75055

Ilmenite Basalt

949.4 grams

Figure 1: Photo of top, exterior surface of 75055, showing zap pits. NASA S73-15097. Sample is about 10 cm across.

Introduction

75055 is made up of three pieces chipped from the side of a large boulder on the rim of Camelot Crater (see excerpt of transcript in section on 75035). Following the concept of "overturned flap", this sample may be from the deepest lava flow at Apollo 17, since Camelot Crater was the largest crater sampled (Wolfe et al. 1981). Together, the three pieces form a thin flat sample. The outside, exposed surface had micrometeorite craters (figure 1).

75055 is a medium-grained ilmenite basalt that appears to be quite similar to some of the Apollo 11 basalt samples. 75055, along with 75015 and 75035 from the same location, is slightly more aluminous and less titanium rich, than other Apollo 17 basalt samples (Rhodes et al. 1976).

The crystallization age has been determined to be 3.78 b.y., with a cosmic ray exposure age of about 80 m.y.

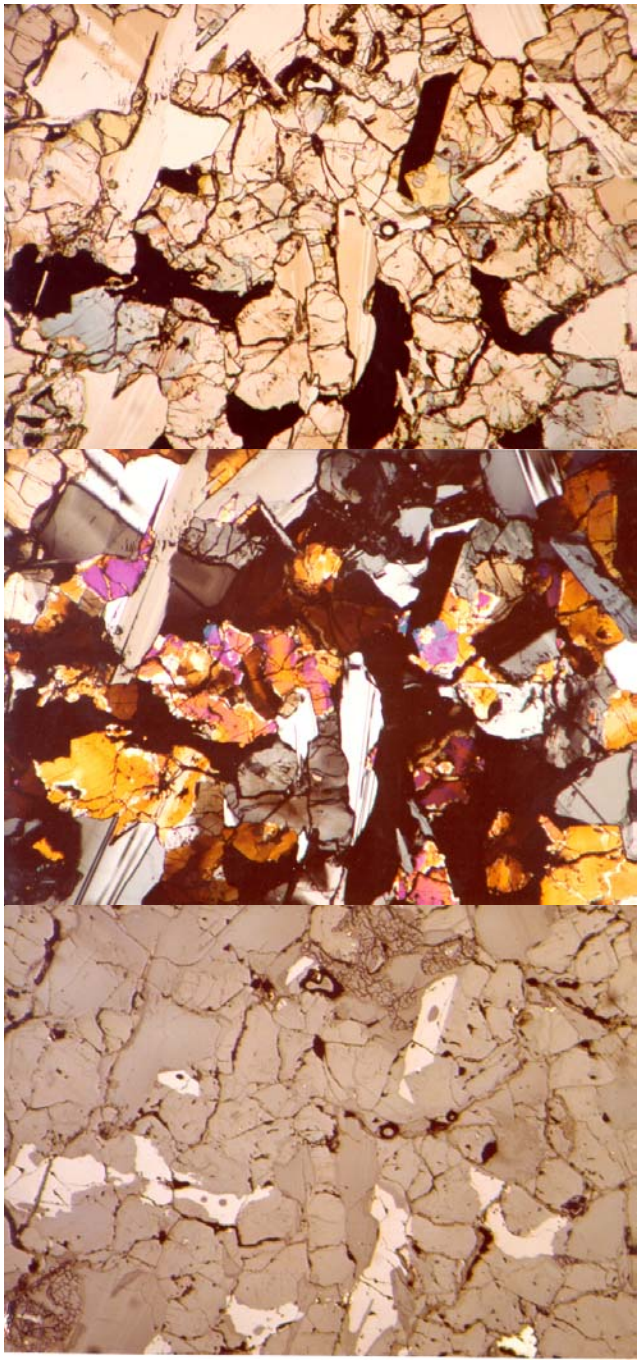


Figure 2: Photomicrographs of thin section 75055,47. Top is transmitted light, middle is with crossed polarizers and bottom is reflected light. NASA S79-27095 to 27097. Field of view is 2.5 mm.

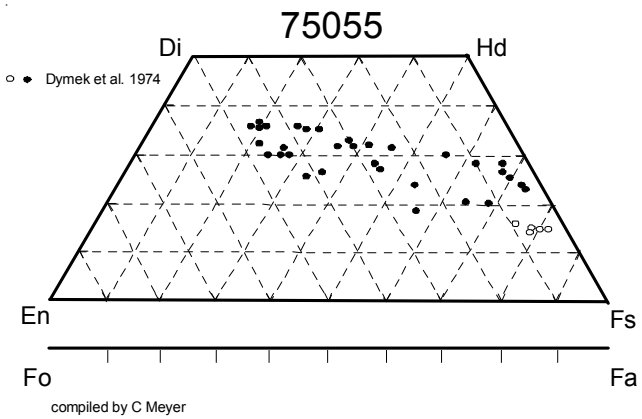


Figure 3: Pyroxene composition for 75055 (replotted from Dymek et al. 1975).

Petrography

Kriedelbaugh and Weill (1973) give the average grain size of 75055 as about 1 mm and describe the texture as ophitic (figures 2 and 4). Dymek et al. (1975) performed a detailed analysis of all minerals in 75055, combining them in the proportions of the mode to successfully calculate the bulk sample composition (Table 1). Dymek et al. described the texture as medium- to fine-grained intergranular to subophitic. McGee et al. (1977) described the texture as coarse grained subophitic with tabular plagioclase (0.05 to 2 mm) intergrown with subhedral to anhedral pyroxene (0.05 to 0.8 mm) and ilmenite laths (0.4 to 1.4 mm). Observations indicate that plagioclase may have been one of the first phases to form, along with ilmenite, during crystallization.

The mesostasis between the major minerals contains silica, troilite, Fe metal, ulvospinel, Ca phosphate and tranquillityite (Dymek et al. 1974).

Mineralogy

Olivine: none

Pyroxene: Pyroxene is chemically zoned from $Wo_{40}En_{44}Fs_{16}$ – $Wo_{16}En_{3}Fs_{81}$ (figure 3). Sector zoning is poorly defined (Dymek et al. 1974).

