74275

Oriented Ilmenite Basalt

1493 grams

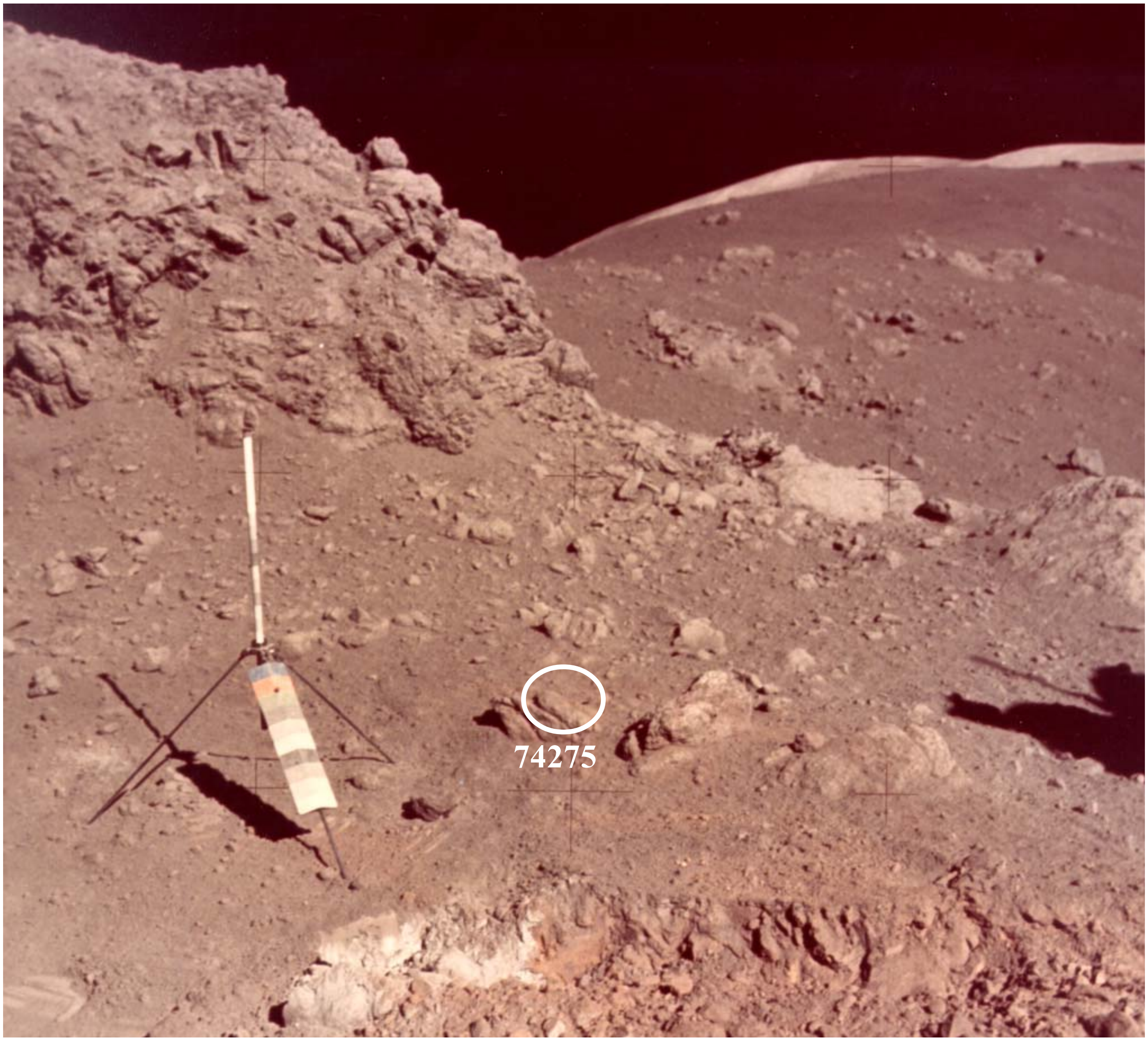


Figure 1: Location of basalt sample 74275 at Shorty Crater - also see 74220. (falce color) AS17-137-20990

Introduction

74275 is a fine-grained, high-Ti mare basalt with significant armalcolite content (Hodges and Kushiro 1974; Neal and Taylor 1993). It contains vesicles, vugs and unusual olivine megacrysts (Fo_{82}) (Meyer and Wilshire 1974).

74275 was collected from the rim of Shorty Crater (figure 1) and was photographed both on the lunar surface and in the laboratory (with similar lighting) to document the exact lunar orientation. (Wolfe et al. 1981). This sample has proven useful to studies that require known lunar orientation with extended exposure history to the extra-lunar environment (micrometeorites, cosmic rays, solar irradiation). The sample is relatively flat 17 by 12 cm and 4 cm thick. The top (T1) surface is somewhat rounded and has many micrometeorite pits (figure 4), while the bottom (B1) surface is flat and angular and without any evidence of exposure to the micrometeorites (figure 5). Fink et al. (1998) have carefully considered the exact orientation (30 deg tilt), shielding (nearby boulder) and detailed exposure history (complex) of 74275.

This basalt has been determined to be very old (> 3.8 b.y.). Based on trace element analysis it is a type C Apollo 17 basalt.

