(d)	0.41	(d)				
S %							0.1		0.1	(d)	0.11	(d)				
sum																
Sc ppm					16.9	(a)	16.5	(a)					16	(a)		
V					80	(a)							50	(a)		
Cr	1309	(c)			869	(a)	1280	(a)			1370	(d)	1300	(a)		
Co					64	(a)	54.2	(a)					49	(a)		
Ni					1030	(a)	830	(a)			248	(d)	720	(a)		
Cu					3.9	(a)	24.9	(a)								
Zn					2.2	(a)	11	(a)								
Ga					4.6	(a)	3.82	(a)								
Ge ppb							800	(a)								
As							250	(a)								
Se							260	(a)								
Rb	9.32	(c)			16	(a)	8.39	(a)			9.3	(d)				
Sr	161	(c)					152	(a)			165	(d)				
Y							166	(a)			193	(d)				
Zr	910	(c)					858	(a)			851	(d)	890	(a)	900	(a)
Nb							43	(a)			49	(d)				
Mo																
Ru																
Rh																
Pd ppb																
Ag ppb																
Cd ppb																
In ppb					10	(a)										
Sn ppb																
Sb ppb																
Te ppb																
Cs ppm					0.45	(a)	0.35	(a)								
Ba	568	(c)			530	(a)	530	(a)					600	(a)		
La	60.1	(c)			57.7	(a)	60.3	(a)					61	(a)		
Ce	153	(c)			146	(a)	160	(a)					150	(a)		
Pr							21.5	(a)								
Nd	94.3	(c)					94	(a)					96	(a)		
Sm	27.1	(c)			22.3	(a)	25.2	(a)					27	(a)		
Eu	2.03	(c)			2.39	(a)	1.93	(a)					2.1	(a)		
Gd	32.2	(c)					31.7	(a)								
Tb					5.1	(a)	5.56	(a)					5.3	(a)		
Dy	35	(c)			35	(a)	35	(a)					32	(a)		
Ho					6	(a)	6.8	(a)								
Er	21.2	(c)			18	(a)	21	(a)								
Tm								(a)								
Yb	18.7	(c)			13.5	(a)	19.4	(a)					19	(a)		
Lu					2.87	(a)	2.59	(a)					2.7	(a)		
Hf	22.5	(c)			20.7	(a)	20.7	(a)					20	(a)	20	(a)
Ta					2.28	(a)	2.17	(a)					2.3	(a)		
W ppb							994									
Re ppb							1.7									
Os ppb																
Ir ppb							17						20	(a)		
Pt ppb																
Au ppb							17.6						16	(a)		
Th ppm	9.93	(c)			9.4	(a)	7.83	(a)			10.5	(d)	10	(a)	9.4	(e)
U ppm	2.53	(c)			3.2	(a)	2.08	(a)					2.2	(a)	2.57	(e)

technique: (a) INAA, (b) strange, (c) IDMS, (d) XRF, (e) radiation counting

Figure 9: Photo of first saw cut of 62235 showing location of slab. S76-21575.

