70035

Ilmenite Basalt

5765 grams

Figure 1: Photograph of top surface of 70035 illustrating vugs and vesicles. Note the smooth, rounded surface shaped by micrometeorite bombardment. Small cube is 1 cm. NASA photo # S72-56385.

Introduction

Sample 70035 is a vesicular, medium–grained, high-Ti basalt (figure 1). It was collected from a boulder on the rim of a subdued crater about 45 meters east northeast of the LM. This large sample was not "oriented". The bottom surface of this sample is coated with glass (figure 11). One side is flat (from the boulder?). The other surfaces are rounded and have micrometeorite pits.

70035 is 3.7 b.y. old and has been exposed on the lunar surface for ~ 100 m.y. It is typical of the high Ti basalts from the moon and has been used for several public displays (figure 12).

Mineralogical Mode of 70035

	Brown et et al. 1975	Weigand 1973	Roedder and Weiblen 1975
Olivine	0.9 vol. %	2.5	
Pyroxene	47.5	46	56.6
Plagioclase	25.9	26	21.6
Opaques	23.7	22	15.4
Silica	1.6		1.6
Mesostasis	0.4	2	4.4
Vesicles		1.5	

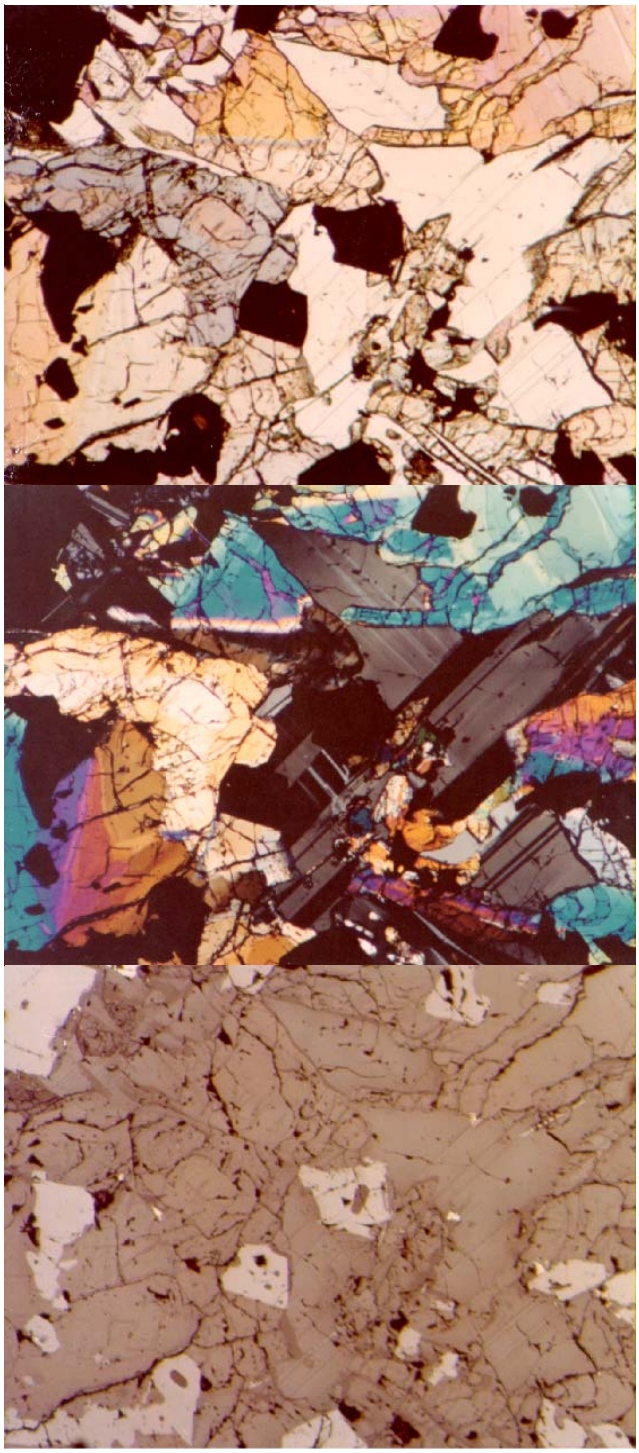


Figure 2: Photomicrographs of thin section 70035,14. Each view of same area, 2.7 mm wide. a) Partially polarized light #S79-26730, b) crossed-polarized light #S79-26631, c) reflected light #S79-26729.

