61175

Regolith Breccia

542.7 grams

Figure 1: Photo of 61175. S72-41197. Cube is 1 cm.

Introduction

61175 and several soil samples were collected from the rim of Flag Crater (240 m across and 40 m deep). The regolith in the sample area was soft. Soil samples from the same location are 61500, 61140, 61160 and 61181 and include a rake sample 61510. There are micrometeorite craters on all sides of 61175 (figures 1 and 2), so it must have "tumbled" on the regolith as it was bombarded.

According to Simon et al. (1988) and Wentworth and McKay (1988), 61175 is a "young" regolith breccia. It contains a high percentage of glass, with some agglutinate. It also contains a small, but significant, mare component.

Petrography

Sample 61175 was the object of a consortium study (Winzer et al. 1977), but from this study it is not now apparent which analyses are from which lithology. 61175 a friable, grey fragmental regolith breccia (Fruland 1983) with relatively low maturity Is/FeO = 8 (McKay et al. 1986). The matrix has a seriate grain size distribution which is welded together with small glass fragments (Winzer et al. 1977). McKay et al. (1986) and Wentworth and McKay (1988) used the freeze thaw technique to disassemble 61175 and determine the grain size. Hunter and Taylor (1981) reported minor, but significant, "rust" and schreibersite in 61175.

Figure 2: Photo of 61175. Cube is 1 cm. S72-41208

Major rock types represented by clasts, include extrusive and plutonic igneous rocks, impact melts and fine- and coarse grained metamorphic rocks (granulites)(figures 4 and 5).

The matrix of 61175 is more mafic than the clasts (Ryder and Norman 1980). The pyroxene composition in clast types was reported by Winzer et al. (1977)(figure 6). Wentworth and McKay (1988) found one sphere of ultramafic glass.

Morrison et al. (1973) and Neukum et al. (1973) analyzed the crater count on 61175 (figure 8). Since

Mineralogical Mode for 61175
(from Simon et al. 1988)

	20-90 micron	90-1000 micron
Matrix < 20 micron	50.6 %	
Mare basalt	0	0.1
KREEP basalt	0	0
Feldspathic basalt	0	2.7
Plutonic rock frag.	0.4	6.8
Granulite	0.1	0.1
Poik. rocks	0.5	1.7
Impact melts	0.4	5.1
Regolith brec.	0.2	0.3
Agglutinate	0.8	3.7
Plagioclase	9.3	6
Olivine	1	0.3
Pyroxene	2.9	1
Opaques	0.2	0
Glass	3.6	4

Mineralogical Mode for 61175
(from McKay et al. 1986) ("Optical")

	>500 micron	20-500 micron
Mare basalt	0	0
KREEP basalt	0	1.3
Plutonic rock frag.	25	10.4
Other lithic	0	6.7
Granulitc	0	3
Poik. Rocks	0	1
Subophitic	3.1	7.3
Intergranular	3.9	4
Intersertal	0	0
Vitric breccia	3.1	1.7
Frag. Breccia	56.9	0
Plagioclase	2.3	40.7
Olivine		2
Pyroxene		2.7
Opaques		0.3
Glass	3.1	15
Agglutinate		3

Figure 3: Matrix of 61175,108. Field of view 3 mm.

Figure 4: Basaltic clast in 61175,97. Field of view 1.5 mm.

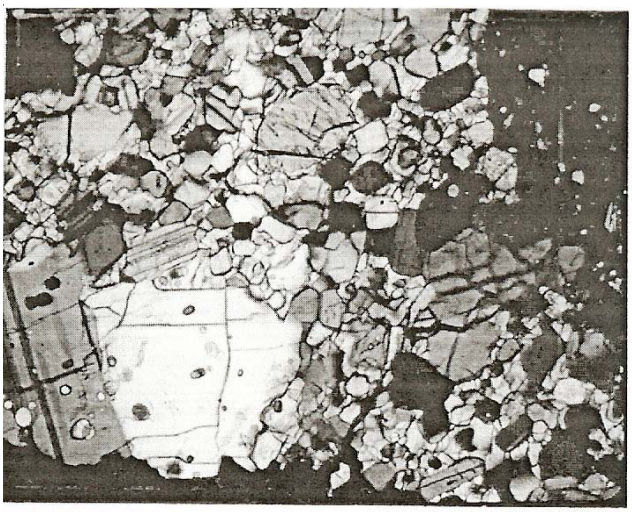


Figure 5: Granoblastic clast in 61175,97. Field of view is 3 mm.

