78155

Feldspathic Granulitic Impactite

401.1 grams

Figure 1: Tray full of pieces of 78155. Largest piece is about 7 cm. Small pieces and cube are 1 cm. NASA S73-15407

Station 8, on slope of Sculptured Hills
CDR Boy, almost pure white and very friable. Oh, boy, is it! Pure white. Right out of a small pit crater on the side of this crater I just walked in, Houston. And it's pure white, very friable. I got one big piece and several small in 567.
LMP Bob, the walls of these craters, the big ones that are, say, 15 meters in diameter, tend to be a little bit lighter albedo than ones down in the mantled area.

Introduction

Sample 78155 is a friable white cataclasite that was found in a small "pit crater" in the wall of a 15-meter crater at station 8, Apollo 17 (Muehlberger et al. 1973, Wolfe et al. 1981). The sample itself may have been the projectile that made the small "pit crater" (Meyer 1994). It appears to be exotic to the site, because other pieces of it were not found in the nearby rake sample (note that it has some similarity to 77017). It was collected as one large piece and several smaller pieces, but the big piece apparently also broke up along the way to Houston (figure 1).

78155 has been age dated at about 4.2 b.y. with an exposure age of about 22 m.y.

Petrography

Bickel (1977) described 78155 as a holocrystalline, weakly-coherent, polymict breccia that has been metamorphosed at a high temperature. Warner et al. (1977) group it with other rocks from the early lunar crust as "feldpathic granulitic impactites". Lindstrom and Lindstrom (1986) have also discussed the polymict nature of 78155. Hudgins et al. (2008) have recently described, analyzed and dated 78155.

Investigators find that about 65% of 78155 is granoblasic matrix (figure 2) with another 20% "crushed material". Small clasts of polygonal anorthosite have been reported (see Meyer 1994). The overall mineralogical mode is ~75% plagioclase (An_{95}) and ~25% mafic silicates (mostly pigeonite $Wo_{10}En_{62}Fs_{18}$), with trace olivine (Fo_{60-65}), augite and opaques.

Evidence for temperatures in excess of 1100 deg C during metamorphism are inferred from coexisting uninverted pigeonite and low-Ca augite (Bickel 1977; Cushing et al. 1999) and from equilibrated olivine and ilmenite (Anderson and Lindsley 1979). Cushing et al. calculate 1140 deg C.

