12018

Olivine Basalt

787 grams

Figure 1: Original "mug shot" for 12018 PET showing main pieces and smaller pieces. NASA #S69-64111. Note the apparent encrustation.

Introduction

12018 is an olivine basalt with an apparent accumulation of mafic minerals. Figures 1 and 14 show an apparent "encrustation" on the surface of 12018.

Petrography

Walter et al. (1971) report that 12018 is comprised of about 70% larger olivine and pyroxene crystals set in 20% variolitic matrix (figure 2). French et al. (1972) describe the sample "as medium-grained with an average grain size of about 0.4 to 1.0 mm". They found that 12018 was "virtually undeformed and no shock-metamorphic effects were observed."

12018 also contains an association of fayalite-K-rich glass-phosphate that is interpreted as residual melt (El Goresy et al. 1971).

Mineralogy

Olivine: Kushiro et al. (1971) reported Fo_{73}-Fo_{43} for olivine phenocrysts. Walter et al. (1971) found that olivine in 12018 had lower trace element contents (figure 5) than for other rocks.

Pyroxene: Walter et al. (1971), Brown et al. (1971) and Kushiro et al. (1971) determined that the pyroxene composition in 12018 did not trend towards Fe-enrichment (figure 4).

Plagioclase: Plagioclase is An_{90-94} (Walter et al. 1971). The plagioclase in 12018 has the least trace element content (figure 6).

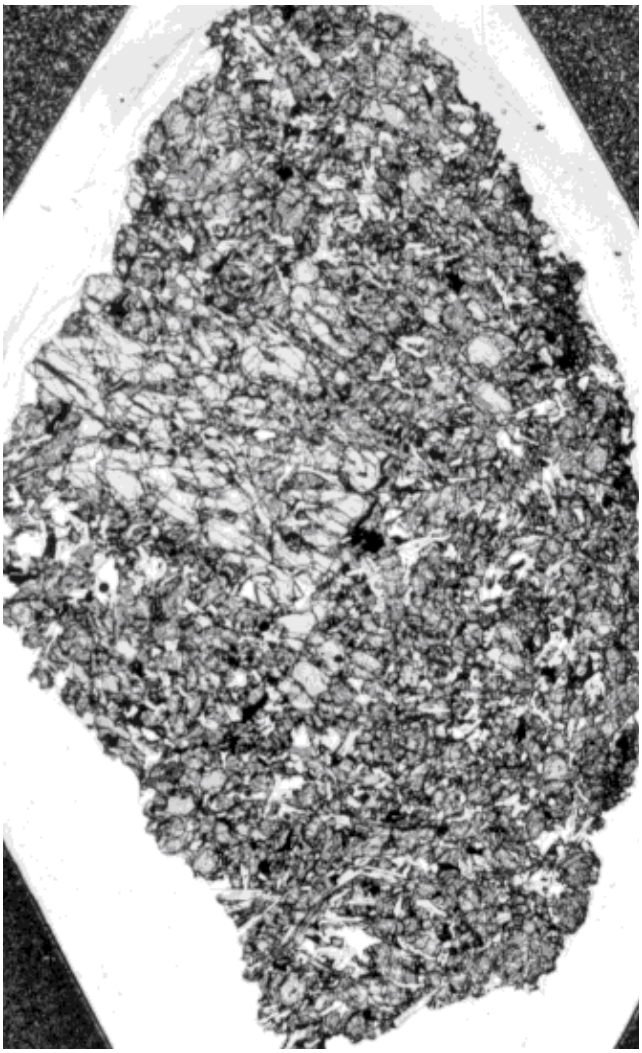


Figure 2: Photo of thin section of 12018 showing large cluster of mafic minerals. NASA # S70-30249. Field of view about 2 cm

Ilmenite: The ilmenite in 12018 is coarse and tabular. The composition is reported by El Goresy et al. (1971)(figure 9).

Tranquillityite: Lovering et al. (1971) give the analysis of tranquillityite found in 12018.