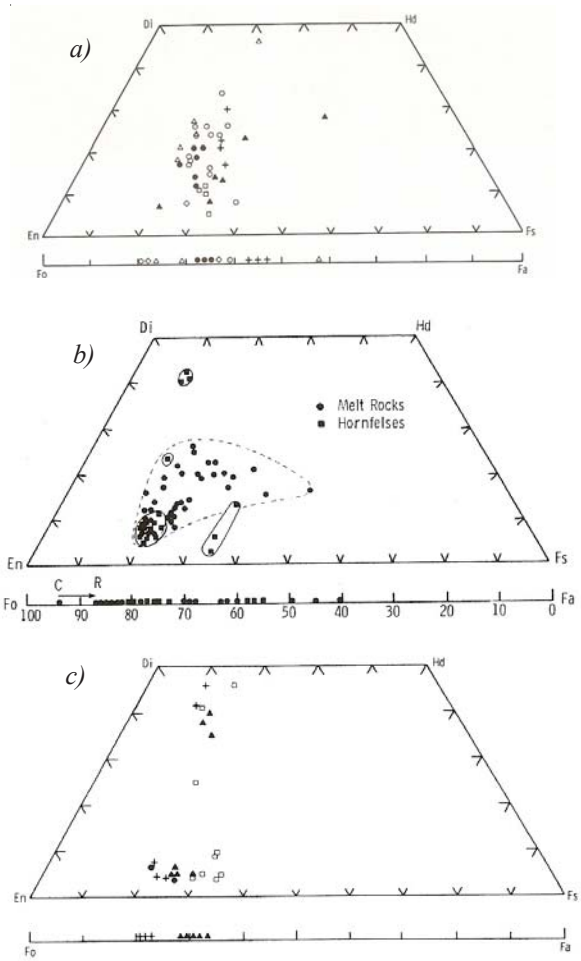


Figure 6: Composition of olivine and pyroxene in a) basalt clasts, b) melt rocks and c) anorthositic, noritic clasts in 61175 (from Winzer et al. 1977).

microcraters are observed on all sides, this sample apparently "tumbled" while on the lunar surface. Schaal et al. (1976) carefully studied one of these microcraters in cross section.

Significant Clasts

Anorthosite ,30 ,151 ,178TS ,179TS

The large (1x2 cm) white clast seen in the slab ,19 was studied by Winser et al. (1977) . It is a moderately shocked anorthosite. An analysis of ,150 by Ebihara et al. (1992) showed it to have low Ir and Au.

"White Clast" ,21 ,131 ,171TS

The smaller white clast with vesicle in figure 13 is trace element rich (Winser et al. 1977).

Dark Aphanitic clast ,126

Table 1a. Chemical composition of 61175.