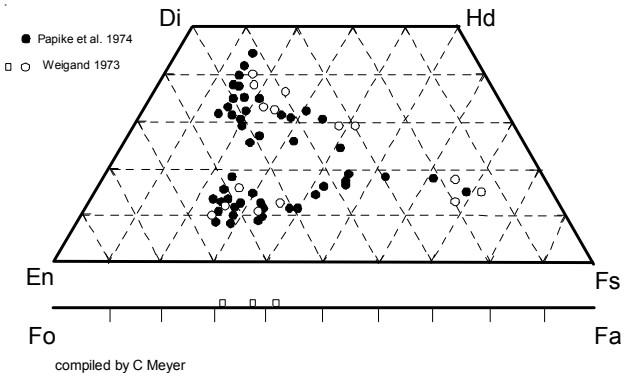


Figure 3: Pyroxene and olivine composition of 70035 (data replotted from Papike et al. 1974, Weigand 1973).

Petrography

Ridley (1973), Weigand (1973), McGee et al. (1977) and Neal and Taylor (1993) have described this large basalt. It is a hypidiomorphic granular basalt with large anhedral clinopyoxene enclosing armalcolite, ilmenite, ulvöspinel and chrome spinel. Interstitial plagioclase encloses ilmenite and olivine (figure 2). The mesostasis includes cristobalite, K-feldspar, tranquillityite, ilmenite, ulvöspinel, troilite and pale brown granitic glass.

El Goresy and Ramdohr (1975) showed that subsolidus reduction of the opaques in 70035 and other Apollo 17 basalts occurred below 830 deg. C. The cooling rate was less than 1 deg. C /hr. (Usselman et al. 1975).

Mineralogy

Pyroxene: Weigand (1973) and Papike et al. (1973) give pyroxene data (figure 3). Augite cores contains up to 3.5 % TiO_2, 4.3 % Al_2O_3 and 1% Cr_2O_3 (Weigand 1973).

Plagioclase: Weigand (1973), Crawford (1973), Delaney and Sutton (1991) and Delaney et al. (1992) discuss plagioclase zonation (An_{88-83}).

Opaques: El Goresy and Ramdohr (1975) studied the subsolidus reduction of ilmenite to rutile, spinel and metallic iron in 70035. They also found that the ulvöspinel reduced to form exsolution of ilmenite and metallic iron.

Glass: Ilmenite in 70035 contains glass inclusions of two types, a) 6-7% K_2O and b) 0.4% K_2O (Roedder and Weiblen 1975).

Metallic iron: El Goresy and Ramdohr (1975) reported a network of metallic iron that penetrates cracks and cleavages through opaque phases as well as silicates. The composition of iron in 70017 has not been reported.

Chemistry

The chemical composition of 70035 is given in table 1. It is typical of Apollo 17 basalts (figures 4 and 5). The trace element content indicates that it is a type A basalt (figure 6).

Radiogenic age dating

Stettler et al. (1973), Evensen et al. (1973a, b) and Nyquist et al. (1974) have dated 70035 (see figures 7-9 and summary table). The ages of basalts from Apollo 17 are similar to those of Apollo 11 (Paces et al. 1991).

Cosmogenic isotopes and exposure ages

Stettler et al. (1973) determined an exposure age of 95-100 m.y. by the ^{38}Ar method. Drozd et al. (1977) determined 122 ± 3 m.y. by ^{81}Kr method.

Other Studies

Pearce et al. (1974) determined the magnetic properties of 70035 and found that Apollo 17 basalts contained more metallic iron than most other basalts (consistent with petrology).

Processing

According to the Apollo 17 Catalog (Butler 1973; page 39), 70035 was opened in the Command Module and studied by Jack Schmitt who picked it up with bare hands (permission granted).

This rock is discussed in great detail in the Apollo 17 catalog by Neal and Taylor (1993). It has been sawn on two occasions (1973 and 1981) (figures 10-11). Nine pieces are used for public display (figure 12).