Petrography

Perhaps the best petrographic description of 74275 is given by Hodges and Kushiro (1974): *"Rock 74275 is a fine-grained ilmenite basalt with microphenocrysts of olivine (Fo_{80-71}), titanaugite (up to 6.8 wt. % TiO_2) and armalcolite rimmed with ilmenite set in a subvariolitic groundmass of clinopyroxene, plagioclase (An_{88-78}), ilmenite, tridymite, metallic iron (Ni<1 wt.%), troilite and glass. Spinel occurs only within olivine grains."*

Neal and Taylor (1993) and Brown et al. (1975) compare 74275 with a suite of high-Ti basalts from Apollo 17. 74275 contains groundmass plagioclase, pyroxene and ilmenite with larger crystals of pink pyroxene (up to 0.5 mm) and olivine (up to 0.7 mm) and ilmenite/armalcolite laths (up to 0.7 mm in length) (figure 6). Pyroxene rims are present on some olivine phenocrysts. Minor blebs of iron metal and troilite are found in the mesostasis. Olivine megacrysts (figure 8), some termed "dunite inclusions", are common in 74275 (Meyer and Wilshire 1974). These can be seen as green inclusions in the photo of the bottom surface (figure 5).

Mineralogy

Pyroxene: The pyroxenes in 74275 are high Ca pyroxene without the presence of low-Ca pyroxene (figure 2). Sung et al. (1974) have shown that the pyroxenes in 74275 contain high concentrations of Ti^{3+}.

Olivine: Delano and Lindsley (1982) have carefully considered the olivine in 74275 (figure 7). The olivine megacrysts in 74275 are too magnesium rich to have formed from the melt (Meyer and Wilshire 1974). Unusual olivine with an "hourglass" structure has been reported by Hodges and Kushiro (1974).

Opaques: Armalcolite is rimmed with ilmenite (Hodges and Kushiro 1974; El Goresy et al. 1974). Small euhedral chromite are found as inclusions in the olivine clusters (Neal and Taylor 1993).

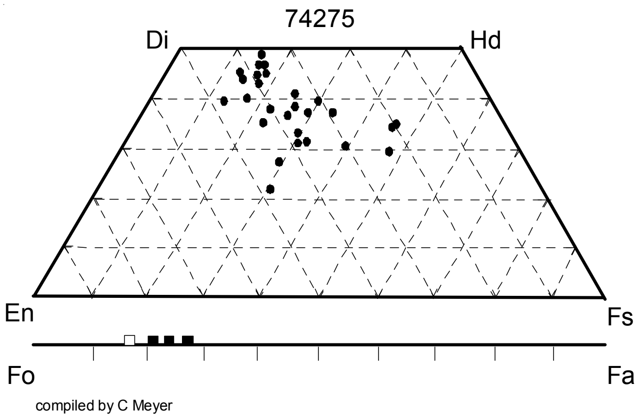


Figure 2: Composition of pyroxene and olivine in 74275 (replotted from Hodges and Kushiro 1974, with apologies). The open symbol at Fo_{82-84} represents the composition of olivine xenocrysts (Delano and Lindsley 1982).

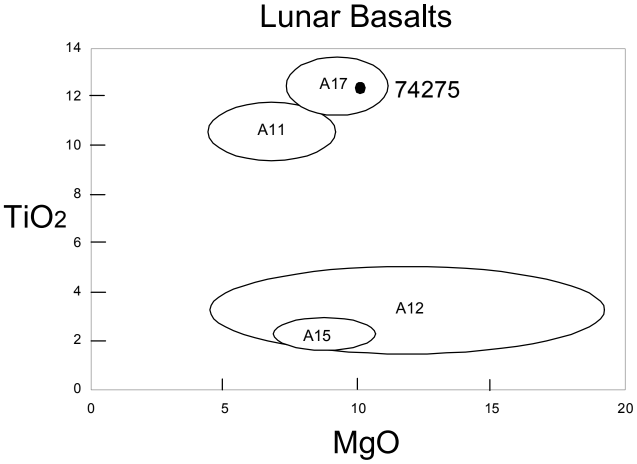


Figure 3: Chemical composition of Apollo basalts with 74275.

Chemistry

The chemical composition of 74275 has been determined by Duncan et al. (1974), Wanke et al. (1974), Rose et al. (1975) and other (table 1). Trace elements have been determined by Rhodes et al. (1976), Wanke et al. (1974) and others (table 1, figure 9). 75275 is a type C, Apollo 17 basalt (figure 10) (Paces et al. 1991). Dickinson et al. (1989) determined Ge. Gibson and Moore (1974) reported 1650 ppm S.

Mineralogical Mode for 74275

	Brown et al. 1975	**Meyer and Wilshire 1974**
Olivine	13 %	16.1
Pyroxene	36	34.9
Opaques	31	33.3
Plagioclase	19	15.6

Figure 4: Top surface of 74275 showing numerous micrometeorite "zap" pits. NASA# S73-16018. Cube is 1 cm.

Figure 5: Bottom surface of 74275 showing vesicles and vugs. NASA# S73-16019 (fadded). Cube is 1 cm.

Figure 6: Photomicrograph of thin section of 74275 (from Neal and Taylor 1993).

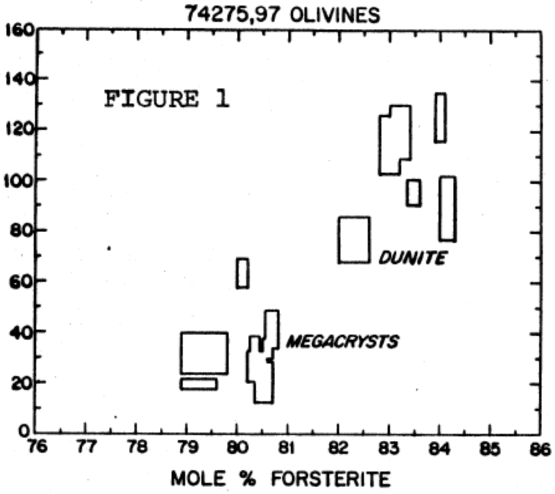


Figure 7: Ni and Mg in olivine in 74275 (from Delano and Lindsley 1982).