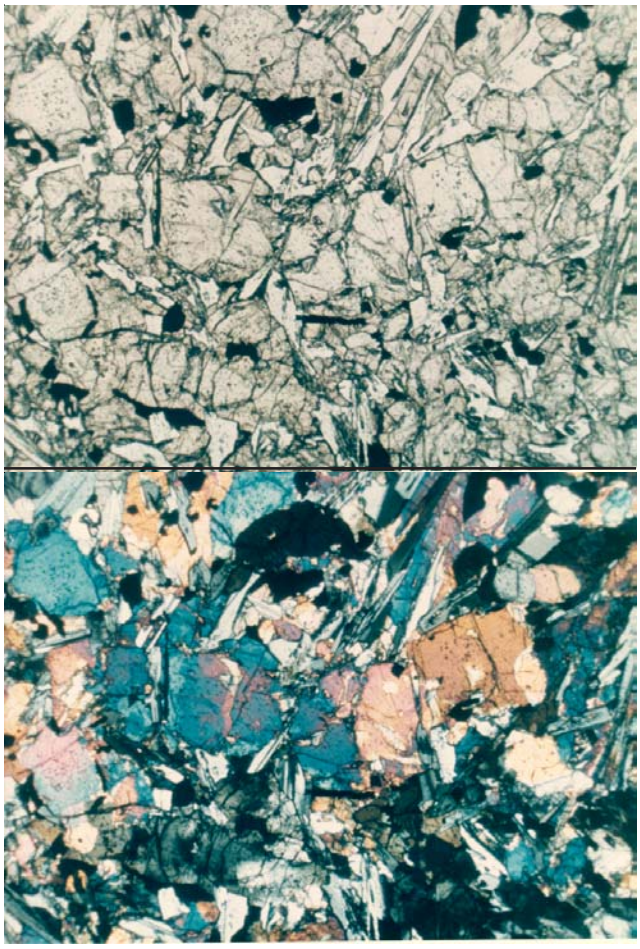


Figure 3: Photomicrographsof 12018,9 showing highly mafic proportions. NASA S70-49554 and 555. Scale is 2.2 mm

Phosphate: Long crystals (50-80 microns) of a phosphate mineral (merrillite?) were reported by El Goresy et al.

Metallic iron: El Goresy et al. (1971) found variation in the Ni content of minute metallic iron grains depending on their location in 12018 (figure 7). Walter et al. (1971) also reported analyses for metallic iron in 12018 (figure 8).

Mineralogical Mode for 12018

	Neal et al. 1994	Papike et al. 1976	Brown et al. 1971	French et al. 1972
Olivine	22.6	11.4	18.7	14
Pyroxene	60.1	62.3	55.7	62
Plagioclase	10.9	19.8	17.7	18
Opaques		6.3	7	6
Ilmenite	0.5			
Chromite +Usp	2			
mesostasis	2.5			
“silica”	0.4	0.2		

Chemistry

12018 has relatively high content of MgO (figure10), possibly due to high mafic mineral content of the piece analyzed (Kushiro and Haramura 1971). However, all thin sections show high mafic mineral content.

Radiogenic age dating

No data.

Cosmogenic isotopes and exposure ages

Stettler et al. (1973) reported ^{38}Ar exposure ages of 170 and 180 m.y. for 12018. Marti and Lugmair (1971) determined a Kr^{81} –K^{83} exposure age of 195 ± 16 m.y. Hintenberger et al. (1971) determined exposure ages for 12018 using ^{3}He (180 m.y.), ^{21}Ne (210 m.y.) and ^{38}Ar (200 m.y.). The suntan age for 12018 (from etched solar flare track studies) is 1.7 m.y. (Bhandari et al. 1971).

Other Studies

Bogard et al. (1971) reported the content and isotopic composition of rare gases in 12018.

Processing

Most allocations were from a column cut from a slab cut through the middle (figure 11). 12018,13 is on public display at the Houston Museum of Natural Science (figure 13).

List of Photo #s of 12018

S69-61967-984	B&W mug
S69-62741-742	
S69-64110-111	color mug
S69-64085-086	color
S70-28681	TS
S70-30249	TS
S70-43526	TS
S70-44547	TS
S70-49133-134	TS
S70-49190-191	TS
S70-49554-555	TS
S70-16780-781	TS
S70-19558-598	processing
S70-19590	column
S72-32079	
S80-42665	

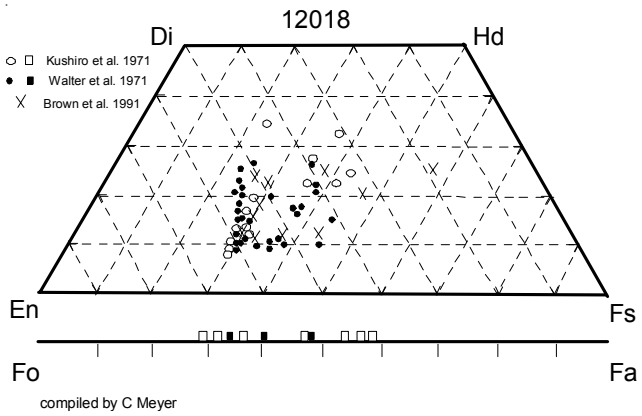


Figure 4: Pyroxene and olivine composition of 12018 (adapted from Walter et al. 1971, Brown et al. 1971 and Kushiro et al. 1971).

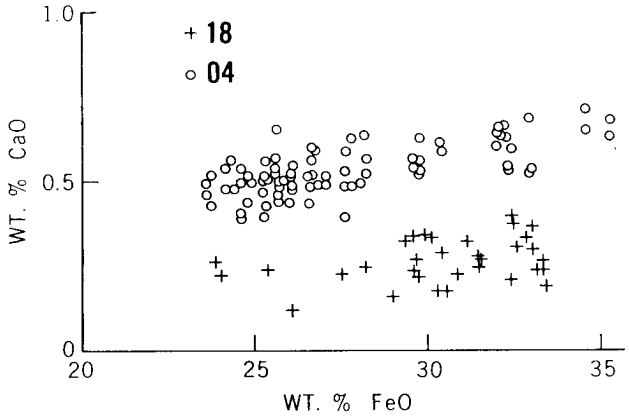


Figure 5: Composition of olivine in 12004 and 12018 (from Walter et al. 1971).