Mineralogical Mode of 75055

	Brown et al. 1975	McGee et al. 1977	Dymek et al. 1975	Kriedelbaugh and Weill 73
Olivine				
Pyroxene	50.2	45-51	50	51.4
Plagioclase	28.6	29-35	33	29.1
Ilmenite	15.9	12-20	12.1	13.4
Silica	4.5	3-5	3.4	3
Mesostasis	0.8	1-2	1.5	3

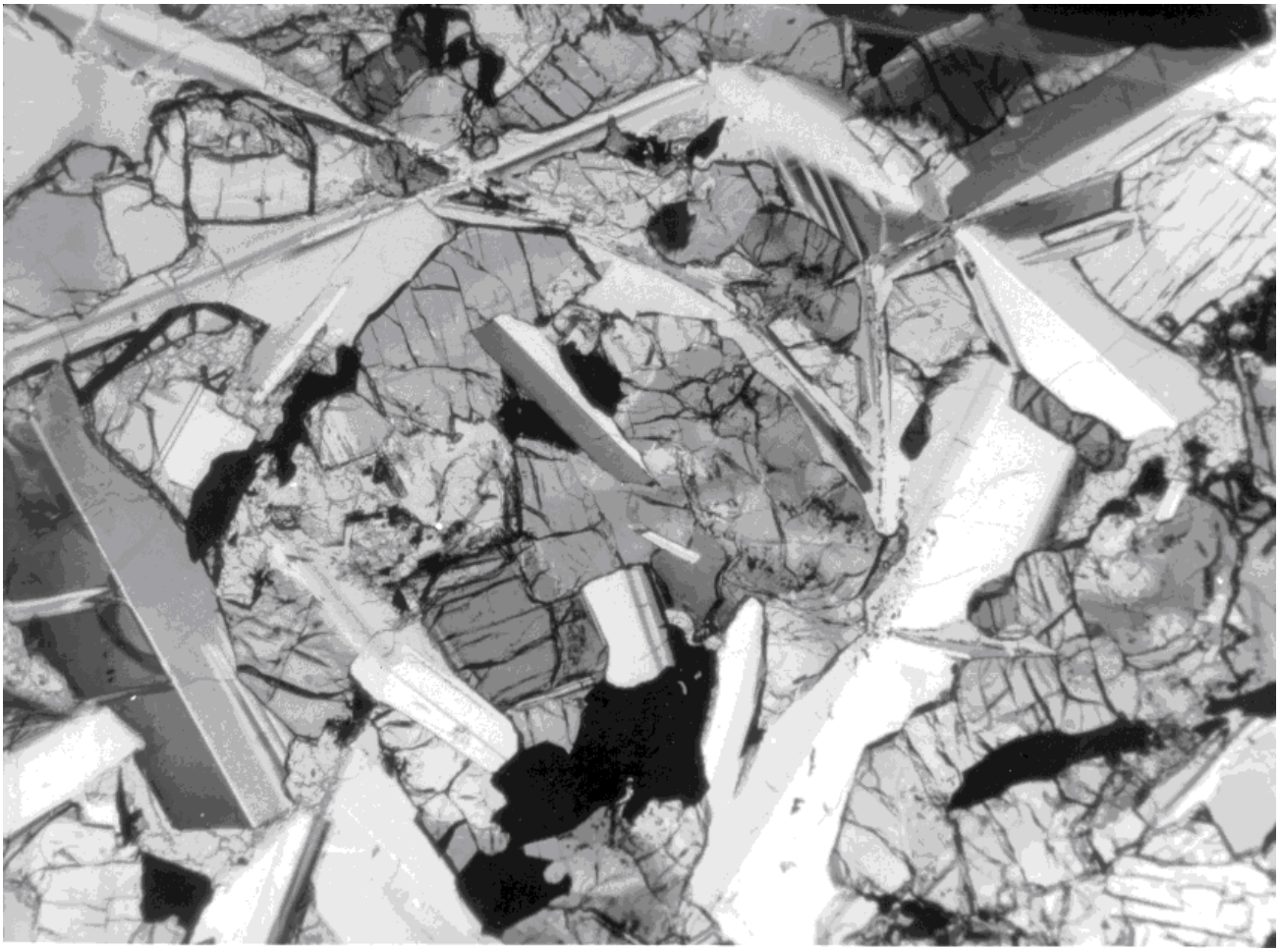


Figure 4: Photomicrograph of thin section of 75055. NASA S74-23074. Field of view is about 1.5 mm.

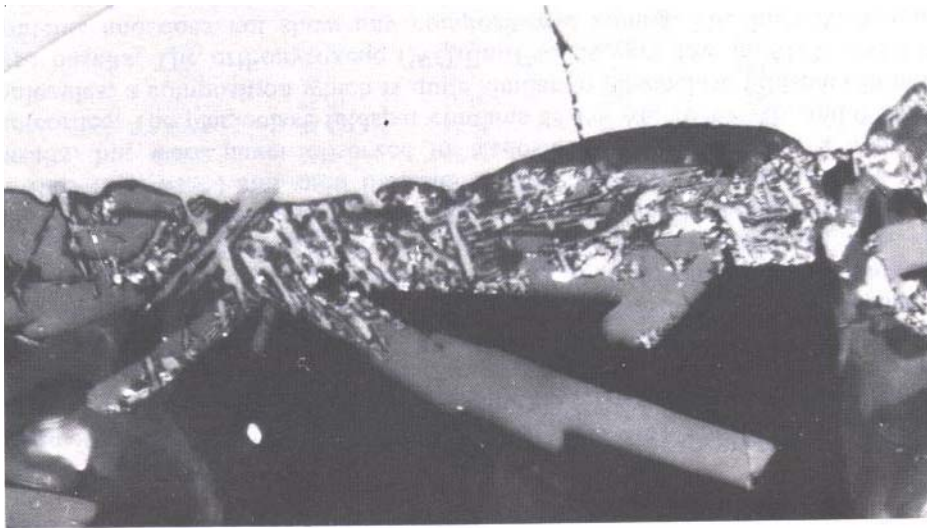


Figure 5: A cluster of tranquillityite crystals (grey), with breakdown to baddeleyite + ilmenite + pyroxene. Width of field 50 microns. From El Goresy et al. (1974).