reference	McKay86		Eldridge73		Simon88		Taylor74	
weight								
SiO2 %							43.9	(c)
TiO2					0.7	(b)	0.05	(c)
Al2O3					29	(b)	35.2	(c)
FeO	4.42	(b)			4.61	(b)	0.41	(c)
MnO					0.06	(b)		
MgO					4.6	(b)	0.83	(c)
CaO	16	(b)			17	(b)	18.9	(c)
Na2O	0.532	(b)			0.55	(b)	0.41	(c)
K2O			0.09	(a)	0.083	(b)	0.06	(c)
P2O5								
S %								
sum								
Sc ppm	7.7	(b)			8.1	(b)	10	(c)
V					22	(b)		
Cr	566	(b)			560	(b)		
Co	17.8	(b)			16.1	(b)	16	(c)
Ni	205	(b)			190	(b)	200	(c)
Cu							9	(c)
Zn								
Ga								
Ge ppb								
As								
Se								
Rb					2.7	(b)	1.28	(c)
Sr	201	(b)			130	(b)		
Y							30	(c)
Zr	120	(b)			140	(b)	109	(c)
Nb							8.1	(c)
Mo								
Ru								
Rh								
Pd ppb								
Ag ppb								
Cd ppb								
In ppb								
Sn ppb								
Sb ppb								
Te ppb								
Cs ppm	0.14	(b)			0.16	(b)	0.07	(c)
Ba	122	(b)			100	(b)	125	(c)
La	10.5	(b)			10.2	(b)	2.3	(c)
Ce	27.1	(b)			25.1	(b)	25.2	(c)
Pr							3.51	(c)
Nd	15	(b)			16.4	(b)	13.8	(c)
Sm	4.76	(b)			4.77	(b)	3.9	(c)
Eu	1.22	(b)			1.3	(b)	1.12	(c)
Gd					5.5		5.01	(c)
Tb	0.89	(b)			1.03	(b)	0.78	(c)
Dy					6.3		5.3	(c)
Ho					1.4		1.24	(c)
Er							3.5	(c)
Tm							0.5	(c)
Yb	3.25	(b)			3.4	(b)	3.01	(c)
Lu	0.464	(b)			0.43	(b)	0.47	(c)
Hf	3.58	(b)			3.6	(b)	2.38	(c)
Ta	0.42	(b)			0.42	(b)		
W ppb								
Re ppb								
Os ppb								
Ir ppb	5.8	(b)			2.6	(b)		
Pt ppb								
Au ppb	3.2	(b)			1	(b)		
Th ppm	1.66	(b)	1.42	(a)	1.54	(b)	1.56	(c)
U ppm	0.42	(b)	0.4	(a)	0.42	(b)	0.35	(c)

technique: (a) radiation counting (b) INAA, (c) spark source mass spec.

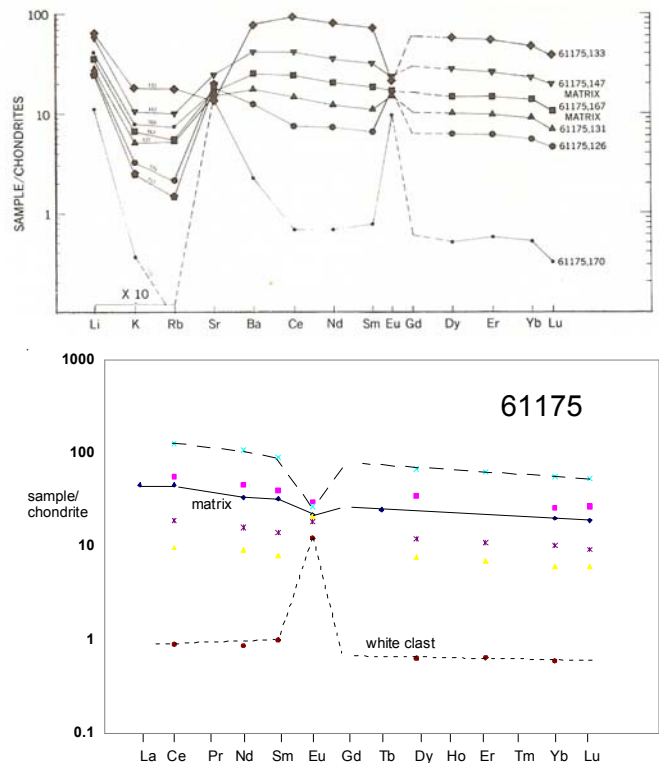


Figure 7: Normalized rare-earth-element diagram for matrix and clasts in 61175 (from Winzer et al. 1977 and McKay et al. 1986).