Gibson (1987), Petrowski et al. (1974), Reese and Thode (1974) and Des Marais (1980) determined S, C, N and H. Garg and Ehman (1976) and Hughes and Schmitt (1985) determined Zr and Hf.

Halogens, Hg and Li have been determined by Jovanovic and Reed (1974).

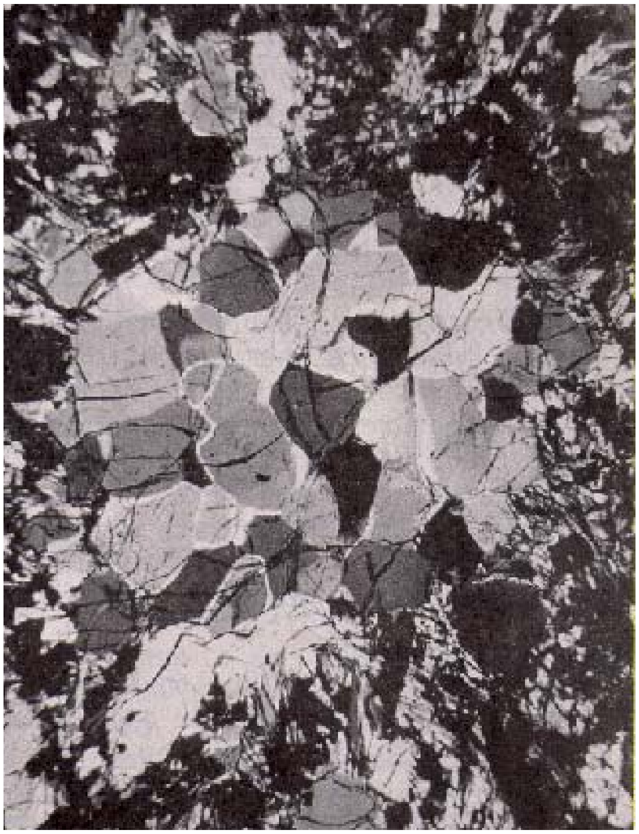


Figure 8: Photomicrograph of "dunite" inclusion in 74275 (from Delano and Lindsley 1982).

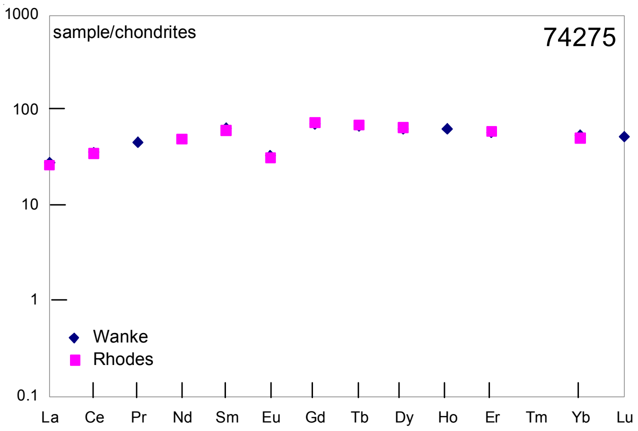


Figure 9: Normalized rare-earth-element diagram for 74275 (data from Wanke et al. 1974, Rhodes et al. 1976).

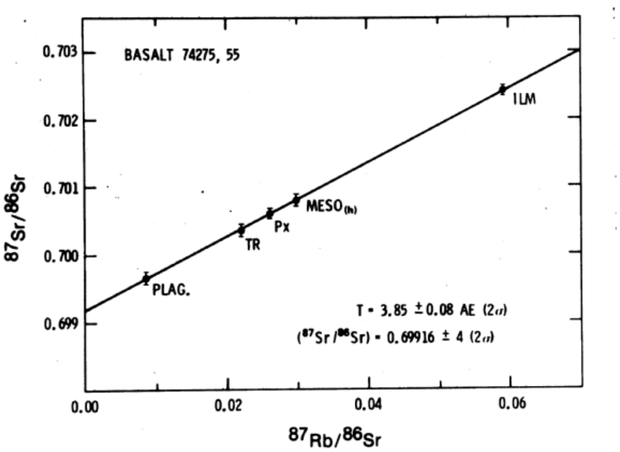


Figure 11: Rb-Sr isochron for 74275 (from Murthy and Coscio 1977).

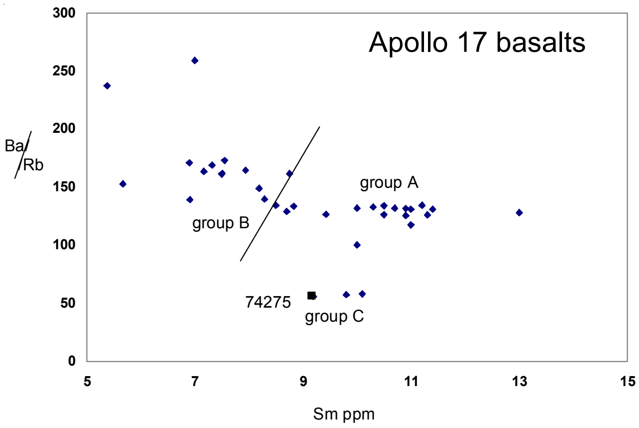


Figure 10: Trace element characterization of Apollo 17 basalts showing 74275 is type C.