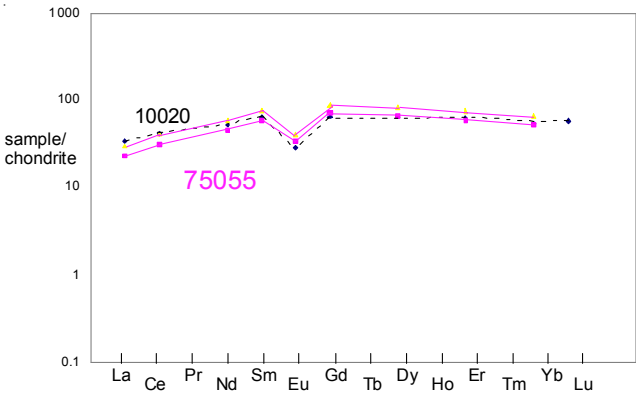


Figure 6: Normalized rare-earth-element diagram for 75055 (isotope dilution data by Shih et al. 1975) compared with Apollo 11 basalt 10020 (Wiesmann et al. 1975).

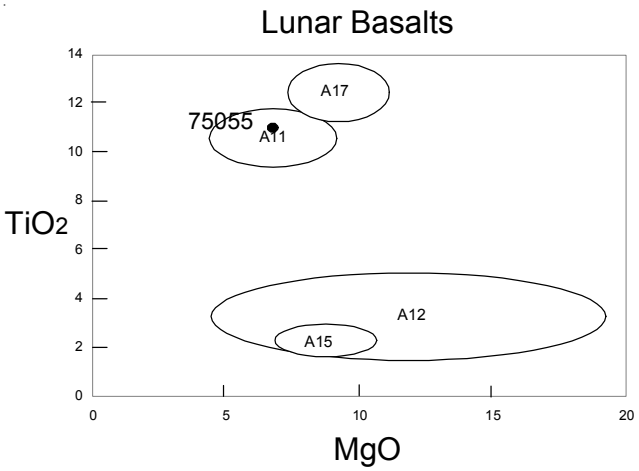


Figure 7: Composition for 75055 compared with other lunar basalts.

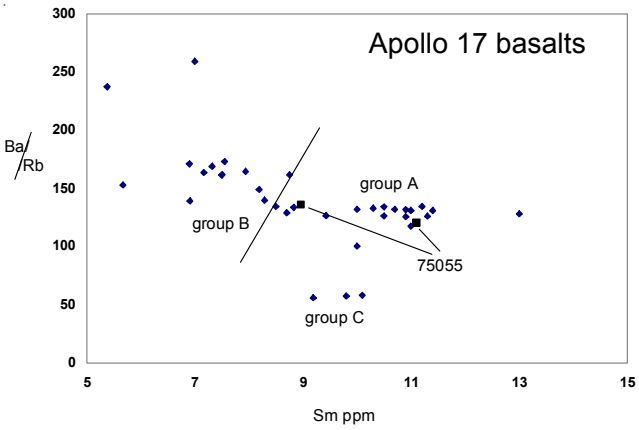


Figure 8: Trace element diagram used to distinguish various lava flows at Apollo 17.

Plagioclase: Plagioclase is zoned (An_{91-72}) with increasing Fe/Mg along with increasing Na.

Ilmenite: Tabular plagioclase has a "swiss-cheese" like texture with glassy inclusions and embayed margins. Dymek et al. observed that one ilmenite was overgrown and resorbed by ulvospinel.

Silica: Both cristobalite and tridymite are present in 75055 (Dymek et al. 1975). Cristobalite has the characteristic fine "mosaic" fracture pattern, while tridymite occurs as needles.

Tranquillityite: Dymek et al. (1975) and El Goresy et al. (1974) reported tranquillityite (figure 5).

Baddeleyite: El Goresy et al. (1974) reported baddeleyite (ZrO_2).

Chemistry

The chemical composition of 75055 is remarkably similar to low K, ilmenite basalts from Apollo 11 (figures 6 and 7). Dymek et al. (1974) noted the remarkable similarity to 10044. The Ba/Rb vs. Sm discriminator indicates it is a type A, Apollo 17 basalt (figure 8).

Gibson et al. (1976) determined 2210 ppm S for 75055 (high). Jovanovic and Reed (1980) reported Cl, Br, U and phosphorous.

Radiogenic age dating

Tatsumoto et al. (1973) and Tera et al. (1974) reported Rb/Sr isochron ages of 3.77 ± 0.06 b.y. and 3.83 ± 0.1 b.y. respectively, while Huneke et al. (1973) determined a more precise age of 3.78 ± 0.02 b.y. by the Argon plateau technique (figure 10). Kirsten et al. (1973) reported an age of 3.82 ± 0.05 b.y. by Ar/Ar (figure 14). Birck et al. (1973) also reported 3.83 b.y. by Rb/Sr (quoted in Kirsten et al.)

Tatsumoto et al. noted that the Pb isotopes in 75055 were very "similar to that of Apollo 11 low-K basalt." Nunes et al. (1974), Tera et al. (1975abs) and Chen and Wasserburg (1980) also reported Pd data (figure 9). Unruh et al. (1983) determined the isotopic composition of Nd and Hf to obtain model ages.

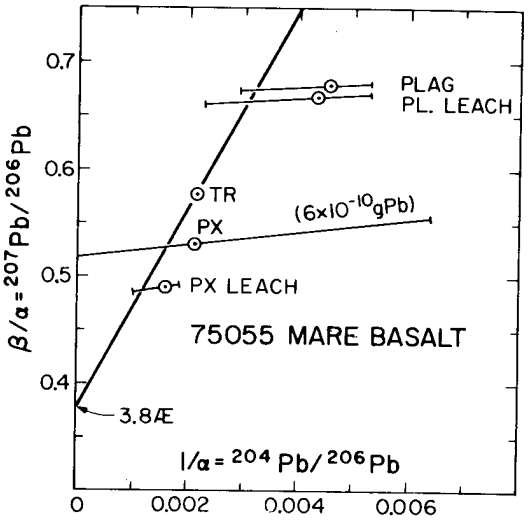


Figure 9: Pb data for mineal separates and leaches of 75055 (from Tera et al. 1975 abs).