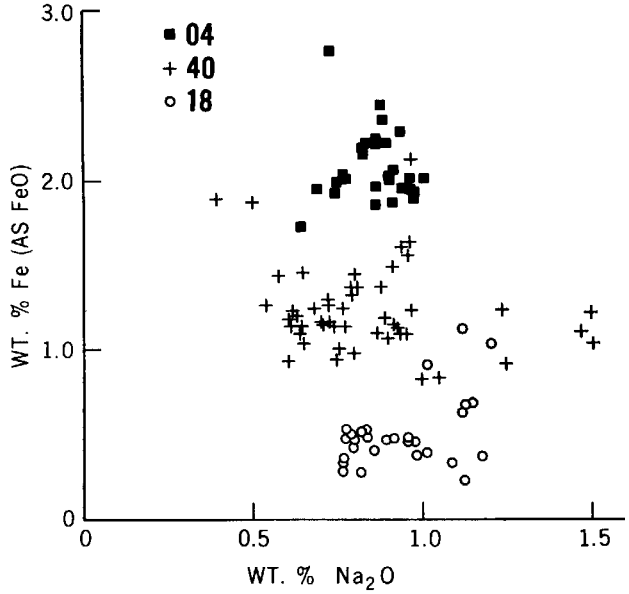


Figure 6: FeO content of plagioclase (~An90-95) for 12004, 12040 and 12018 (from Walter et al. 1971).

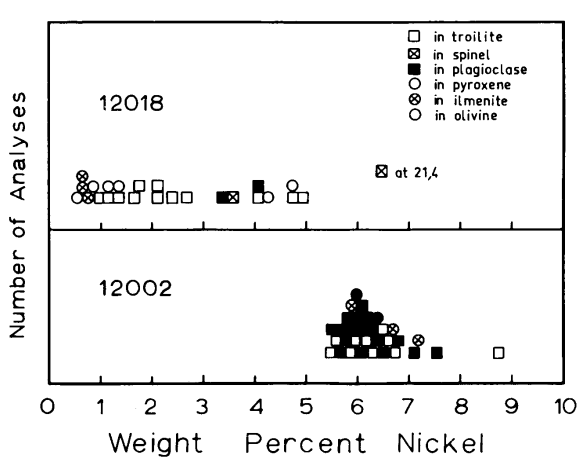


Figure 7: Ni in metallic iron grains found in 12018 and 12002 (El Goresy et al. 1971).

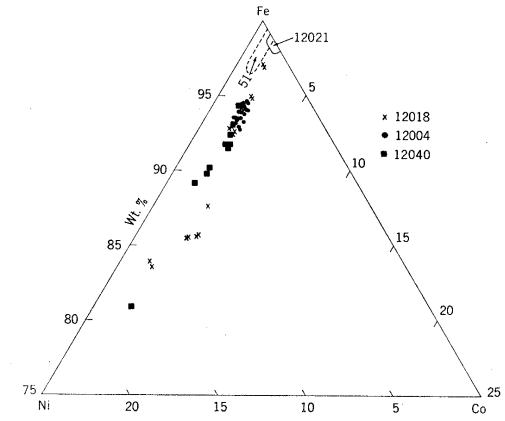


Figure 8: Composition of iron grain in 12004, 12018 and 12040 (from Walter et al. 1971).

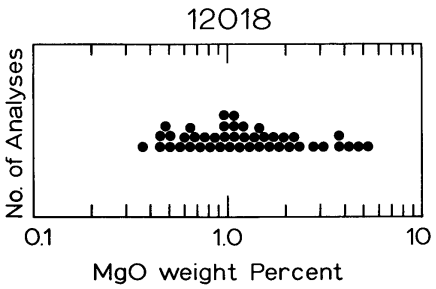


Figure 9: Variation of MgO contnet of ilmenite in 12018 (from El Goresy et al. 1971).

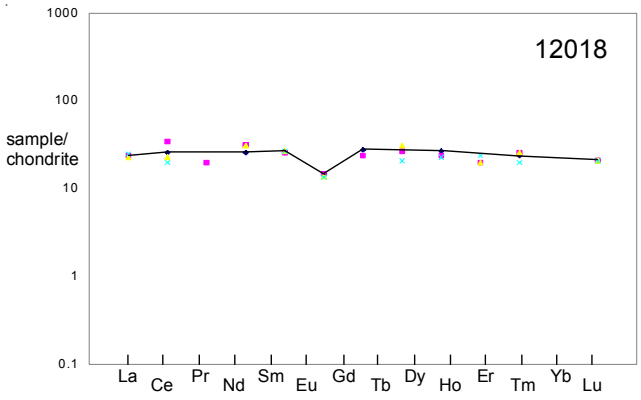


Figure 10: Comparison of rare-earth-element data for 12018 obtained by neutron activation analysis (Wanke et al. 1971, Goles et al. 1971 and Brunfelt et al. 1971) with isotope dilution data (line by Schnetzler and Phillpotts 1971).