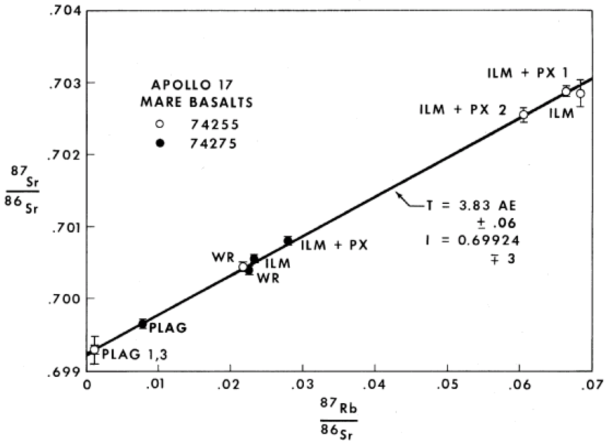


Figure 12: Rb-Sr isochron for 74255 with added data from 74275 (from Nyquist et al. 1976). The isochron fit for 74275 is 3.81 +/- 0.32 b.y.).

Radiogenic age dating

Murthy and Coscio (1977) dated 74275 at 3.85 ± 0.08 b.y. using Rb-Sr (figure 11). Nyquist et al. (1976) obtained an age of 3.81 ± 0.32 b.y. (figure 12). Nunes et al. (1974) and Paces et al. (1991) determined whole rock U-Th-Pb and Sm-Nd isotopics, respectively.

Summary of age dating 74275

	Rb/Sr
Murthy and Coscio 1977	3.85 ± 0.08
Nyquist et al. 1976	3.81± 0.32
Nunes et al. 1974	

Caution: Old decay constants.

Cosmogenic isotopes and exposure ages

Goswami and Lal (1974) determined a SUNTAN exposure age of 2.8 m.y. from the density and gradient of nuclear tracks caused by very heavy cosmic ray bombardment and this was initally thought to be the age of Shorty crater. Eugster et al. (1977) measured the isotopic ratio of all the rare gases and determined an "exposure age" of 32.2 ± 1.4 m.y. by the ^{81}Kr-Kr method for 74275. However, the age of Shorty crater (~19 m.y.) was determined from the samples of a nearby boulder, thus sample 74275 is thought to have had a complicated exposure history. Crozaz (1978), Arvidson et al. (1975) and Eberhardt et al. (1974) have also discussed the exposure age of 74275 and it relationship to the age of Shorty Crater.

Fruchter et al. (1982), Klein et al. (1990) and Fink et al. (1998) have reported precise depth profiles of the cosmogenic radionuclides ^{10}Be, ^{22}Na, ^{26}Al and ^{41}Ca (figures 14-17) and modeled the flux and energy of cosmic rays. The ^{22}Na activity is residual from the 1972 solar flare event (Sisterson and Reedy 1997).

Table 1. Chemical composition of 74275.

reference	Duncan74		Rose 75		Rhodes76		Wanke 74		Murthy77		Miller 74			Hodges74		Green75		Brunfelt74	
weight											recalculated								
SiO2 %	38.43	(a)	38.44	(a)	- - - -		38.73				38.3	39.58	(c)	38.4	(d)	37.9	(d)		
TiO2	12.66	(a)	12.75	(a)			11.71				11.88	8.75		14.1	(d)	12.6	(d)	13.1	(c)
Al2O3	8.51	(a)	8.93	(a)			8.4				8.51	9.07		8.5	(d)	8.3	(d)	8.83	(c)
FeO	18.25	(a)	18.03	(a)			18.29				18.31	18.18		17.4	(d)	19.1	(d)	18	(c)
MnO	0.247	(a)	0.27	(a)			0.241				0.25	0.25		0.35	(d)	0.2	(d)	0.25	(c)
MgO	10.26	(a)	10.46	(a)			10.16				10.47	10.14		8.6	(d)	10.4	(d)	10.8	(c)
CaO	10.38	(a)	10.26	(a)			10.08				10.36	10.08		10.7	(d)	10.2	(d)	11.3	(c)
Na2O	0.37	(a)	0.33	(a)			0.37				0.38	0.39		0.22	(d)	0.4	(d)	0.34	(c)
K2O	0.075	(a)	0.09	(a)			0.08		0.04	(b)				0.07	(d)	0.1	(d)	0.07	(c)
P2O5	0.074	(a)	0.06	(a)	Gibson		0.063												
S %	0.141	(a)			0.14														
sum																			
Sc ppm			78	(a)			74	(c)										83	(c)
V	79	(a)	62	(a)														146	(c)
Cr	4372	(a)	4447	(a)			3688	(c)										4100	(c)
Co	24	(a)	31	(a)			22.5	(c)										21.3	(c)
Ni	<3	(a)	16	(a)			-											<10	(c)
Cu			40	(a)			3.5	(c)										3.3	(c)
Zn			5.8	(a)			1.7	(c)										2	(c)
Ga			6.2	(a)			3.4	(c)			Dickinson 89							4.1	(c)
Ge ppb											6.8								
As ppb							4	(c)											
Se											Nyquist 76	Paces 91							
Rb	1.9	(a)			1.2	(b)	1.22	(c)	1.03	(b)	1.2	0.864						0.9	(c)
Sr	158	(a)	152	(a)	153	(b)	195	(c)	135	(b)	153	116						115	(c)
Y	81.5	(a)	116	(a)			79	(c)			Hughes 85								
Zr	248	(a)	290	(a)			246	(c)			261								
Nb	22.1	(a)					19	(c)											
Mo																			
Ru																			
Rh																			
Pd ppb																			
Ag ppb																			
Cd ppb																			
In ppb																			
Sn ppb																			
Sb ppb																			
Te ppb																			
Cs ppm							53	(c)										60	(c)
Ba	89	(a)			67.3	(b)	83	(c)	73.8	(b)								65	(c)
La					6.33	(b)	6.7	(c)										5.98	(c)
Ce					21.4	(b)	22.1	(c)										16.5	(c)
Pr							4.2	(c)											
Nd					22.8	(b)						22.5							
Sm					9.19	(b)	9.76	(c)				9.24						9.7	(c)
Eu					1.8	(b)	1.91	(c)										1.93	(c)
Gd					14.8	(b)	14.2	(c)											
Tb							2.5	(c)										2.05	(c)
Dy					16.3	(b)	15.8	(c)										17.9	(c)
Ho							3.6	(c)											
Er					9.66	(b)	9.4	(c)											
Tm																			
Yb			11		8.47	(b)	9.02	(c)										7.5	(c)
Lu							1.3	(c)			Hughes 85							1.34	(c)
Hf							8.33	(c)			8.4							8.3	(c)
Ta							1.5	(c)										1.57	(c)
W ppb							60	(c)										99	(c)
Re ppb							<0.5	(c)											
Os ppb																			
Ir ppb																			
Pt ppb																			
Au ppb							0.19	(c)			Nunes 74								
Th ppm											0.4654	(b)						0.38	(c)
U ppm							0.16	(c)			0.136	(b)						0.131	(c)