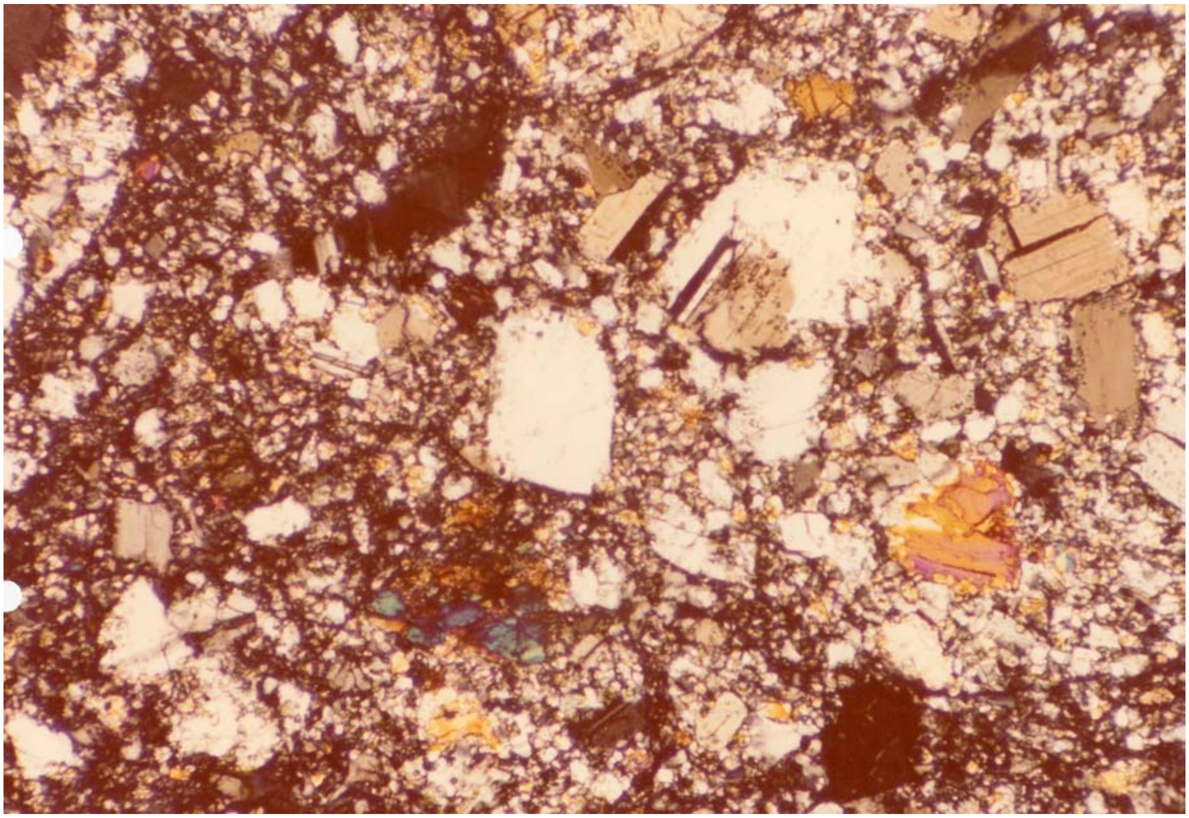


Figure 2: Photomicrograph of thin section 78155,41 (crossed-polarizers). Field of view is 1.4 mm. NASA S79-27704

In point of fact, 78155 is polymict and made up of a variety of lithic clasts from the highlands (Bickel 1977). So far, clast studies have been limited to small clasts in thin section. Most of the lithic clasts have mineral compositions like those of the matrix (relatively Fe-rich pyroxene), but a few have Mg-rich pyroxene (figure 3). According to Bickel (1977), Type-I clasts are fine-grained anorthosites with a felty texture in which the interticies between tabular plagioclase are occupied by crystals of pigeonite and olivine. Type-II lithic clasts in 78155 are coarse-grained and display a range in compositions (40-80% plagioclase; the major mineral is olivine in some, low-Ca pyroxene in other, and augite in one) and texture (subophitic, poikiloblastic, and granoblastic).

Mineralogical Mode of 78155

Olivine	tr.
Plagioclase	75
Augite	tr.
Pigeonite	25
Orthopyroxene	tr.
Ilmenite	tr.
Chromite	tr.
Phosphate	tr.
Metallic Iron	tr.

Mineralogy

Olivine: Olivine in 78155 has a limited range in composition (Fo_{62-65}).

Pyroxene: Bickel (1977) (figure 3), Cushing et al. (1999) and Hudgins et al. (2008) reported pyroxene composition. The main pyoxene is pigeonite ($Wo_{6-14}En_{53-63}Fs_{27-34}$), but augite and orthopyroxene are also present.

Plagioclase: According to Bickel (1977), plagioclase in 78155 has a rather wide range in composition (An_{91-97}). Hudgins et al. (2008) found a wider range (An_{89-97}).

Ilmenite: According to Hudgins et al. (2008), ilmenite has 2.8 – 7.1 % MgO.

Metallic Iron: Hewins and Goldstein (1975) found the iron grains in 78155 to be limited to about 5% Ni (figure 4), but Hudgins et al. (2008) found two large iron grains with 28%Ni and 2.5% Co.

Merrillite: Hudgins et al. (2008) reported rare grains of merrillite.

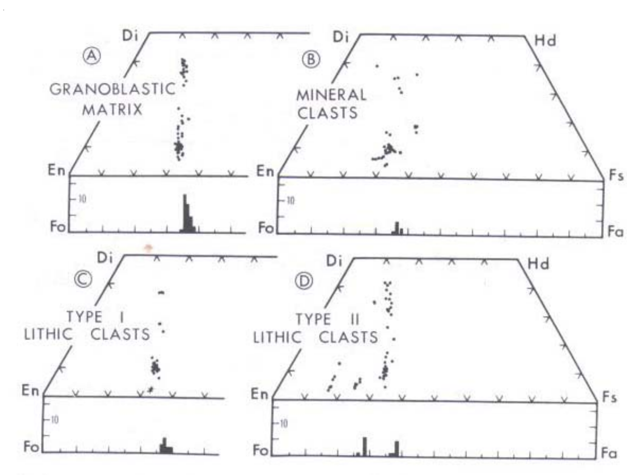


Figure 3: Composition of pyroxene and olivine in 78155 (from Bickel 1977).