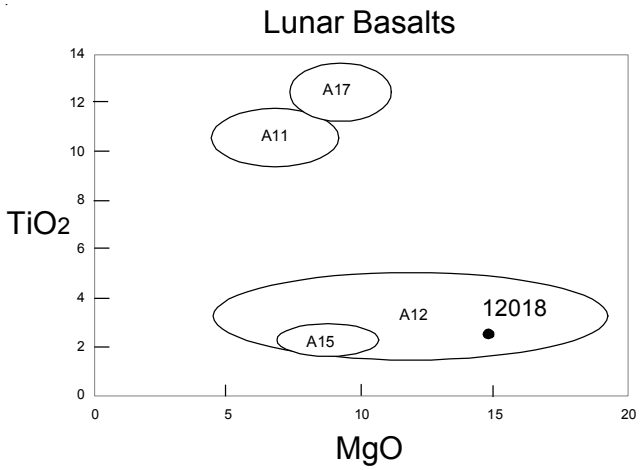
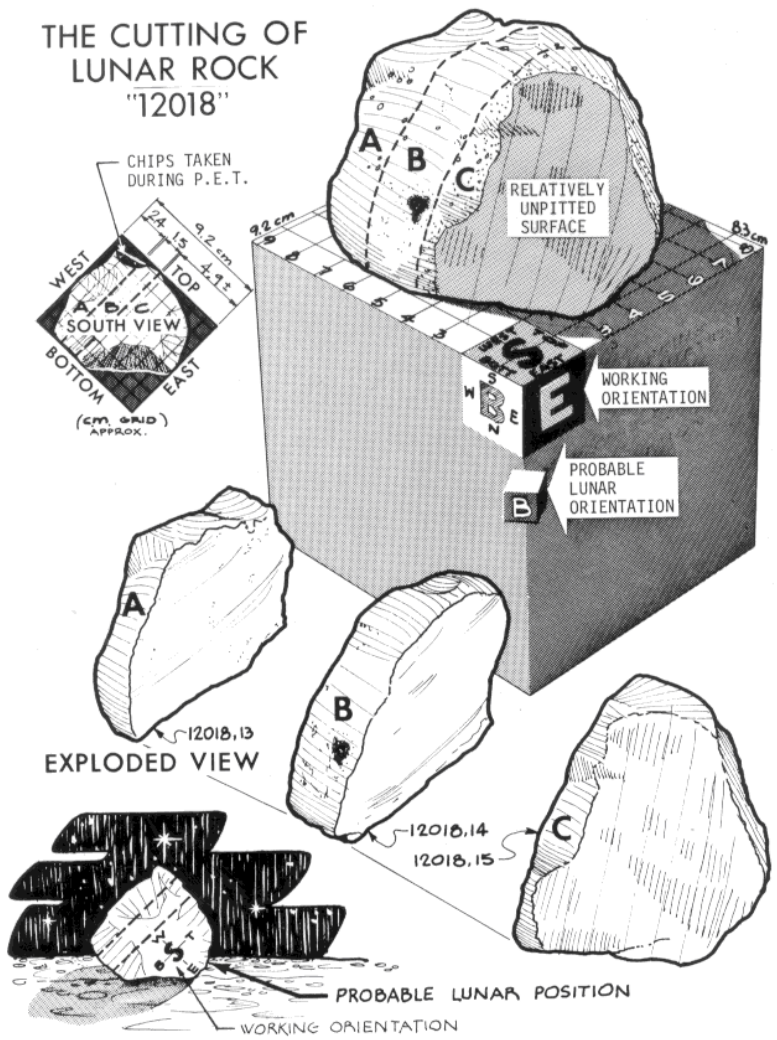


Figure 11: Compsoition of 12018 compared with other lunar basalts.

Table 1. Chemical composition of 12018.