technique (a) XRF, (b) IDMS, (c) INAA, (d) fused bead, elc. Probe

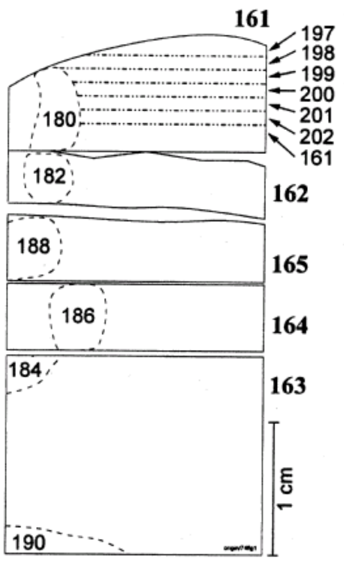


Figure 13: Schematic drawing of column cut from 74275 for study of cosmogenic radionuclide production from energetic solar cosmic ray (from Fink et al. 1998).

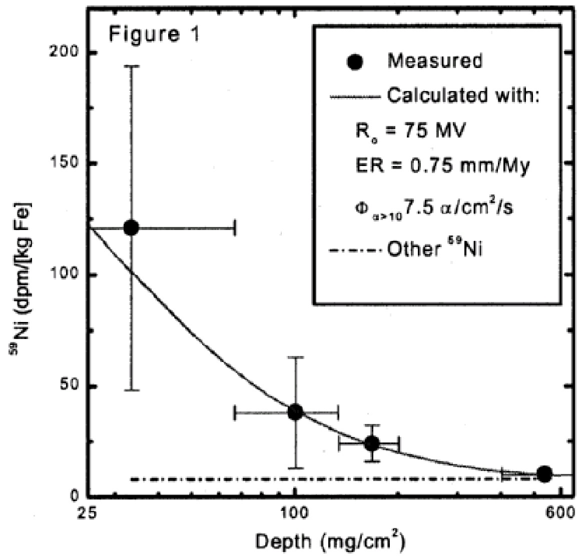


Figure 14: Ni 59 depth profile of very surface of 74275 (from Schnabel et al. 2000) due to irradiation by solar alpha particles.

Schnabel et al. (2000) used accelerator mass spectroscopy to determine a depth profile for ^{59}Ni , produced by SCR alpha particles in the very surface layer (figure 14). However, the erosion rate due to micrometeorite bombardment remains unknown for this sample.

Other Studies

74275 is one of the most Mg rich of the high-Ti Apollo samples, and for this reason the composition of 74275

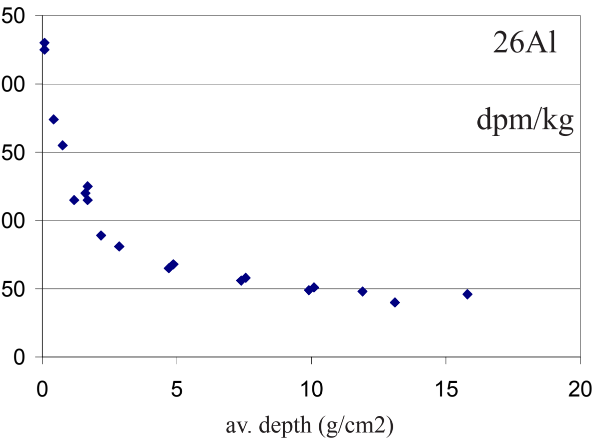


Figure 15: Al 26 depth profile for 74275 (from data by Fruchter et al. (1982); Klein et al (1988); Fink et al. (1998).

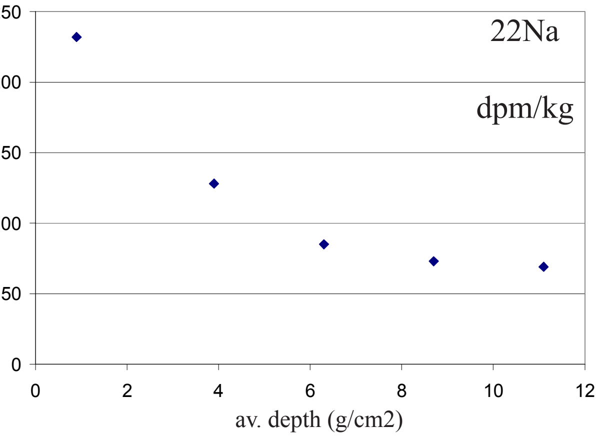


Figure 16: Na 22 depth profile for 74275 (from data by Fruchter et al. (1982) due to irradiation by 1972 solar flare (Sisterson and Reedy 1997).