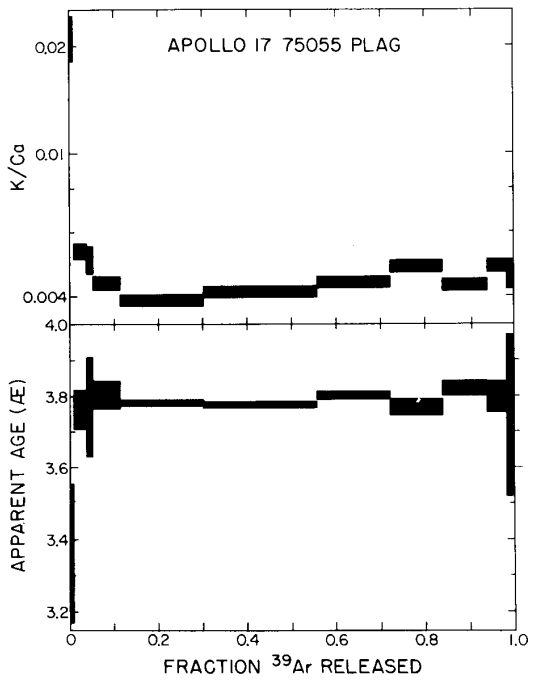


Figure 10: Argon plateau diagram for plagioclase from 75055 (Huneke et al. 1973).

Cosmogenic isotopes and exposure ages

Rancitelli et al. (1974) determined significant cosmic-ray-induced activity for ^{26}Al = 69 dpm/kg., ^{22}Na = 85 dpm/kg., ^{54}Mn = 139 dpm/kg., ^{56}Co = 210 dpm/kg., ^{7}Be = 140 dpm/kg., etc.

Turner et al. (1973) and Huneke et al. (1973) determined ^{38}Ar cosmic ray exposure ages of 90 and 95 m.y. respectively, which would be interpreted as the age of Camelot Crater. Kirsten et al. (1973) reported 85 m.y. (or 70 m.y. taking the geometry of the boulder into account). Arvidson et al. (1976) review the expsoure age of 75055 along with adjacent samples, concluding that the numerous craters and the landside at Apollo 17, including Camelot Crater might be a secondary crater from Tycho!

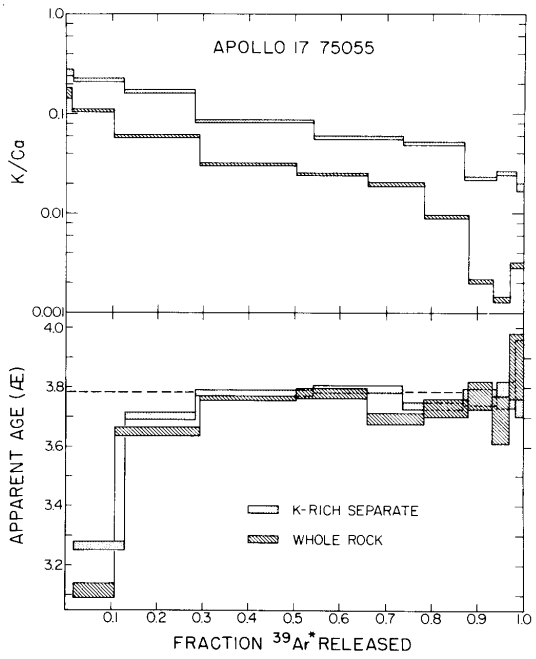


Figure 11: Argon plateau diagram for whole rock and "K-rich separate" 75055 (Huneke et al. 1973).

Summary of Age Data for 75055

	Rb/Sr	Ar/Ar
Tatsumoto et al. 1973	3.83 ± 0.10 b.y.	
Tera et al. 1974	3.77 ± 0.06	
Huneke et al. 1973		3.82 ± 0.05
		3.78 ± 0.02
Turner et al. 1973		3.76 ± 0.05
Kirsten et al. 1973		3.82 ± 0.05

Caution: Decay Constant

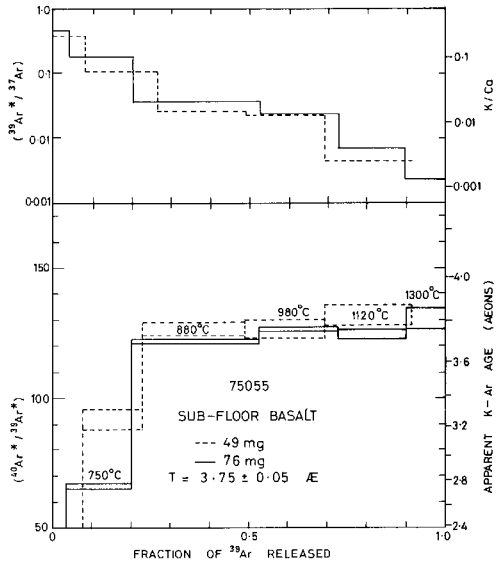


Figure 12: Argon release plateau for 75055 (Turner and Cadogan 1973).

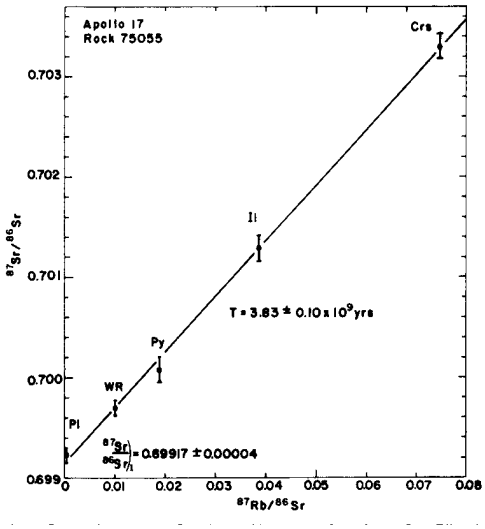


Figure 13: Rb/Sr mineral isochron for 75055 (Tatsumoto et al. 1973).