List of Photos #s for 70035

S72-56381 – 386
S72-56418 – 448 B&W
S75-34392 – 398 color
S79-26729 – 731 TS
S81-27728 – 729 color

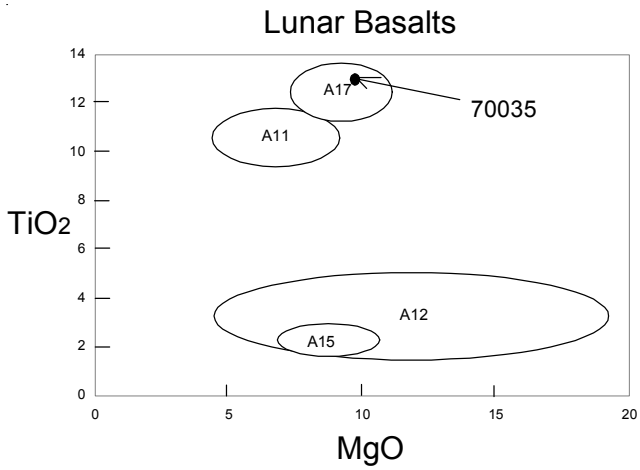


Figure 4: 70035 is a typical high Ti Apollo 17 basalt.

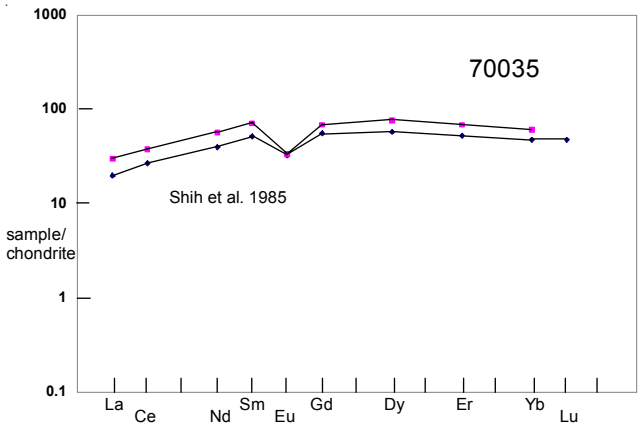


Figure 5: Normalized rare-earth-element diagram for 70035 (data from Shih et al. 1975).

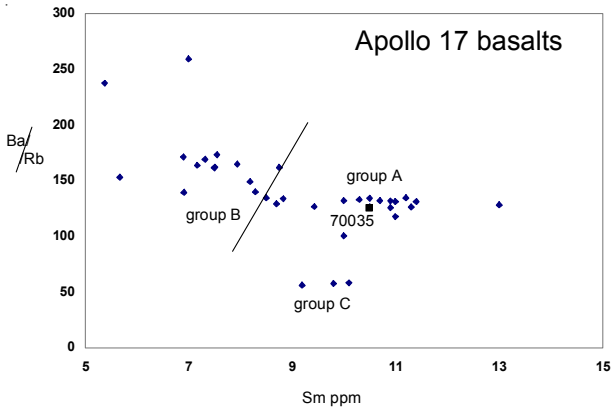


Figure 6: Trace element content of Apollo 17 basalts showing 70035 is type A.

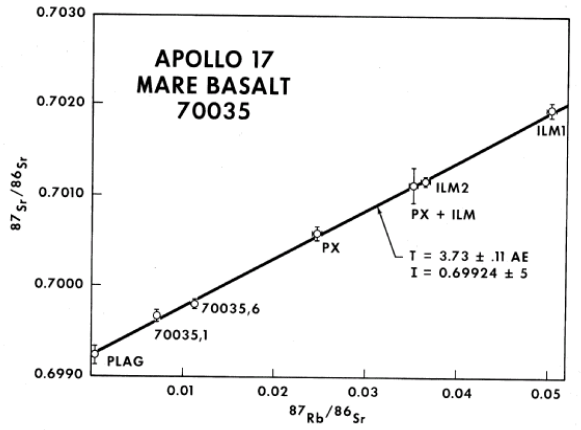


Figure 7: Rb-Sr isochron for 70035 (from Nyquist et al. 1974).

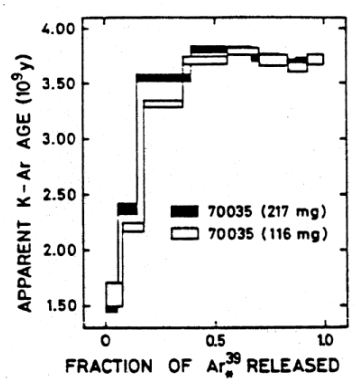


Figure 9: Ar-Ar release diagram for 70035 (from Stettler et al. 1974).