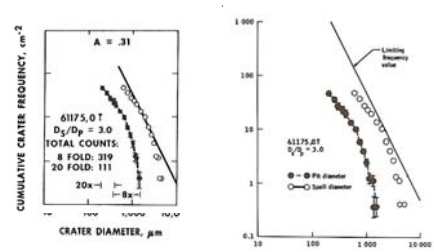


Figure 8: Crater density for 61175 (Neukum et al. 1973; Morrison et al. 1973).

Chemistry

Eldridge et al. (1973), Winzer et al. (1977), McKay et al. (1986) and Simon et al. (1988) have each reported analyses of the matrix of 61175 (table 1, figure 7). Taylor (1974) gave an analysis of a plagioclase separate. Winzer et al. (1977) and Ebihara et al. (1992) also analyzed several fragments for trace elements, however these analyses are not easy to coordinate with petrographic descriptions (Ryder and Norman 1980).

Table 1b. Chemical composition of 61175.

reference	Winzer 77								Ebihara92						
weight	matrix	matrix	matrix	dk. clast	dk. clast	white clasts			,122	,123	,125	,132	,149	,150	
SiO2 %	45.5		45.6	45.5				(d)							
TiO2	0.53		0.52	0.47				(d)							
Al2O3	27.88		27.87	28.78				(d)							
FeO	4.33		4.25	3.38				(d)							
MnO	0.06		0.06	0.05				(d)							
MgO	4.88		4.76	4.46				(d)							
CaO	16.14		16.19	16.75				(d)							
Na2O	0.51		0.5	0.58				(d)							
K2O	0.126	0.08	0.095	0.038	0.22	0.06	0.004	(c)							
P2O5															
S %															
sum															
Sc ppm															
V															
Cr															
Co															
Ni									160	463	90	62	421	19	(e)
Cu															
Zn									14	5	33	12	32	1	(e)
Ga															
Ge ppb									317	1130	625	172	858	7	(e)
As															
Se									189	338	230	96	227	26	(e)
Rb	2.97	1.64	2.19	0.636	5.41	1.57	0	(c)	1.9	3.6	2.3	1.2	2.6	0.6	(e)
Sr	246	177	182	200	149	174	163	(c)							
Y															
Zr		194						(c)							
Nb															
Mo															
Ru															
Rh															
Pd ppb									15	36	12	5.4	20	1	(e)
Ag ppb									8	3	17	7	14	1	(e)
Cd ppb									26	25	207	99	180	11	(e)
In ppb									6.7	1	59	8.3	22	1.4	(e)
Sn ppb															
Sb ppb									1.7	6	1.2	1.6	3.4	2.2	(e)
Te ppb									15	24	28	10	29	1	(e)
Cs ppm									0.18	0.08	0.13	0.05	0.11	0.02	(e)
Ba	153	91.8		45.7	280	65.3	8.34	(c)							
La															
Ce	33	18.9		5.87	76	11.4	0.541	(c)							
Pr															
Nd	21.1	11.8		4.18	48.2	7.05	0.392	(c)							
Sm	5.91	3.37		1.17	13.2	2.04	0.144	(c)							
Eu	1.66	1.2		1.19	1.5	1.03	0.695	(c)							
Gd															
Tb															
Dy	8.41	4.4		1.85	16.6	2.97	0.155	(c)							
Ho															
Er	4.69	2.59		1.09	9.94	1.75	0.104	(c)							
Tm															
Yb	4.29	2.51		1.01	9.06	1.67	0.095	(c)							
Lu	0.654	0.35		0.152	1.27	0.23	0.108	(c)							
Hf															
Ta															
W ppb															
Re ppb									0.7	1.1	0.46	0.22	0.87	0.05	(e)
Os ppb									10	11	6.4	3.1	8.5	0.5	(e)
Ir ppb									9.4	10.6	6.1	2.9	11	0.5	(e)
Pt ppb															
Au ppb									2.3	11	2.2	0.8	3.7	0.04	(e)
Th ppm															
U ppm															

technique: (a) radiation counting (b) INAA, (c) IDMS, (d) defocused e. beam, (e) RNAA

Figure 9: Photo of sawn surface of 61175,20. Cube is 1 cm. S78-31342.