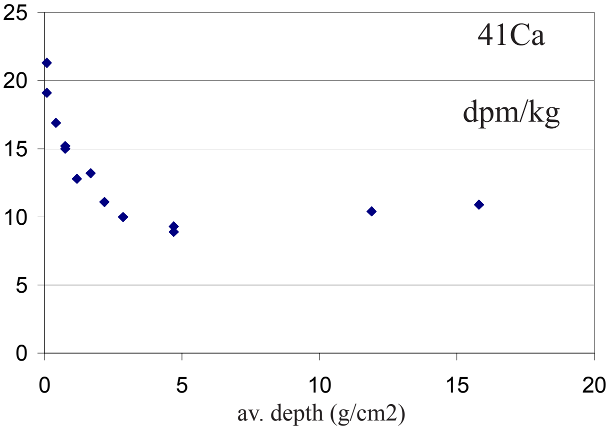


Figure 17: Ca 41 depth profile for 74275 (from data by Fink et al. 1998).

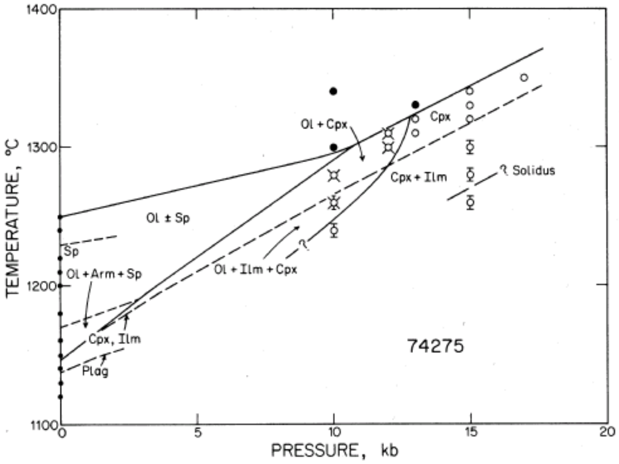


Figure 18: Experimentally determined phase relations as function of pressure for 74275 (from Green et al. 1975).

became the starting point for high-pressure phase-relation experiments (figure 18) aimed at determining the depth of origin of high-Ti mare basalt (Green et al. 1974, 1975; Walker et al. 1976; Delano and Lindsey 1982). However, 74275 contains olivine inclusions that are too mg* to have crystallized from the melt they are in, and the bulk composition of 74275 may not represent the composition of a true melt.

Additional experiments on 74275 include element partioning between phases (Irving et al. 1978), cooling rate and nucleation (Usselman and Lofgren 1976) and the effects of oxygen fugacity and stability of armalcolite (O'Hara and Humphries 1975; Satan and Taylor 1979).

The magnetic properties of 74275 have been studied by Brecher et al. (1974); Pearce et al. (1974); and Nagata et al. (1975).

Mizutani and Osako (1974) determined the compressional and shear wave velocity as a function of pressure using a sample of 74275.

Processing

Two partial slabs and two columns (4 cm deep) were cut from this sample. The first partial slab (,13 to ,34) was cut in 1973 (figures 19 and 20). A second slab (,166 and ,167) and a column (,161 top; to ,165 middle) was cut in 1981 (figure 21). A second column was cut from ,166 in 1998 (figure 22). Apparently the big piece ,2 broke in storage. A well-documented surface piece ,159 can be identified in the center of the top surface. There are 19 thin sections.

List of Photos # for 74275

S73-16018 to 16024 Color PET
S73-19156 to 19171 B&W PET
S81-34492 to 34494
S98-02167 to 02174

Table 3: Analysis of armalcolite.

TiO_2	72.9	73.5	72.8	74.2	73.6	72.8	72.7
FeO	16.6	15.5	17.5	15	16.6	15.5	17.4
MnO	0.12	0.29	0.17	0.08	0.13	0.05	0.16
MgO	6.59	6.92	6.35	7.39	6.64	7	6.38
Cr_2O_3	1.69	2.3	1.81	2.05	2.06	2.01	1.52
Al_2O_3	2.11	2.13	1.94	2.1	2.1	2.04	2.06
total	100.01	100.64	100.57	100.8	101.13	99.4	100.22

Stanin and Taylor (1980).

Figure 19: First partial slab cut from 74275. Positon of first column and second slab indicted. NASA# 73-28789. Nice illustration of our 1 cm cube as well as our 1 inch cube!