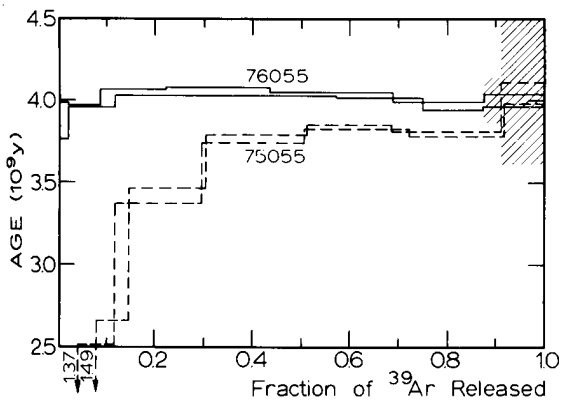


Figure 14: Ar-Ar plateau diagram for 75055 (Kirsten et al. 1973).

Table 2	U ppm	Th ppm	K ppm	Rb ppm	Sr ppm	Nd ppm	Sm ppm	technique
Nunes et al. 1974	0.1359	0.4472						idms
Shih et al. 1975	0.13	0.44		0.685	201	27.1	11.3	idms
				0.482	180	20.7	8.8	idms
Rancitelli et al. 1973	0.1	0.4	650					counting
Wolf et al. 1979	0.128							RNAA
Unruh et al. 1983						25.2	10.6	idms

Table 1a. Chemical composition of 75055.

reference	LSPET73		Garg76			Rancitelli 74		Boynton75			Shih 75			Rhodes76		Dymek74	
weight						405 g		473 mg	505 mg		Nyquist 75						
SiO2 %	41.27	(b)												39.93	(b)	41.51	(e)
TiO2	10.17	(b)						10.4		(a)				11.41	(b)	10.48	(e)
Al2O3	9.75	(b)						10.77		(a)				9.58	(b)	10.28	(e)
FeO	18.24	(b)	20.3		(a)			16.8	15.6	(a)				17.77	(b)	17.86	(e)
MnO	0.29	(b)						0.25		(a)				0.27	(b)	0.25	(e)
MgO	6.84	(b)												7.26	(b)	5.75	(e)
CaO	12.3	(b)						12.6	11.62	(a)				12.4	(b)	12.83	(e)
Na2O	0.44	(b)						0.46	0.42	(a)				0.42	(b)	0.58	(e)
K2O	0.09	(b)				0.078	(c)				0.056	0.075	(d)	0.06	(b)	0.07	(e)
P2O5	0.07	(b)												0.06	(b)	0.05	(e)
S %	0.19	(b)												0.14	(b)	0.03	(e)
sum																	
Sc ppm			83.3		(a)			79	75	(a)	82.7		(d)				
V																	
Cr	1847	(b)	1660		(a)			1950	1840	(a)		1857	(d)	1748	(b)	2670	(e)
Co			16.7		(a)			16	13	(a)	14.5		(d)				
Ni	2	(b)															
Cu																	
Zn	7	(b)															
Ga																	
Ge ppb																	
As																	
Se																	
Rb	0.7	(b)									0.482	0.685	(d)				
Sr	209	(b)									180	201	(d)				
Y	112	(b)															
Zr	272	(b)	362	350	(a)											190	(e)
Nb	25	(b)															
Mo																	
Ru																	
Rh																	
Pd ppb																	
Ag ppb																	
Cd ppb																	
In ppb																	
Sn ppb																	
Sb ppb																	
Te ppb																	
Cs ppm																	
Ba											66	86.4	(d)				
La								6	5.7	(a)	5.39	7.14	(d)				
Ce			49.6		(a)			26	27	(a)	18.5	24.5	(d)				
Pr																	
Nd											20.7	27.1	(d)				
Sm								9.6	9	(a)	8.8	11.3	(d)				
Eu			2.39		(a)			2	1.86	(a)	1.91	2.27	(d)				
Gd											13.9	17.5	(d)				
Tb			3		(a)			2.1	2.5	(a)							
Dy											16.1	20.1	(d)				
Ho																	
Er											9.54	11.9	(d)				
Tm																	
Yb								9.1	9.2	(a)	8.68	10.9	(d)				
Lu			1.9		(a)			1.4	1.24	(a)							
Hf			11.6	11.7	(a)			7.4	7	(a)							
Ta																	
W ppb																	
Re ppb																	
Os ppb																	
Ir ppb																	
Pt ppb																	
Au ppb																	
Th ppm						0.4	(c)					0.44	(d)				
U ppm						0.1	(c)					0.13	(d)				

technique: (a) INAA, (b) XRF , (c) radiation counting, (d) IDMS, (e) elec. probe

Table 1b. Chemical composition of 75055.

reference	Wolf 79		Hughes 85		Nunes74	Tera 74		Unruh84		Chen80
weight	51 mg									
SiO2 %										
TiO2										
Al2O3										
FeO										
MnO										
MgO										
CaO										
Na2O										
K2O						0.0725	(d)			
P2O5										
S %										
sum										
Sc ppm										
V										
Cr										
Co										
Ni	<4	(f)								
Cu										
Zn	1.53	(f)								
Ga										
Ge ppb	2.54	(f)								
As										
Se	119	(f)								
Rb	0.538	(f)				0.796	(d)			
Sr						188	(d)			
Y										
Zr			150	(a)						
Nb			6.9	(a)						
Mo										
Ru										
Rh										
Pd ppb	1.1	(f)								
Ag ppb	0.76	(f)								
Cd ppb	1.92	(f)								
In ppb	0.57	(f)								
Sn ppb	<40	(f)								
Sb ppb	0.99	(f)								
Te ppb	<2	(f)								
Cs ppm	0.019	(f)								
Ba										
La										
Ce										
Pr										
Nd								25.2	(d)	
Sm								10.6	(d)	
Eu										
Gd										
Tb										
Dy										
Ho										
Er										
Tm										
Yb										
Lu								1.66	(d)	
Hf			6.9	(a)				9.61	(d)	
Ta										
W ppb										
Re ppb	0.0031	(f)								
Os ppb	<0.02	(f)								
Ir ppb	0.035	(f)								
Pt ppb										
Au ppb	0.007	(f)								
Th ppm					0.4472		(d)			
U ppm					0.1359		(d)			43 ng