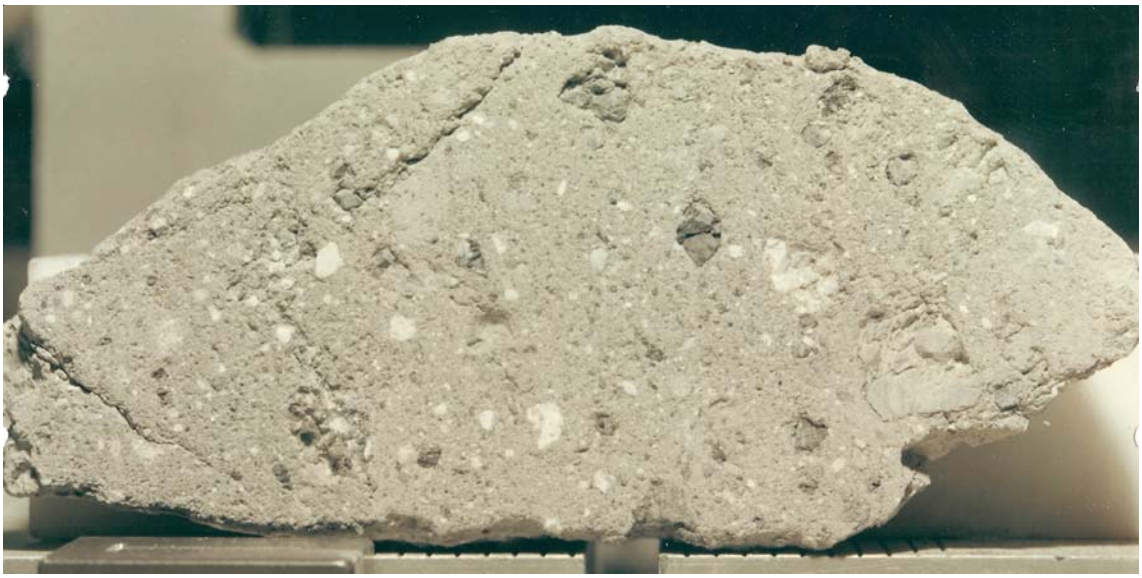


Figure 10: Photo of sawn surface of 61175,19 (slab). Sample is about 10 cm across. S73-22079.

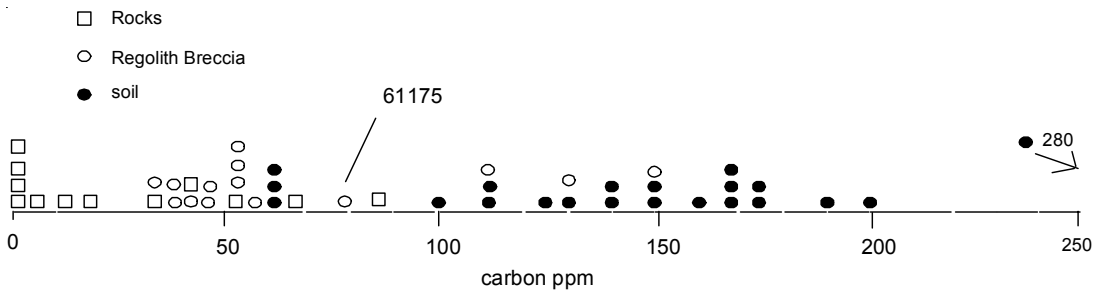


Figure 11: Carbon content of Apollo 16 samples.

Figure 12: Photo of sawn surface of 61175,19 (slab). Sample is about 10 cm across. S73-22080.