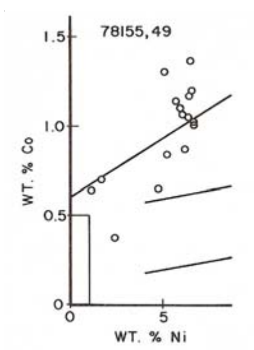


Figure 4: Ni and Co content of iron grains in 78155 (Hewins and Goldstein 1975).

Chemistry

The chemical composition of 78155 has been determined by Wanke et al. (1976), Laul and Schmitt (1973), Hubbard et al. (1974), Lindstrom and Lindstrom (1986) and Hudgins et al. (2008). Gibson and Moore 1974) reported sulfur and Moore and Lewis (1976) reported nitrogen. The REE pattern is essentially flat (figure 6). Trace elements were reported by Morgan et al. (1974). Everyone found high Ir (see table). Warner et al. (1977) noticed that while the sample was apparently of impact origin, it did not incorporate KREEP.

Radiogenic age dating of 78155

Turner and Cadogen (1975) obtained a nice plateau age of 4.12 ± 0.04 b.y. (figure 7). Fernandez et al. (2008) determined 4.196 ± 0.074 b.y. and Hudgins et al. (2008) determined 4.106 ± 0.043 b.y., along with numerous laser spots ranging in age (figures 8-10).

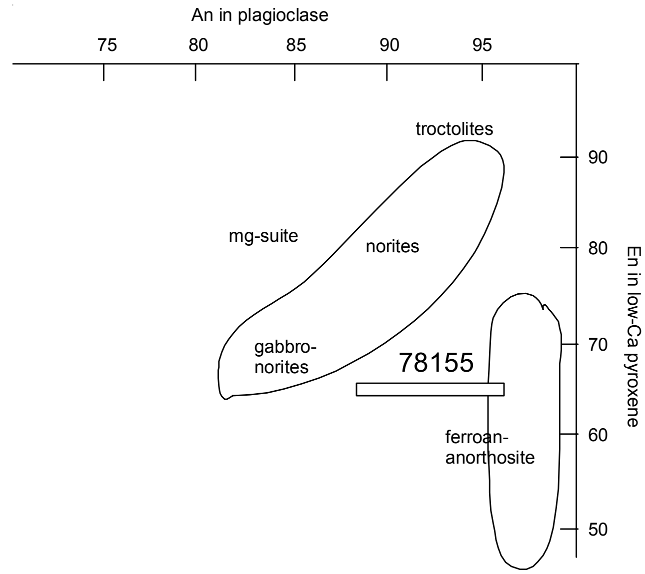


Figure 5: Composition of plagioclase and pyroxene in 78155 compared with plutonic rock types.

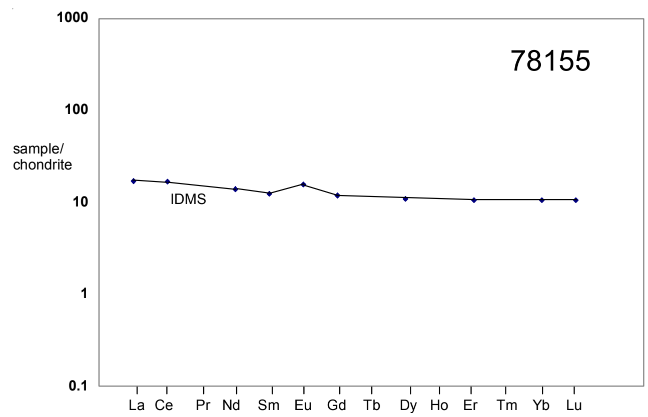


Figure 6: Norm Hubbard (1974) precisely determined the REE pattern for 78155 by isotope dilution mass spectrometry, and everyone else seems to have identical data (seee table).