technique: (a) INAA, (d) IDMS, (f) RNAA

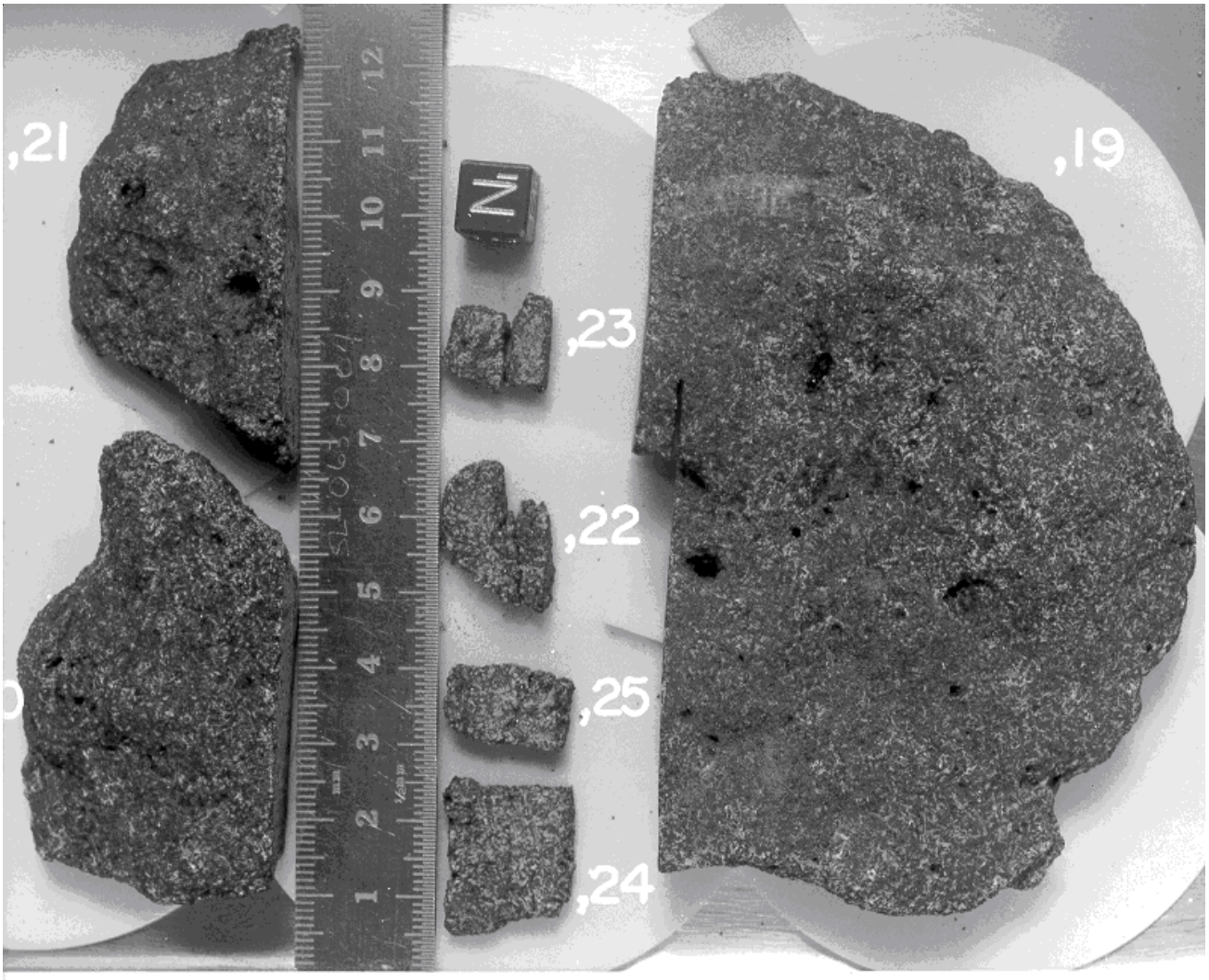
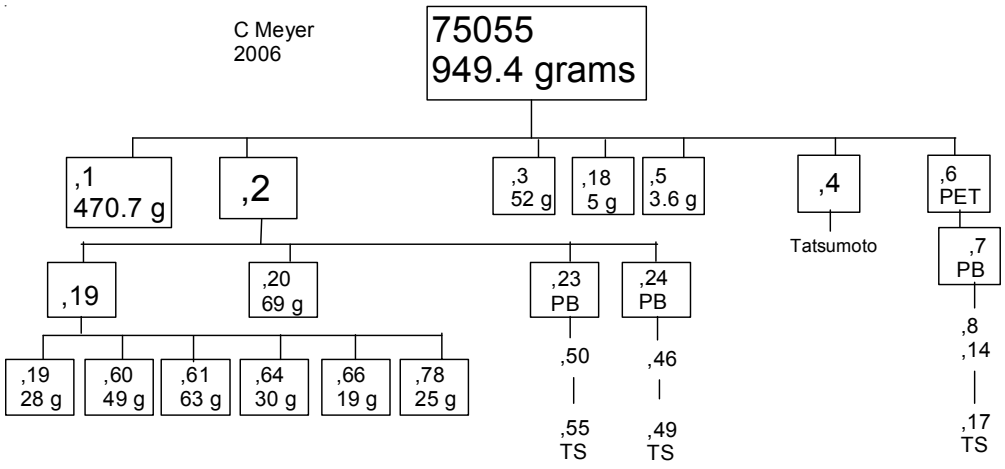


Figure 15: Processing photo of 75055. NASA S74-17400. Cube and scale are cm and cm.



References for 75055

Arvidson R., Drozd R., Guiness E., Hohenberg C., Morgan C., Morrison R. and Oberbeck V. (1976) Cosmic ray exposure ages of Apollo 17 samples and the age of Tycho. Proc. 7th Lunar Sci. Conf. 2817-2832.

Boynton W.V., Baedecker P.A., Chou C.-L., Robinson K.L. and Wasson J.T. (1975a) Mixing and transport of lunar surface materials: Evidence obtained by the determination of lithophile, siderophile, and volatile elements. Proc. 6th Lunar Sci. Conf. 2241-2259.