reference	Kushiro71		Goles71		Wanke71		Cuttitta71		Schnetzler71		Compston71		Brunfelt71		
weight									175 mg						
SiO2 %	43.89	(a)	43.64	(b)	45.14	(b)	43.6	(c)			44.21	(e)			
TiO2	2.56	(a)	2.42	(b)	2.65	(b)	2.6	(c)			2.62	(e)	2.64	2.73	(f)
Al2O3	8.2	(a)	6.91	(b)	7.97	(b)	8.28	(c)			7.42	(e)	8.67	8.26	(f)
FeO	20.56	(a)	20.61	(b)	21.23	(b)	20.6	(c)			21.73	(e)	20.7	20.84	(f)
MnO	0.25	(a)	0.245	(b)	0.256	(b)	0.28	(c)			0.28	(e)	0.27	0.26	(f)
MgO	15.54	(a)			14.41	(b)	15.1	(c)			15.05	(e)			
CaO	8.21	(a)	7.27	(b)	6.2	(b)	8.54	(c)			8.25	(e)			
Na2O	0.2	(a)	0.2	(b)	0.19	(b)	0.26	(c)			0.2	(e)	0.2	0.2	(f)
K2O	0.05	(a)			0.049	(b)	0.04	(c)	0.052	(d)	0.059	(e)	0.049	0.048	(f)
P2O5	0.02	(a)					0.07	(c)			0.07	(e)			
S %											0.05	(e)			
sum															
Sc ppm			38.9	(b)	41.7	(b)	42	(c)					39.4	40.2	(f)
V			190	(b)			158	(c)			140	(e)	191	200	(f)
Cr	4516	(a)	3690	(b)	3730	(b)	4600	(c)			3540	(e)	3720	3940	(f)
Co					51.6	(b)	70	(c)			54	(e)	54.2	55	(f)
Ni					100	(b)	84	(c)			55	(e)			
Cu					5.5	(b)	8.1	(c)			8	(e)	5	4.4	(f)
Zn													2.6	1.9	(f)
Ga					3.2	(b)	5	(c)			1.5	(e)	2.6	2.8	(f)
Ge ppb					100	(b)									
As					0.01	(b)							0.05		(f)
Se													0.181	0.177	(f)
Rb					1.5	(b)	1.2	(c)	1.04	(d)	0.94	(e)	1.42		(f)
Sr					96	(b)	58	(c)	89.3	(d)	86.1	(e)	79	77	(f)
Y							37	(c)			30	(e)			
Zr			60	(b)			99	(c)							
Nb															
Mo															
Ru															
Rh															
Pd ppb					3	(b)									
Ag ppb													10	10	(f)
Cd ppb															
In ppb					1.9	(b)							3	3.3	(f)
Sn ppb															
Sb ppb													210	50	(f)
Te ppb															
Cs ppm					0.09	(b)							0.047	0.035	(f)
Ba			70	(b)	84	(b)	67	(c)	60.3	(d)			65	61	(f)
La			5.3	(b)	5.68	(b)							5.8		(f)
Ce			14	(b)	21	(b)			15.9	(d)			12	18	(f)
Pr					1.75	(b)									
Nd			14	(b)	14.7	(b)			11.8	(d)					
Sm			3.89	(b)	3.8	(b)			3.91	(d)			3.9	3.9	(f)
Eu			0.797	(b)	0.84	(b)			0.834	(d)			0.76	0.76	(f)
Gd					4.7	(b)			5.55	(d)					
Tb			1.13	(b)	1	(b)							0.76	0.74	(f)
Dy					5.8	(b)			6.54	(d)			5.6	5.3	(f)
Ho					1.11	(b)							1.33		(f)
Er					4.2	(b)			3.8	(d)			3.2		(f)
Tm															
Yb			3.5	(b)	3.45	(b)	5.4	(c)	3.42	(d)			3.5	3.7	(f)
Lu					0.4	(b)			0.52	(d)			0.61	0.56	(f)
Hf			2.48	(b)	3.4	(b)							3	2.8	(f)
Ta			0.48	(b)	0.36	(b)							0.36	0.37	(f)
W ppb					150	(b)							115	92	(f)
Re ppb															
Os ppb															
Ir ppb					*0.5*	(b)							0.1		(f)
Pt ppb															
Au ppb					*3.6*	(b)							1.9	1.7	(f)
Th ppm			1.12	(b)	0.85	(b)							0.48	0.44	(f)
U ppm					0.252	(b)							0.22	0.17	(f)

technique (a) conventional wet, (b) INAA, (c) mixed chem, XRF, spark, (d) IDMS, (e) XRF, (f) various NAA