Additional data has been presented by Oberli et al. (1979) and Garrick-Bethell et al. (2008).

Nyquist et al. (1974) determined Rb/Sr and Sr isotope data for "whole rock" (figure 11) and Murthy (1978) reported the initial Sr isotope ratio for plagioclase from 78155. However, petrography indicates that there is more than one lithology.

Nunes et al. (1974, 1975) and Oberli et al. (1979) studied the U/Th/Pb systematics and obtain a precise age for 78155 at 4.17 ± 0.2 b.y.

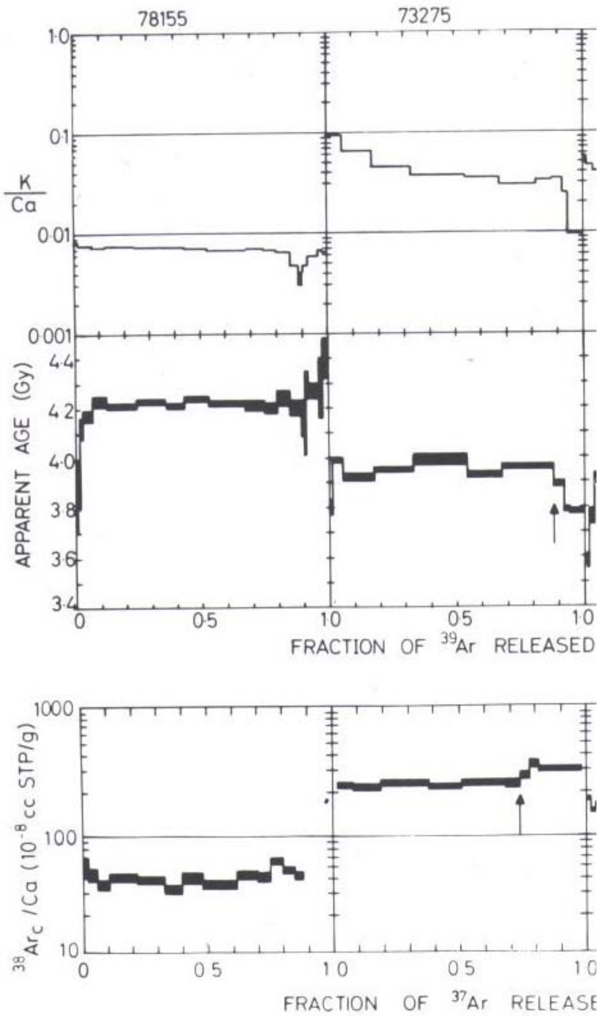


Figure 7: Ar/Ar plateau diagram for 78155 and 73275 including crystallization ages and exposure ages (Turner and Cadogen 1975).

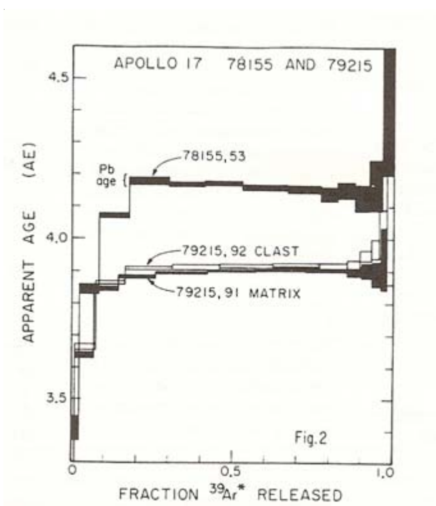


Figure 8: Ar/Ar plateau diagram for 78155 compared with that of 79215 (Oberli et al. 1979).