Brown G.M., Peckett A., Emeleus C.H., Phillips R. and Pinsent R.H. (1975a) Petrology and mineralogy of Apollo 17 mare basalts. Proc. 6th Lunar Sci. Conf. 1-13.

Brown G.M., Peckett A., Phillips R. and Emeleus C.H. (1975b) Mineralogy and petrology of Apollo 17 basalts (abs). Lunar Sci. VI, 95-97. Lunar Planetary Institute, Houston.

Butler P. (1973) **Lunar Sample Information Catalog Apollo 17.** Lunar Receiving Laboratory. MSC 03211 Curator's Catalog. pp. 447.

Chen J.H. and Wasserburg G.J. (1980) The isotopic composition of U in meteorites and lunar samples (abs). Lunar Planet. Sci. XI, 131-133. Lunar Planetary Institute, Houston

Dymek R.F., Albee A.L. and Chodos A.A. (1975a) Comparative mineralogy and petrology of Apollo 17 mare basalts: Samples 70215, 71055, 74255, and 75055. Proc. 6th Lunar Sci. Conf. 49-77.

Gamble R.P. and Taylor L.A. (1979) The effects of kinetics on crystal-liquid partitioning in augite (abs). Lunar Planet. Sci. X, 419-421. Lunar Planetary Institute, Houston

Gamble R.P. and Taylor L.A. (1980) Crystal/liquid partitioning in augite: Effects of cooling rate. Earth Planet. Sci. Lett. 47, 21-33.

Garg A.N. and Ehmann W.N. (1976a) Zr-Hf fractionation in chemically defined lunar rock groups. Proc. 7th Lunar Sci. Conf. 3397-3410.

Gibson E.K., Chang S., Lennon K., Moore G.W. and Pearce G.W. (1975a) Sulfur abundances and distributions in mare basalts and their source magmas. Proc. 6th Lunar Sci. Conf. 1287-1301.

Gibson E.K., Chang S., Lennon K., Moore G.W. and Pearce G.W. (1975b) Carbon, sulfur, hydrogen and metallic iron abundances in Apollo 15 and Apollo 17 basalts (abs). Lunar Sci. VI, 290-292. Lunar Planetary Institute, Houston

Gibson E.K., Usselman T.M. and Morris R.V. (1976a) Sulfur in the Apollo 17 basalts and their source regions. Proc. 7th Lunar Sci. Conf. 1491-1505.

Green D.H., Ringwood A.E., Ware N.G. and Hibberson W.O. (1974) Petrology and petrogenesis of Apollo 17 basalts and Apollo 17 orange glass (abs). Lunar Sci. V, 287-289. Lunar Planetary Institute, Houston

Green D.H., Ringwood A.E., Hibberson W.O. and Ware N.G. (1975a) Experimental petrology of Apollo 17 mare basalts. Proc. 6th Lunar Sci. Conf. 871-893.

Green D.H., Ringwood A.E., Ware N.G. and Hibberson W.O. (1975b) Experimental petrology and petrogenesis of Apollo 17 mare basalts (abs). Lunar Sci. VI, 311-313. Lunar Planetary Institute, Houston

Hess P.C., Rutherford M.J., Guillemette R.N., Ryerson F.J. and Tudffeld H.A. (1975) Residual products of fractional crystallization of lunar magmas: An experimental study. Proc. 6th Lunar Sci. Conf. 895-909.

Hughes S.S. and Schmitt R.A. (1985) Zr-Hf-Ta fractionation during lunar evolution. Proc. 16th Lunar Planet. Sci. Conf. in J. Geophys. Res. D31-D45.

Huneke J.C., Jessberger E.K., Podosek F.A. and Wasserburg G.J. (1973b) 40Ar/39Ar measurements in Apollo 16 and 17 samples and the chronology of metamorphic and volcanic activity in the Taurus Littrow region. Proc. 4th Lunar Sci. Conf. 1725-1756.

Jovanovic S. and Reed G.W. (1980b) $P_2 0_5$, U and Br associated with mineral separates from a low and a high Ti mare basalt. Proc. 11th Lunar Planet. Sci. Conf. 125-134.

Kirsten T., Horn P. and Heymann D. (1973b) Chronology of the Taurus-Littrow region. 1 Ages of two major rock types from the Apollo 17 site. Earth Planet. Sci. Lett. 20, 125-130.

Kirsten T., Horn P., Heymann D., Hubner W. and Storzer D. (1973c) Apollo 17 crystalline rocks and soils: Rare gases, ion tracks, and ages (abs). EOS 54, 595-597. AGU

Kirsten T. and Horn P. (1974a) Chronology of the Taurus-Littrow region III: ages of mare basalts and highland breccias and some remarks about the interpretation of lunar highland rock ages. Proc. 5th Lunar Sci. Conf. 1451-1475.

Kridelbaugh S.J. and Weill D.F. (1973) The mineralogy and petrology of ilmenite basalt 75055 (abs). EOS 54, 597-598. AGU

LSPET (1973) Apollo 17 lunar samples: Chemical and petrographic description. Science 182, 659-672.

LSPET (1973) Preliminary Examination of lunar samples. Apollo 17 Preliminary Science Rpt. NASA SP-330. 7-1 – 7-46.

Mayeda T.K., Shearer J. and Clayton R.N. (1975) Oxygen isotope fractionation of Apollo 17 rocks. Proc. 6th Lunar Sci. Conf. 1799-1802.

McGee P.E., Warner J.L. and Simonds C.H. (1977) Introduction to the Apollo Collections: Part 1 Lunar Igneous Rocks. Curators Office, JSC.

Muehlberger et al. (1973) Documentation and environment of the Apollo 17 samples: A preliminary report. Astrogeology 71 322 pp superceeded by Astrogeolgy 73 (1975) and by Wolfe et al. (1981)

Muehlberger W.R. and many others (1973) Preliminary Geological Investigation of the Apollo 17 Landing Site. *In* **Apollo 17 Preliminary Science Report.** NASA SP-330.