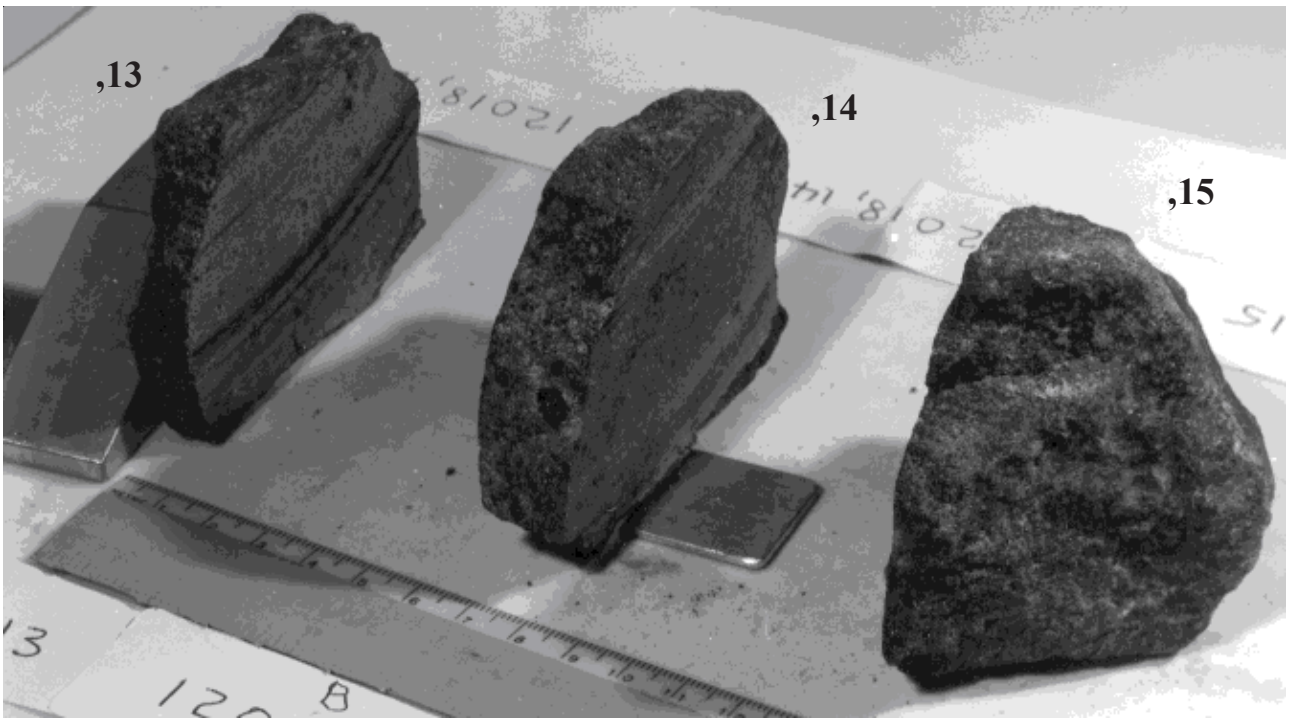


Figure 12: Slab and end pieces cut from 12018. NASA # S70-19564.

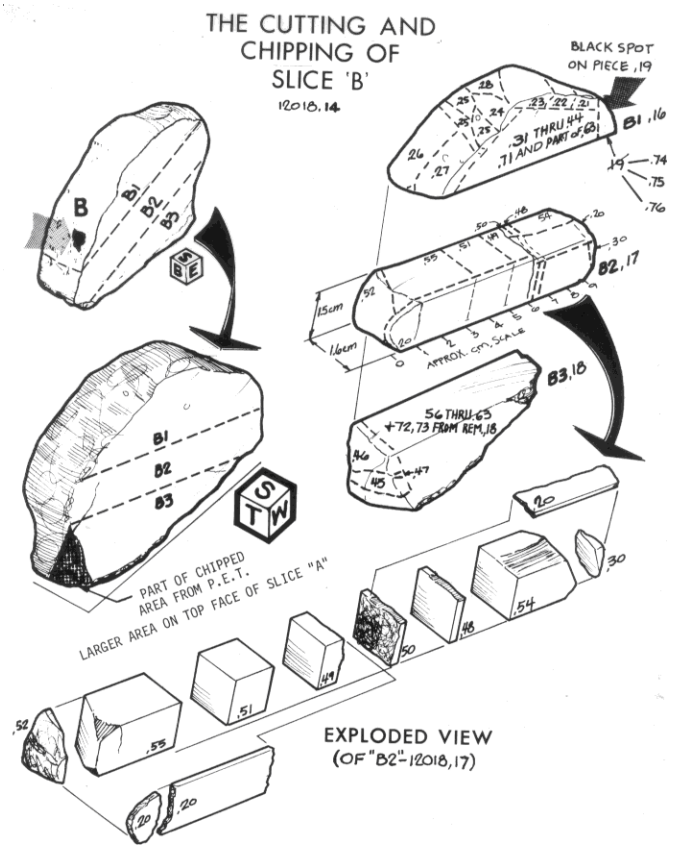
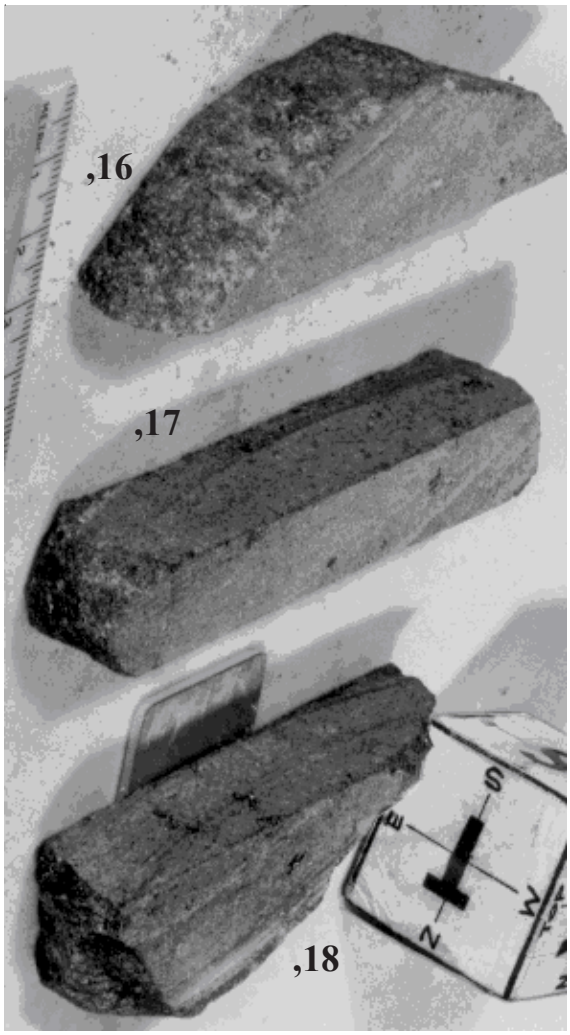