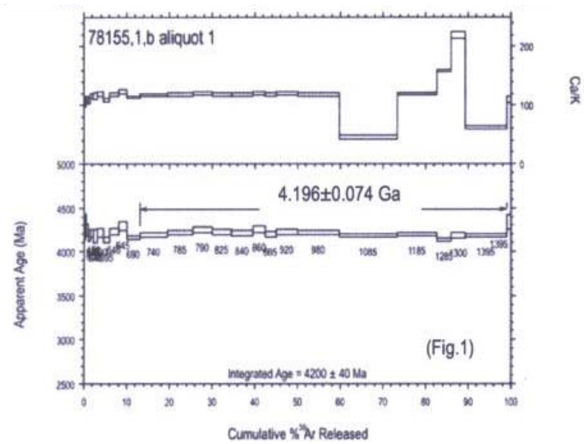


Figure 9: Ar/Ar age plateau for 78155 (Fernandes et al. 2008).

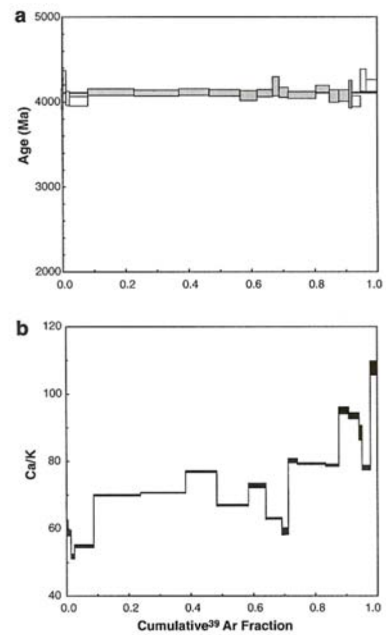


Figure 10: Ar/Ar plateau diagram for 78155 (from Hudgins et al. 2008).

Summary of Age Data for 78155

	Ar/Ar	U/Pb
Turner and Cadogen 1975	4.12 ± 0.04 b.y.	
Nunes et al. 1975		4.22 b.y.
Fernandez et al. 2008	4.196 ± 0.074 b.y.	
Hudgins et al. 2008	4.106 ± 0.043 b.y.	
Oberli et al. 1979	4.17	4.17 ± 0.02 by.
Garrick-Bethell 2008	4.2	

Ages corrected to Steiger and Jager 1977.

Table 1. Chemical composition of 78155.