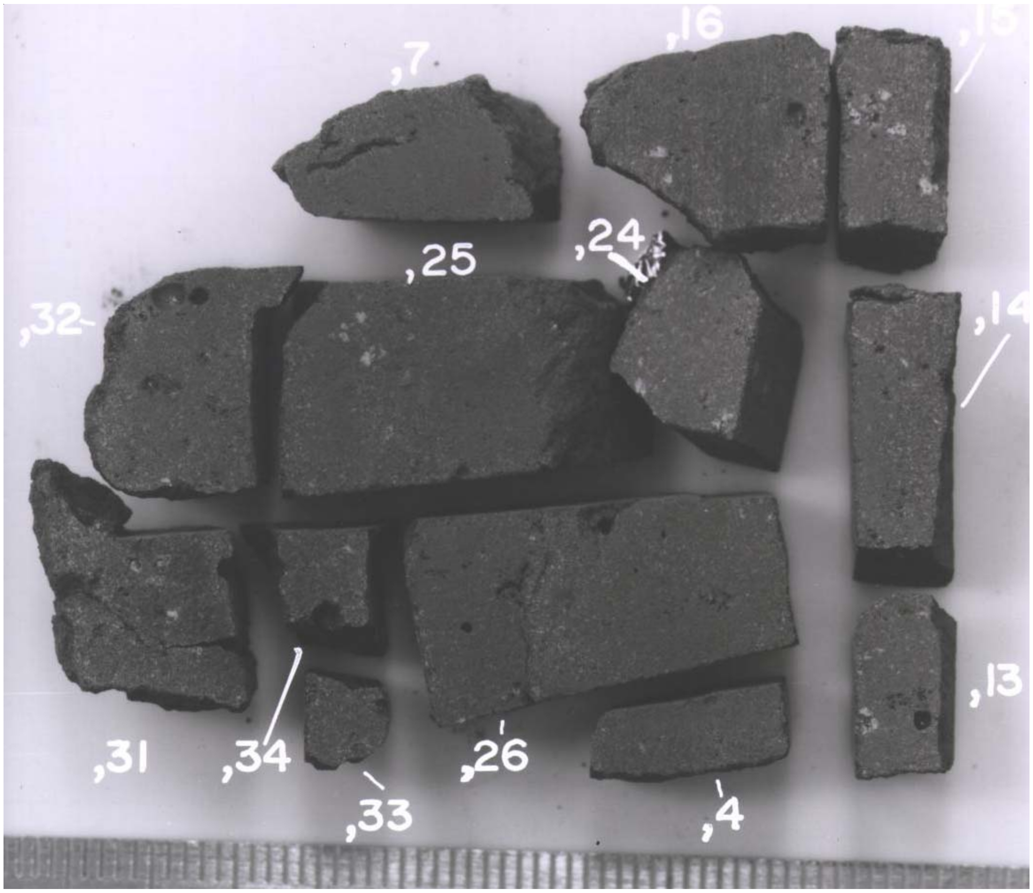


Figure 20: Documentation of first slab (,4?). NASA S73-28788

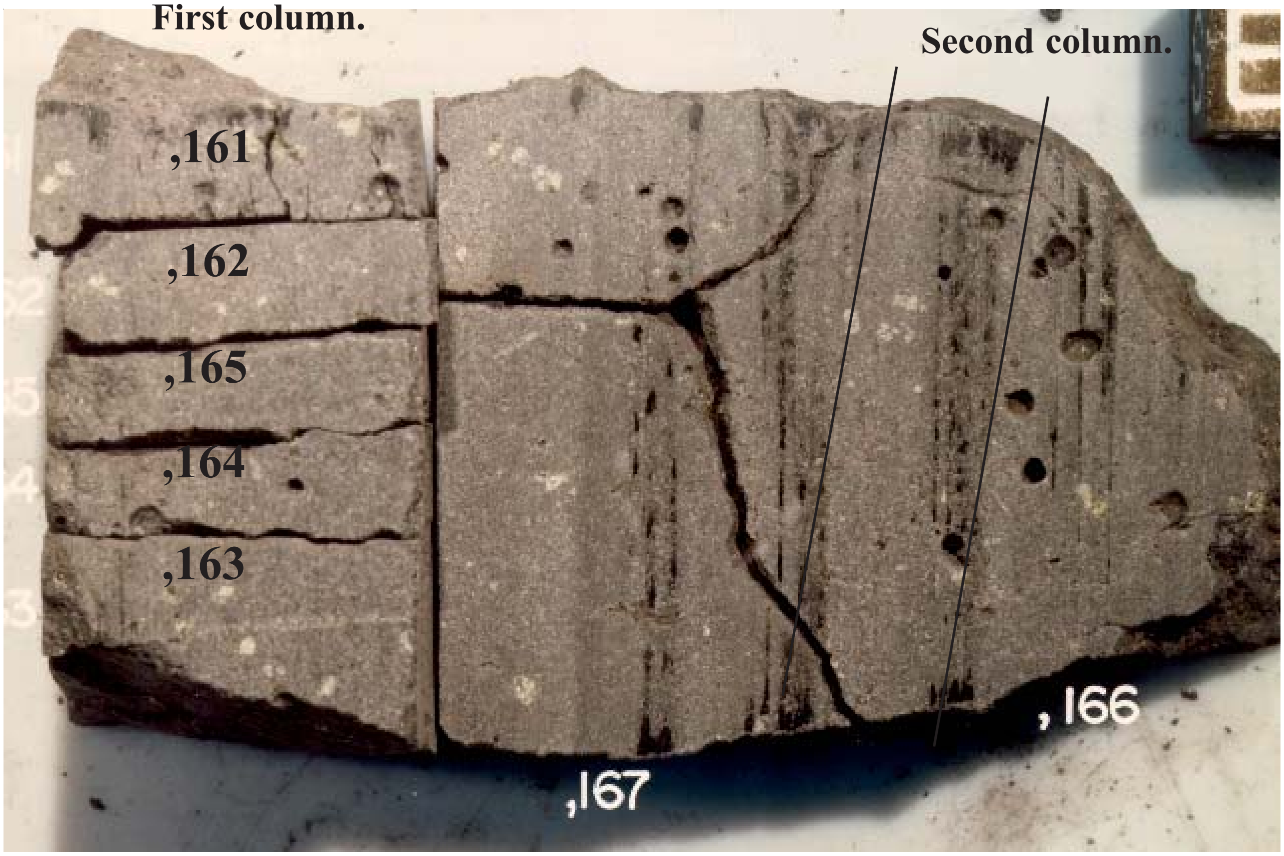
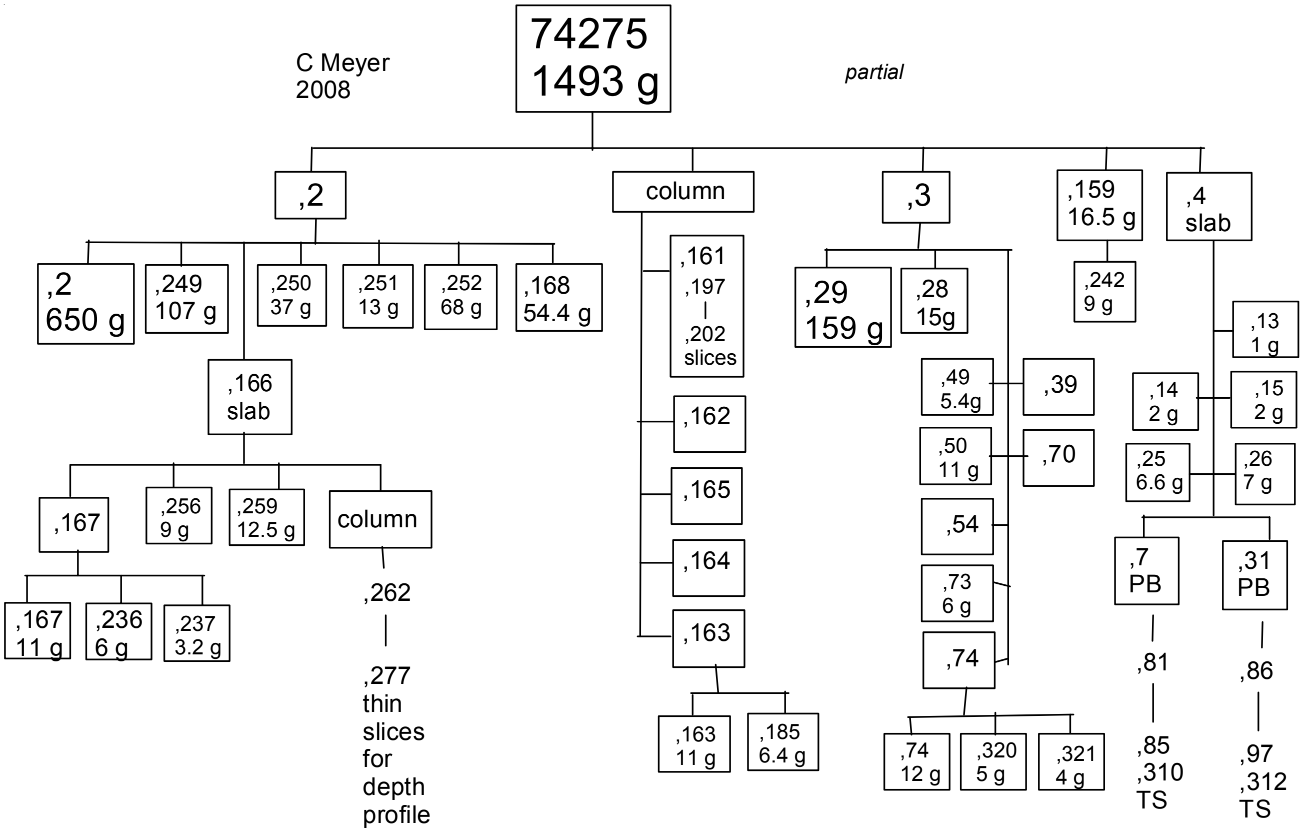


Figure 21: Second slab and first column cut from 74275. Approximate