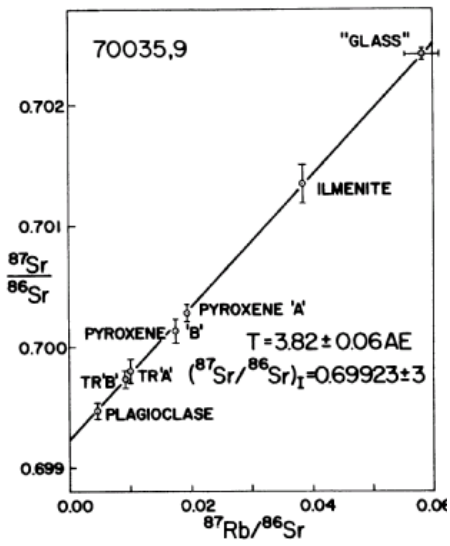


Figure 8: Rb-Sr isochron diagram for 70035 (from Evensen et al. 1973).

Summary of Age Data for 70035

	Rb-Sr	Ar-Ar
Evensen et al. 1973a,b	3.82 ± 0.06	
Stettler et al. 1973		3.75 ± 0.07
Nyquist et al. 1974	3.73 ± 0.11	

Caution: Old decay constants

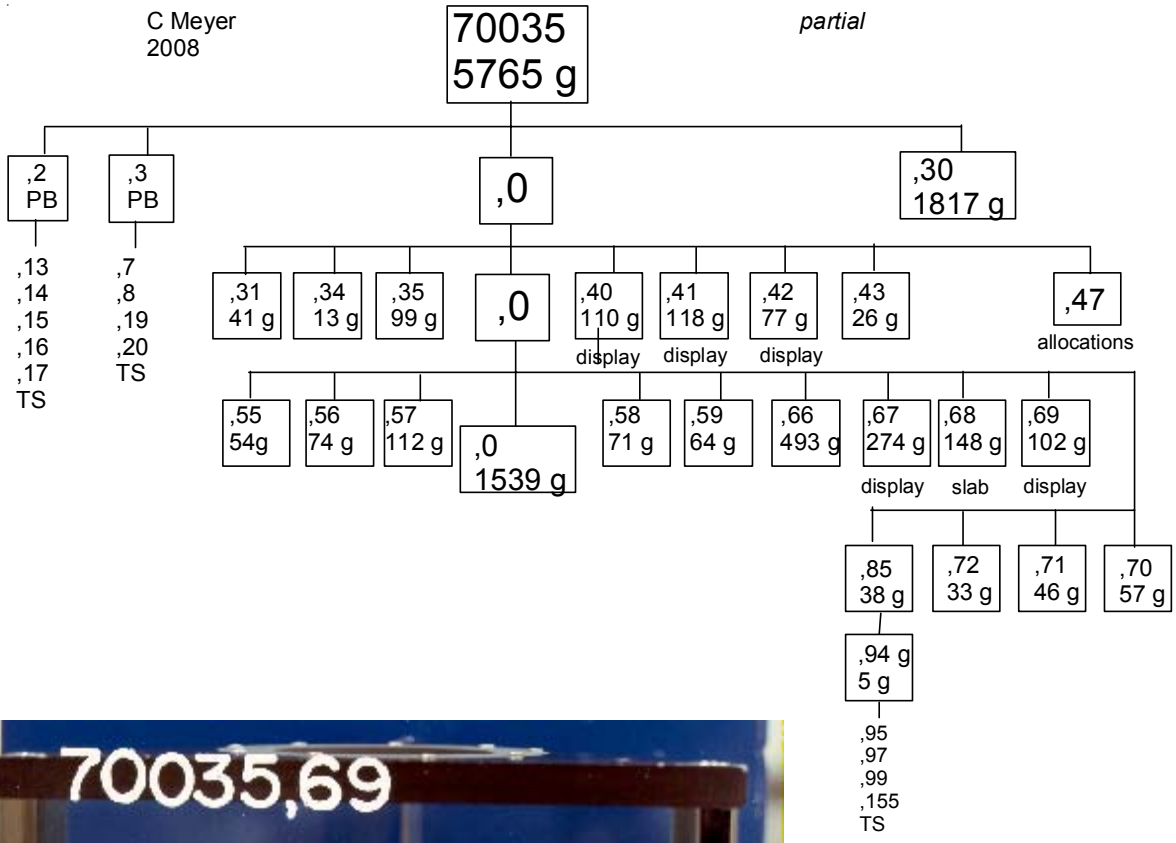
Table 1. Chemical composition of 70035.