reference	Wanke 76		Laul73		Morgan74		Nunes74		Hubbard74		Lindstrom86		LSPET73		Hudgins2008				
weight	Wanke 77								Wiesmann75		137		,2						
SiO2 %	45.33	(d)											45.57	(e)					
TiO2	0.28	(d)	0.22						0.27	(c)	0.32	(a)	0.27	(e)					
Al2O3	25.3	(d)	26.2								26	(a)	25.94	(e)					
FeO	5.63	(d)	5.3								5.62	(a)	5.82	(e)					
MnO	0.085	(d)	0.076										0.1	(e)					
MgO	6.42	(d)	6.2						0.43	(c)	6.2	(a)	6.33	(e)					
CaO	15.2	(d)	15.2								15.2	(a)	15.18	(e)					
Na2O	0.385	(d)	0.39								0.39	(a)	0.33	(e)					
K2O	0.073	(d)	0.07						0.079				0.08	(e)					
P2O5													0.04	(e)					
S %	0.024	(d)											0.04	(e)					
sum																			
Sc ppm	13.3	(d)	11	(a)							12.9	(a)			13.33	13.84	12.9	13.14	(a)
V	38.7		30	(a)															
Cr	980	(d)	821	(a)					1008	(c)	965	(a)							
Co	14.3	(d)	14	(a)							15.8	(a)			14.9	15.6	14.7	15.3	(a)
Ni	80	(d)	90	(a)	68	(b)					100	(a)			67	83	61	73	(a)
Cu	4.52	(d)																	
Zn	4.13	(d)			2.3	(b)													
Ga	2.9	(d)																	
Ge ppb					27	(b)													
As	4.8	(d)																	
Se	60	(d)			49	(b)													
Rb	2.01	(d)			1.76	(b)			2.061	(c)									
Sr	141	(d)							147	(c)	165	(a)			137	144	144	152	(a)
Y	16	(d)																	
Zr	54	(d)									48	(a)			50	47	40	49	(a)
Nb	2	(d)																	
Mo																			
Ru																			
Rh																			
Pd ppb																			
Ag ppb					1	(b)													
Cd ppb					63	(b)													
In ppb																			
Sn ppb																			
Sb ppb					20.4	(b)													
Te ppb					3.2	(b)													
Cs ppm	0.11	(d)			0.084	(b)					0.103	(a)							
Ba	63.6	(d)	50	(a)					58.8	(c)	61	(a)			59	64	59	62	(a)
La	4.28	(d)	4.3	(a)					4.02	(c)	3.98	(a)			3.99	3.96	3.93	3.85	(a)
Ce	11.3	(d)	12	(a)					10.2	(c)	9.9	(a)			10	10	9.8	9.6	(a)
Pr	1.5	(d)																	
Nd	7.3	(d)	8	(a)					6.29	(c)	5.7	(a)			6.1	5.2	5.3	6.2	(a)
Sm	1.69	(d)	1.9	(a)					1.81	(c)	1.74	(a)			1.8	1.82	1.78	1.78	(a)
Eu	0.862	(d)	0.9	(a)					0.874	(c)	0.835	(a)			0.88	0.87	0.87	0.86	(a)
Gd	2.3	(d)							2.32	(c)									
Tb	0.39	(d)	0.35	(a)							0.41	(a)			0.38	0.41	0.39	0.38	(a)
Dy	2.63	(d)	2.3	(a)					2.64	(c)									
Ho	0.61	(d)																	
Er	1.9	(d)							1.69	(c)									
Tm																			
Yb	1.83	(d)	1.7	(a)					1.73	(c)	1.57	(a)			1.7	1.76	1.71	1.68	(a)
Lu	0.27	(d)	0.23	(a)					0.259	(c)	0.244	(a)			0.238	0.248	0.24	0.241	(a)
Hf	1.49	(d)	1.4	(a)							1.42	(a)			1.39	1.5	1.44	1.37	(a)
Ta	0.25	(d)	0.23	(a)							0.22	(a)			0.21	0.21	0.2	0.2	(a)
W ppb	104	(d)																	
Re ppb	0.24	(d)			0.278	(b)													
Os ppb																			
Ir ppb	3.9				3.32	(b)					8	(a)			3.6	3.7	3.6	4.7	(a)
Pt ppb																			
Au ppb	0.68	(d)			0.66	(b)									5	5	5	5	(a)
Th ppm	0.84	(d)	0.9	(a)			0.935	(c)	1.01	(c)	0.86	(a)			0.9	0.9	0.92	0.91	(a)
U ppm	0.24	(d)	0.4	(a)	0.25	(b)	0.27	(c)	0.28	(c)	0.25	(a)			0.28	0.27	0.29	0.27	(a)