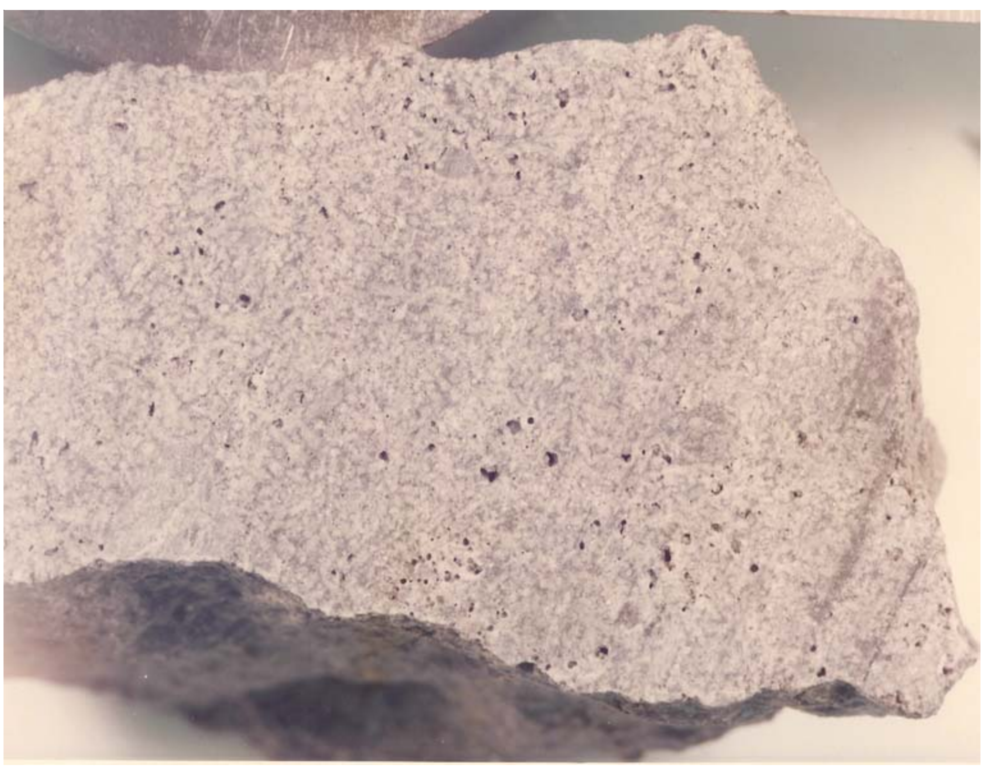


Figure 10: Closeup photo of end piece ,63 of 62235 showing small vesicles. S75-33394.

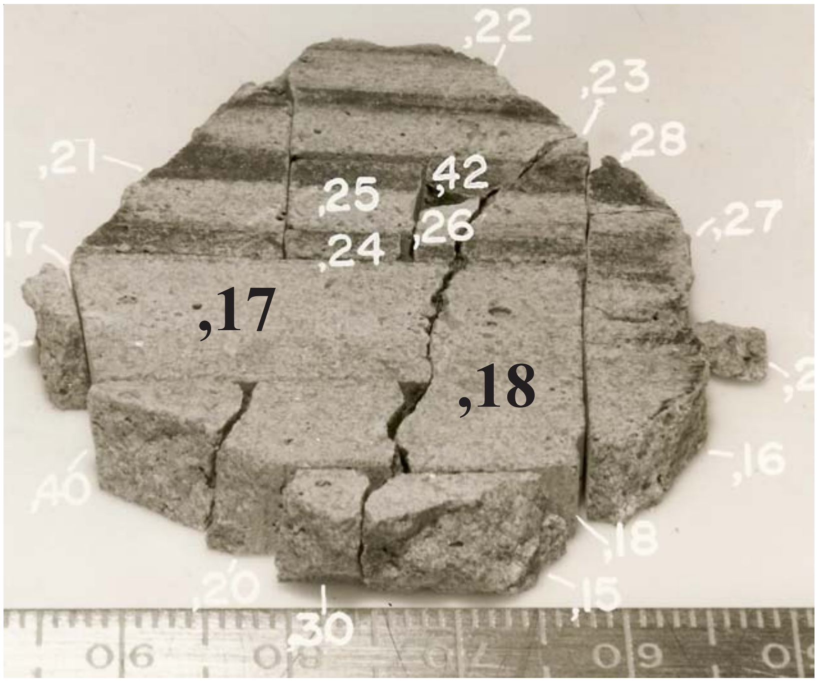
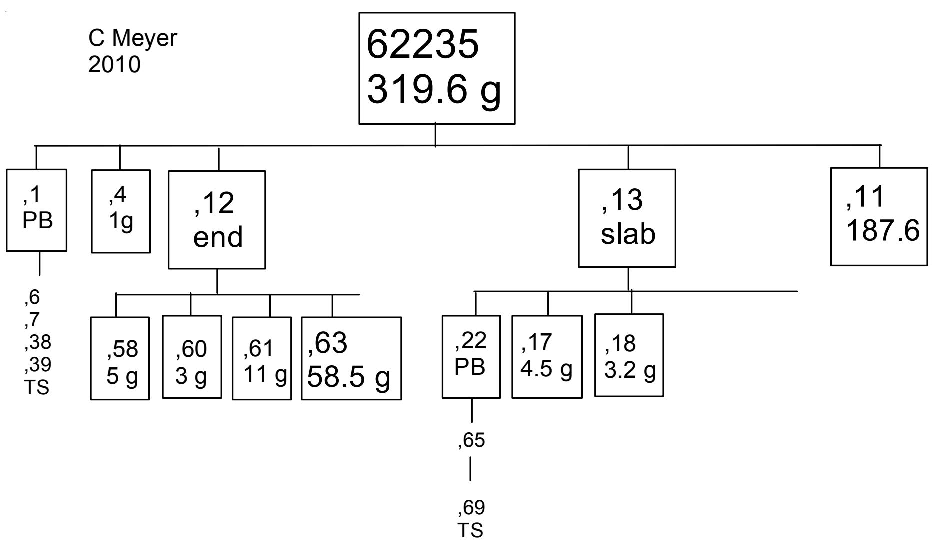


Figure 11: Photo of slab of 62235. Scale in cm/mm. S72-53507.



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