reference	LSPET 73		Shih 75			Hughes85		Evenson73		
weight	Rhodes76		Wiesmann75							
SiO2 %	37.8	(a)								
TiO2	13	(a)	13	13	(b)					
Al2O3	8.85	(a)								
FeO	18.5	(a)								
MnO	0.28	(a)								
MgO	9.89	(a)								
CaO	10.1	(a)								
Na2O	0.35	(a)	0.36	0.31						
K2O	0.06	(a)	0.04	0.05	(b)					
P2O5	0.05	(a)				Gibson74				
S %	0.15	(a)				0.158				
sum										
Sc ppm				82.5	(c)					
V										
Cr	4174	(a)	3890	3634	(b)					
Co				20.7	(c)					
Ni	2	(a)								
Cu										
Zn	4	(a)								
Ga										
Ge ppb										
As										
Se										
Rb	0.7	(a)	0.461	0.628	(b)			0.58	0.51	(b)
Sr	176	(a)	174	161	(b)			164	158	(b)
Y	75	(a)								
Zr	205	(a)	217	200	(b)	144	(c)			
Nb	20	(a)								
Mo										
Ru										
Rh										
Pd ppb										
Ag ppb										
Cd ppb										
In ppb										
Sn ppb										
Sb ppb										
Te ppb										
Cs ppm										
Ba			62.1	79.5	(b)			62.1	61.1	(b)
La			4.79	7.04	(b)					
Ce			16.4	23.4	(b)					
Pr										
Nd			18.2	25.9	(b)					
Sm			7.63	10.5	(b)					
Eu			1.82	1.88	(b)					
Gd			11	13.5	(b)					
Tb										
Dy			14.1	18.8	(b)					
Ho										
Er			8.4	11	(b)					
Tm										
Yb			7.79	10	(b)					
Lu			1.17							
Hf						4.9	(c)			
Ta										
W ppb										
Re ppb										
Os ppb										
Ir ppb										
Pt ppb										
Au ppb										
Th ppm										
U ppm			0.091	0.12	(b)					

technique: (a) XRF, (b) IDMS, (c) INAA

Figure 10: First saw cuts of 70035 made in 1972. Cube is 1 cm. NASA S75-34392. Compare with figure 1.

Figure 11: Additional saw cuts of 70035 made in 1981 (see flow diagram). Note glass coating in this side. NASA S81-27729. Cube is 1 inch.



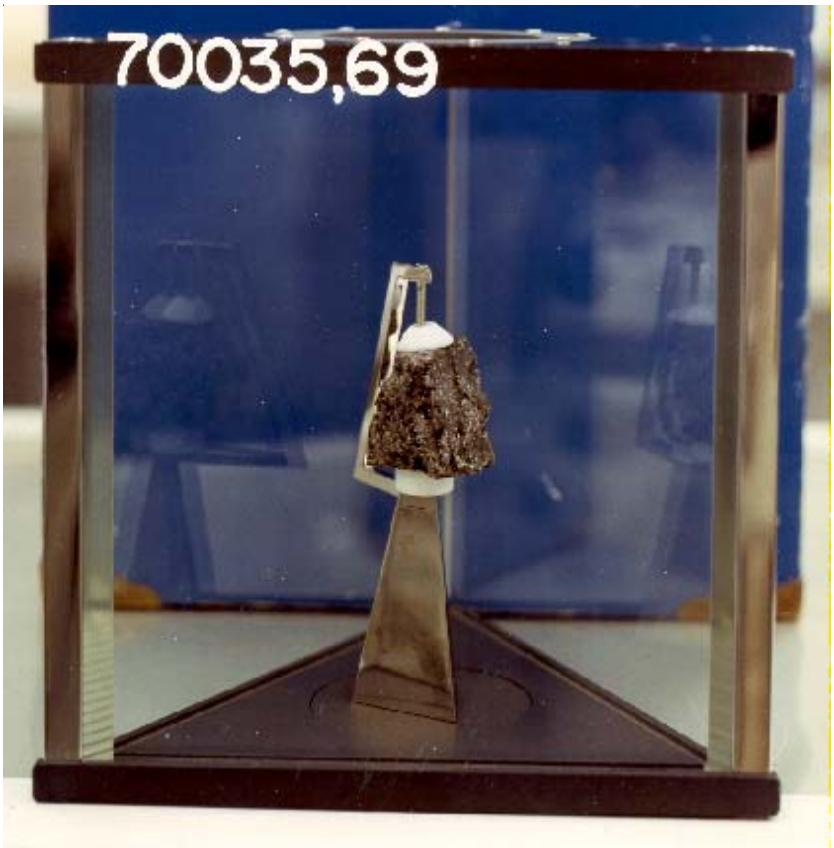


Figure 12: A piece of 70035 in its dry nitrogen display case. NASA S84-34617.

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