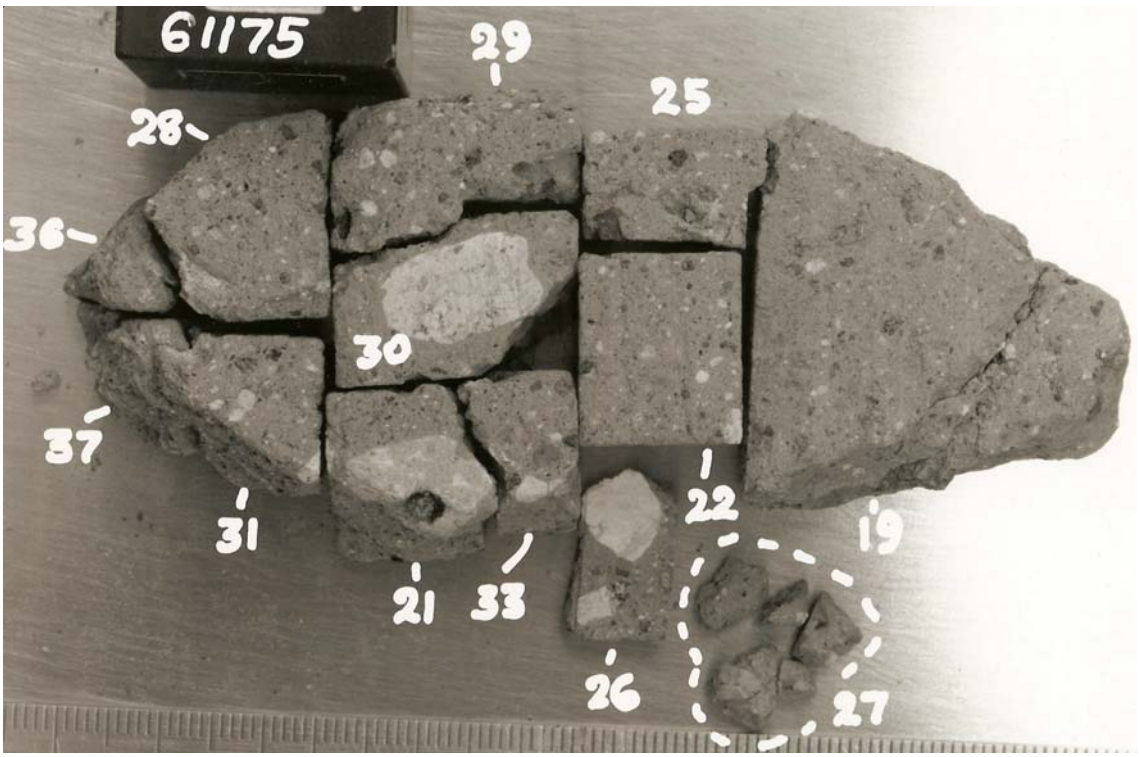


Figure 13: Processing figure of 61175 slab ,19. Scale is in cm; cube is 1 inch. S73-25606.

Moore and Lewis (1976) reported 91 ppm nitrogen and 69 ppm carbon (figure 11).