***technique:** (a) INAA, (b) RNAA, (c) IDMS, (d) all, (e) XRF*

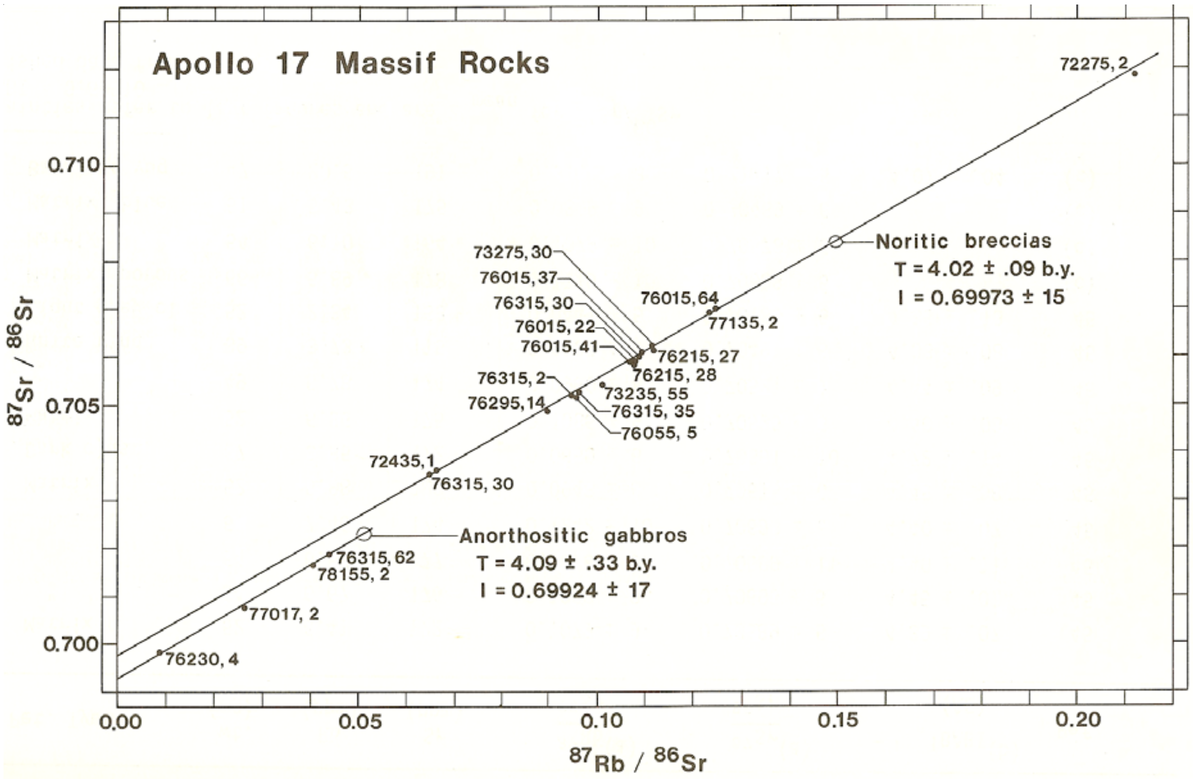


Figure 11: Look for 78155 on this diagram (Nyquist et al. 1974, Phinney 1981).

Cosmogenic isotopes and exposure ages

Drozd et al. (1977) determined an exposure age of 22 m.y. by ^{81}Kr, while Turner and Cadogen (1975) determined 30 m.y and Hudgins et al. (2008) determined 20.7 ± 1.5 m.y. by ^{38}Ar , respectively.

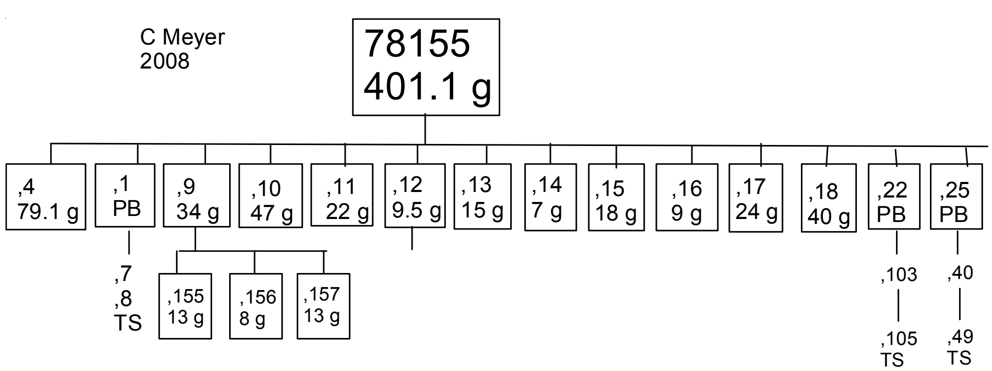
Coments ?

Sill et al. (1974) studied the carbon content of 78155 with the hope of finding evidence of a cometary contribution to breccia 78155. They found that it was the most volatile-rich of all samples studied. The evolved CO_2, CO and CH_4 content represent 267 ppm carbon. Hydrocarbons (exclusive of CH4) were present in approximatly 60 ppm quantitiy; the most abundant ion was m/e 43. This sample also outgassed hydrogen cyanide (~5 ppm) and hydrogen sulfide (~6 ppm).

Other Studies

Adams and Charatte (1975) have determined the reflectance spectra of 78155.

Nagata et al. (1974, 1975) and Hargraves and Dorety (1975) studied the remanent magnetism of 78155. Ben Weiss is currently studying the magnetic properties of this rock.



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