Niederer F.R., Papanastassiou D.A. and Wasserburg G.J. (1980) Titanium abundances in terrestrial, lunar and meteoritic samples (abs). Lunar Planet. Sci. XI, 809-811. Lunar Planetary Institute, Houston.

Neal C.R., Taylor L.A., Patchen A.D., Hughes S.S. and Schmitt R.A. (1990a) The significance of fractional crystallization in the petrogenesis of Apollo 17 Type A and B high-Ti basalts. Geochim. Cosmochim. Acta 54, 1817-1833.

Neal C.R. and Taylor L.A. (1993) Catalog of Apollo 17 rocks. Vol. 3 Central Valley

Neal C.R. and Taylor L.A. (1993) Catalog of Apollo 17 rocks. Vol. 2 Basalts

Nunes P.D., Tatsumoto M. and Unruh D.M. (1974b) U-Th-Pb systematics of some Apollo 17 lunar samples and implications for a lunar basin excavation chronology. Proc. 5th Lunar Sci. Conf. 1487-1514.

Nunes P.D., Tasumoto M. and Unruh D.M. (1974c) U-Th-Pb systematics of some Apollo 17 samples (abs). Lunar Sci. V, 562-564. Lunar Planetary Institute, Houston

Nyquist L.E. (1977) Lunar Rb-Sr chronology. Phys. Chem. Earth 10, 103-142.

Nyquist L.E., Bansal B.M., Wiesmann H. and Jahn B.-M. (1974a) Taurus-Littrow chronology: some constraints on early lunar crustal development. Proc. 5th Lunar Sci. Conf. 1515-1539.

Nyquist L.E., Bansal B.M., Wiesmann H. and Jahn B.-M. (1974b) Taurus-Littrow chronology: Implications for early lunar crustal development (abs). Lunar Sci. V, 565-567. Lunar Planetary Institute, Houston

Nyquist L.E., Bansal B.M. and Wiesmann H. (1975a) Rb-Sr ages and initial 87Sr/86Sr for Apollo 17 basalts and KREEP basalt 15386. Proc. 6th Lunar Sci. Conf. 1445-1465.

Paces J.B., Nakai S., Neal C.R., Taylor L.A., Halliday A.N. and Lee D.-C. (1991) A strontium and neodymium isotopic study of Apollo 17 high-Ti mare basalts: Resolution of ages, evolution of magmas, and origin of source heterogeneities. Geochim. Cosmochim. Acta 55, 2025-2043.

Papike J.J., Hodges F.N., Bence A.E., Cameron M. and Rhodes J.M. (1976) Mare basalts: Crystal chemistry, mineralogy and petrology. Rev. Geophys. Space Phys. 14, 475-540.

Pearce G.W., Strangway D.W. and Gose W.A. (1974a) Magnetic properties of Apollo samples and implications for regolith formation. Proc. 5th Lunar Sci. Conf. 2815-2826.

Rancitelli L.A., Perkins R.W., Felix W.D. and Wogman N.A. (1974a) Solar flare and lunar surface process characterization at the Apollo 17 site. Proc. 5th Lunar Sci. Conf. 2185-2203.

Rhodes J.M., Hubbard N.J., Wiesmann H., Rodgers K.V., Brannon J.C. and Bansal B.M. (1976a) Chemistry, classification, and petrogenesis of Apollo 17 mare basalts. Proc. 7th Lunar Sci. Conf. 1467-1489.

Russell W.A., Papanastassiou D.A., Tombrello T.A. and Epstein S. (1977a) Ca isotope fractionation on the Moon. Proc. 8th Lunar Sci. Conf. 3791-3805.

Shih C.-Y., Haskin L.A., Wiesmann H., Bansal B.M. and Brannon J.C. (1975a) On the origin of high-Ti mare basalts. Proc. 6th Lunar Sci. Conf. 1255-1285.

Shih C.-Y., Wiesmann H. and Haskin L.A. (1975b) On the origin of high-Ti mare basalts (abs). Lunar Sci. VI, 735-737. Lunar Planetary Institute, Houston.

Tatsumoto M., Nunes P.D., Knight R.J., Hedge C.E. and Unruh D.M. (1973) U-Th-Pb, Rb-Sr, and K measurements of two Apollo 17 samples (abs). EOS 54, 614-615.

Taylor H.P. and Epstein S. (1975) O^{18}/O^{16} and Si^{30}/Si^{28} studies of some Apollo 15, 16 and 17 samples. Proc. 4th Lunar Sci. Conf. 1657-1679.

Tera F., Papanastassiou D.A. and Wasserburg G.J. (1974a) Isotopic evidence for a terminal lunar cataclysm. Earth Planet. Sci. Lett. 22, 1-21.

Tera F., Papanastassiou D.A. and Wasserburg G.J. (1974b) The lunar time scale and a summary of isotopic evidence for a terminal lunar cataclysm (abs). Lunar Sci. V, 792-794. Lunar Planetary Institute, Houston.

Turner G., Cadogan P.H. and Yonge C.J. (1973a) Argon selenochronology. Proc. 4th Lunar Sci. Conf. 1889-1914.

Turner G., Cadogan P.H. and Yonge C.J. (1973b) Apollo 17 age determinations. Nature 242, 513-515.

Unruh D.M., Stille P., Patchett P.J. and Tatsumoto M. (1984) Lu-Hf and Sm-Nd evolution in lunar mare basalts. Proc. 14th Lunar Planet. Sci. Conf. in J. Geophys. Res. 88, B459-B477.

Usselman T.M., Lofgren G.E., Donaldson C.H. and Williams R.J. (1975) Experimentally reproduced textures and mineral chemistries of high-titanium mare basalts. Proc. 6th Lunar Sci. Conf. 997-1020.

Wolfe E.W., Bailey N.G., Lucchitta B.K., Muehlberger W.R., Scott D.H., Sutton R.L and Wilshire H.G. (1981) The geologic investigation of the Taurus-Littrow Valley: Apollo 17 Landing Site. US Geol. Survey Prof. Paper, 1080, pp. 280.

Wolf R., Woodrow A. and Anders E. (1979) Lunar basalts and pristine highland rocks: Comparison of siderophile and volatile elements. Proc. 10th Lunar Planet. Sci. Conf. 2107-2130.