Radiogenic age dating

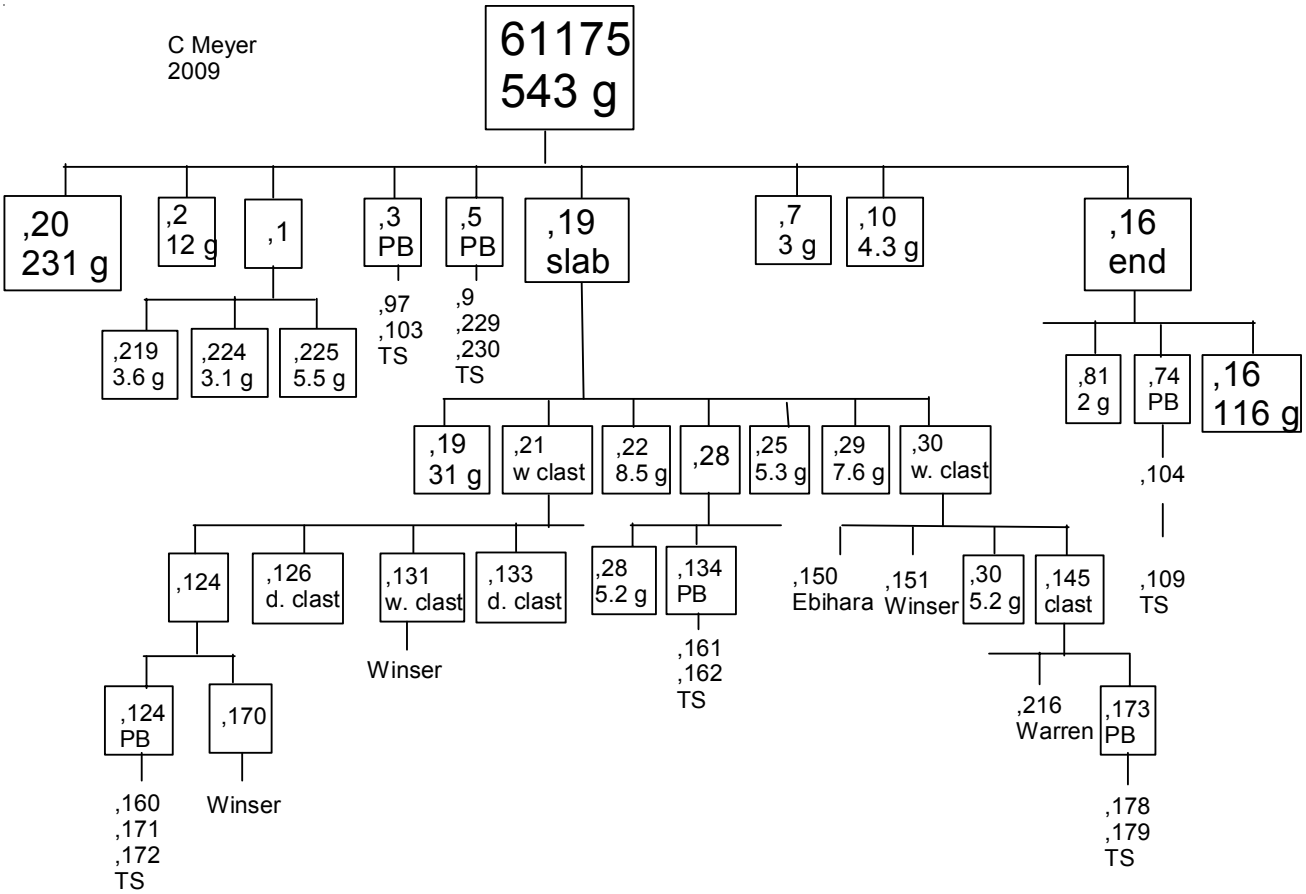
None

Cosmogenic isotopes and exposure ages

Crozaz et al. (1974) reported an exposure age of 20 m.y., but don't tell us how they got that result (would this be the age of Flag Crater?). Eldridge et al. (1973) determined the cosmic-ray-induced activity of ^{26}Al = 137 dpm/kg. and ^{22}Na = 41 dpm/kg.

Other Studies

Morrison et al. (1973) and Neukum et al. (1973) reported the density and size distribution of micrometeorite craters (otherwise known as 'zap' pits) on 61175 (figure 8).



McKay et al. (1986) determined the rare gas content and isotopic ratios for bulk 61175 and for fine fractions. These rare gas studies showed that 61175 lacked the high $^{40}Ar/^{38}Ar$ ratio characteristic of an "ancient regolith breccias" and it is assumed that 61175 is of a more recent, local origin.

Clayton et al. (1973) determined the oxygen isotopes.

Mizutani and Osako (1976) used a piece of 61175 to measure the sound velocity as function of pressure in 61175 (important for seismic studies).

Processing

Sample 61175 was the object of a consortium study (Winzer et al. 1977). A slab was cut from the middle of ,0. There are 34 thin sections.

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