positon of second column shown. NASA# S81-34494. Cube is 1 cm.



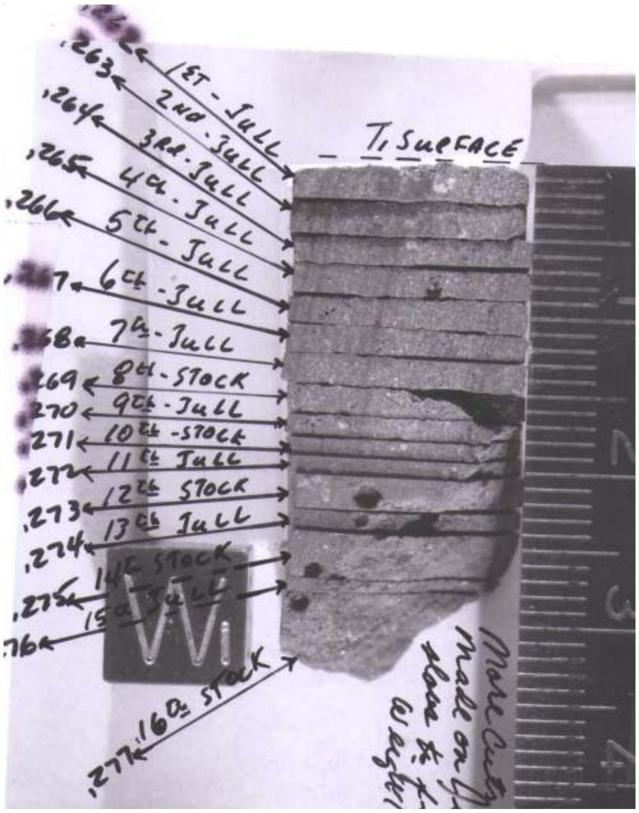


Figure 22: Photo of second column cut from 74275,166. Cube is 1 cm. Processing photo.

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