Figure 13: Exploded parts diagram for slab and column 12018,17. NASA # S70-19598.



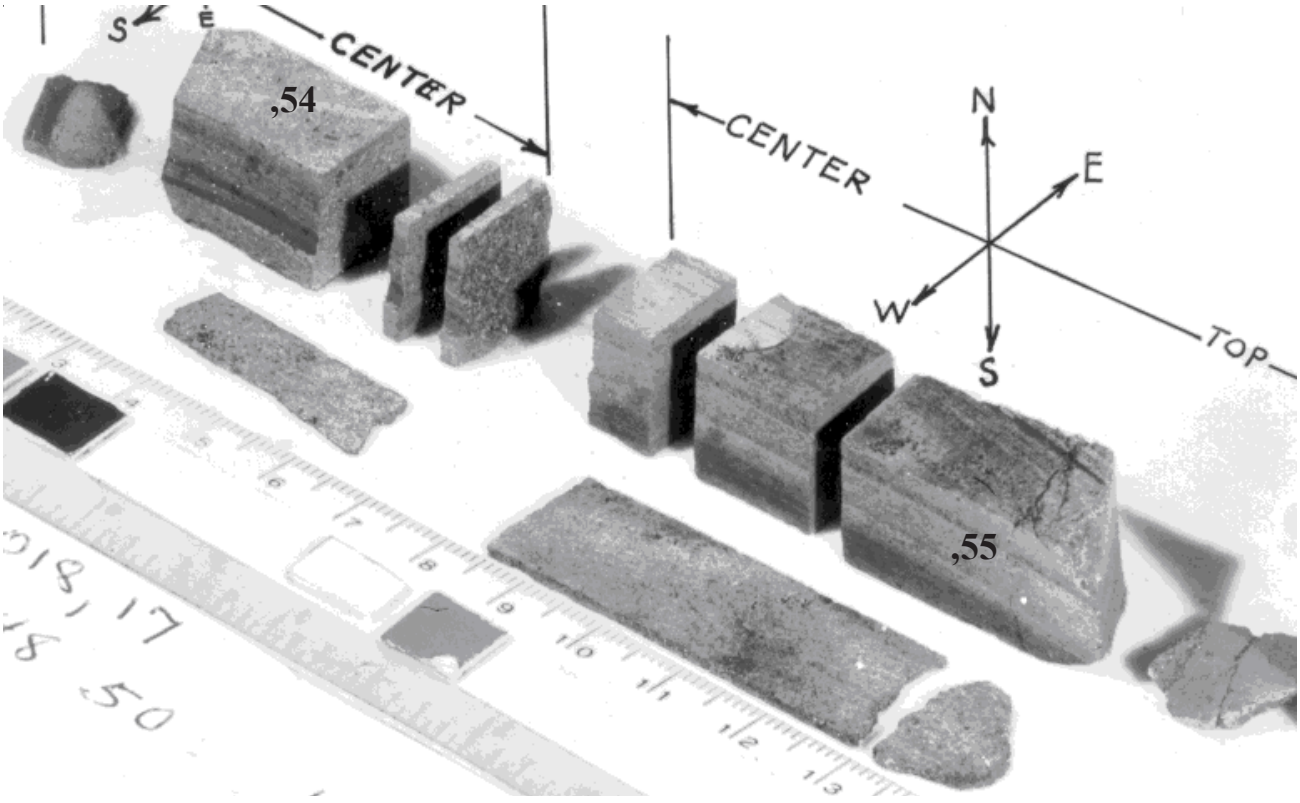
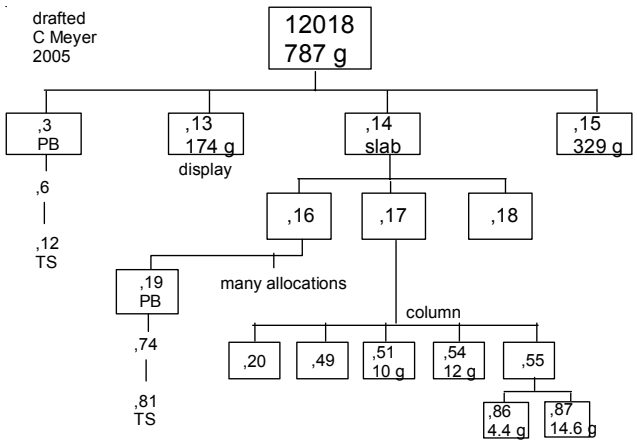


Figure 14: Display sample 12018,13. NASA S80-42665. Note the apparent encrustation.



References for 12018

Bhandari N., Bhat S., Lal D., Rajagopalan G., Tamhane A.S. and Venkatavaradan V.S. (1971) High resolution time averaged (millions of years) energy spectrum and chemical composition of iron-group cosmic-ray nuclei at 1 A.U. based on fossil tracks in Apollo samples. *Proc. 2nd Lunar Sci. Conf.* 2611-2619.

Bogard D.D., Funkhouser J.G., Schaeffer O.A. and Zahringer J. (1971) Noble gas abundances in lunar material-cosmic ray spallation products and radiation ages from the Sea of Tranquillity and the Ocean of Storms. *J. Geophys. Res.* **76**, 2757-2779.

Brown G.M., Emeleus C.H., Holland J.G., Peckett A. and Phillips R. (1971) Picrite basalts, ferrobasalts, feldspathic norites, and rhyolites in a strongly fractionated lunar crust. *Proc. 2nd Lunar Sci. Conf.* 583-600.

Brunfelt A.O., Heier K.S. and Steiennes E. (1971a) Determination of 40 elements in Apollo 12 materials be neutron activation analysis. *Proc. 2nd Lunar Sci. Conf.* 1281-1290.

Compston W., Berry H., Vernon M.J., Chappell B.W. and Kay M.J. (1971) Rubidium-strontium chronology and chemistry of lunar material from the Ocean of Storms. *Proc. 2nd Lunar Sci. Conf.* 1471-1485.

Cuttitta F., Rose H.J., Annell C.S., Carron M.K., Christian R.P., Dwornik E.J., Greenland L.P., Helz A.P. and Ligon D.T. (1971) Elemental composition of some Apollo 12 lunar rocks and soils. *Proc. 2nd Lunar Sci. Conf.* 1217-1229.

El Goresy A., Ramdohr P. and Taylor L.A. (1971a) The opaque minerals in the lunar rocks from Oceanus Procellarum. *Proc. 2nd Lunar Sci. Conf.* 219-235.

French B.M., Walter L.S., Heinrich K.F.J., Loman P.D., Doan A.S. and Adler I. (1972) Composition of major and minor minerals in five Apollo 12 crystalline rocks. NASA SP-306

Goles G.G., Duncan A.R., Lindstrom D.J.,Martin M.R., Beyer R.L., Osawa M., Randle K., Meek L.T., Steinborn T.L. and McKay S.M. (1971) Analyses of Apollo 12 specimens: Compositional variations, differentiation processes, and lunar soil mixing models. *Proc. 2nd Lunar Sci. Conf.* 1063-1081.

Hintenberger H., Weber H.W. and Takaoka N. (1971) Concentrations and isotopic abundances of the rare gases in lunar matter. *Proc. 2nd Lunar Sci. Conf.* 1607-1625.

Kushiro I. and Haramura H. (1971) Major element variation and possible source materials of Apollo 12 crystalline rocks. *Science* **171**, 1235-1237.

Kushiro I., Nakamura Y., Kitayama K. and Akimoto S-I. (1971) Petrology of some Apollo 12 crystalline rocks. *Proc. 2nd Lunar Sci. Conf.* 481-495.

Lovering J.F. and 14 authors (1971) Tranquillityite: A new silicate mineral from Apollo 11 and Apollo 12 basaltic rocks. *Proc. Second Lunar Science Conf.* 39-45.

LSPET (1970) Preliminary examination of lunar samples from Apollo 12. *Science* **167**, 1325-1339.

Marti K. and Lugmair G.W. (1971) Kr^{81}-Kr and Kr-Ar^{40} ages, cosmic-ray spallation products and neutron effects in lunar samples from Oceanus Procellarum. *Proc. 2nd Lunar Sci. Conf.* 1591-1605.

Schnetzler C.C. and Philpotts J.A. (1971) Alkali, alkaline earth, and rare earth element concentrations in some Apollo 12 soils, rocks, and separated phases. *Proc. 2nd Lunar Sci. Conf.* 1101-1122.

Stettler A., Eberhardt Peter, Geiss J., Grogler N. and Maurer P. (1973) Ar^{39}-Ar^{40} ages and Ar^{37}-Ar^{38} exposure ages of lunar rocks. *Proc. 4th Lunar Sci. Conf.* 1865-1888.

Walter L.S., French B.M., Heinrich K.F.J., Lowman P.D., Doan A.S. and Adler I. (1971) Mineralogical studies of Apollo 12 samples. *Proc. Second Lunar Sci. Conf.* 343-358.

Wänke H., Wlotzka F., M. and Rieder R. (1971) Apollo 12 samples: Chemical composition and its relation to sample locations and exposure ages, the two component origin of the various soil samples and studies on lunar metallic particles. *Proc. 2nd Lunar Sci. Conf.* 1187-1208