12053

Pigeonite Basalt

879 grams

Figure 1: Photo of 12053,0 - about 9 cm across. NASA #S69-60624.

Introduction

12053 is a porphyritc pigeonite basalt very like 12052 and 12055. It has been dated at 3.17 b.y. and has a cosmic ray exposure age of 130 m.y.

Petrography

According to a brief description by Dence et al. (1971), 12053 is a "porphyritic variolitic basalt with zoned pyroxene and minor olivine phenocrysts. It differs from 12021 mainly in having smaller phenocrysts of pyroxene and olivine as a second phenocryst mineral. Chromites enclosed in olivine are commonly euhedral and have thin discontinuous rim of ulvöspinel; chromite in clinopyroxene have more extensive and commonly complete ulvöspinel rims". Baldridge et al. (1979) describe 12053 as "porphyritic with fine-grained

Figure 2: Transmitted light photomicrograph of thin section 12053,75 showing long, hollow pyroxene phenocrysts in variolitic groundmass. Section is about 3 cm long. NASA #S70-36473.

variolitic groundmass (plagioclase laths 65 microns wide)". Gay et al. (1971) shows remarkable, skeletal olivine.

Mineralogy

Pyroxene: Pyroxenes in 12052, 12053 and 12055 are remarkable. They have hollow cores and are shaped like straws (figure 3).

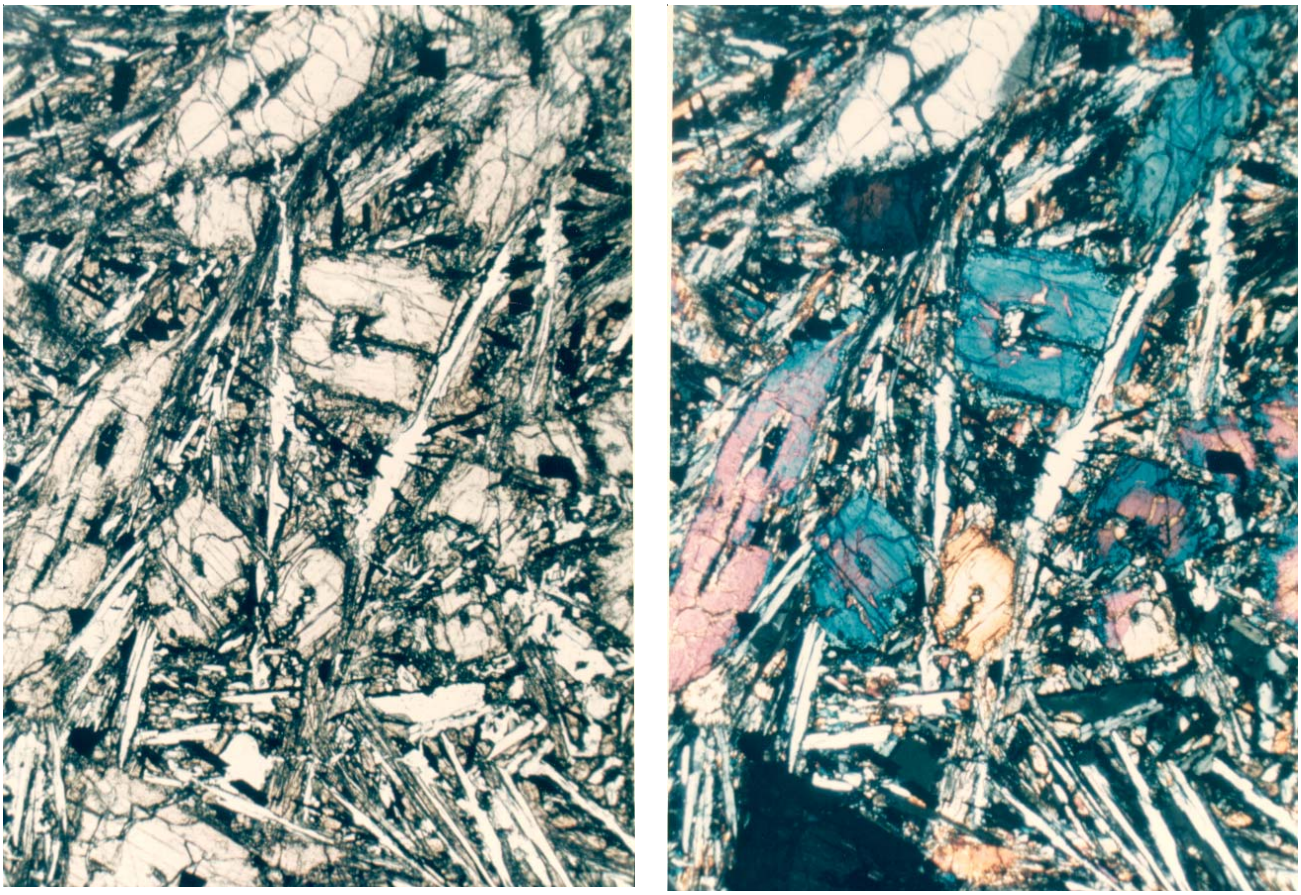
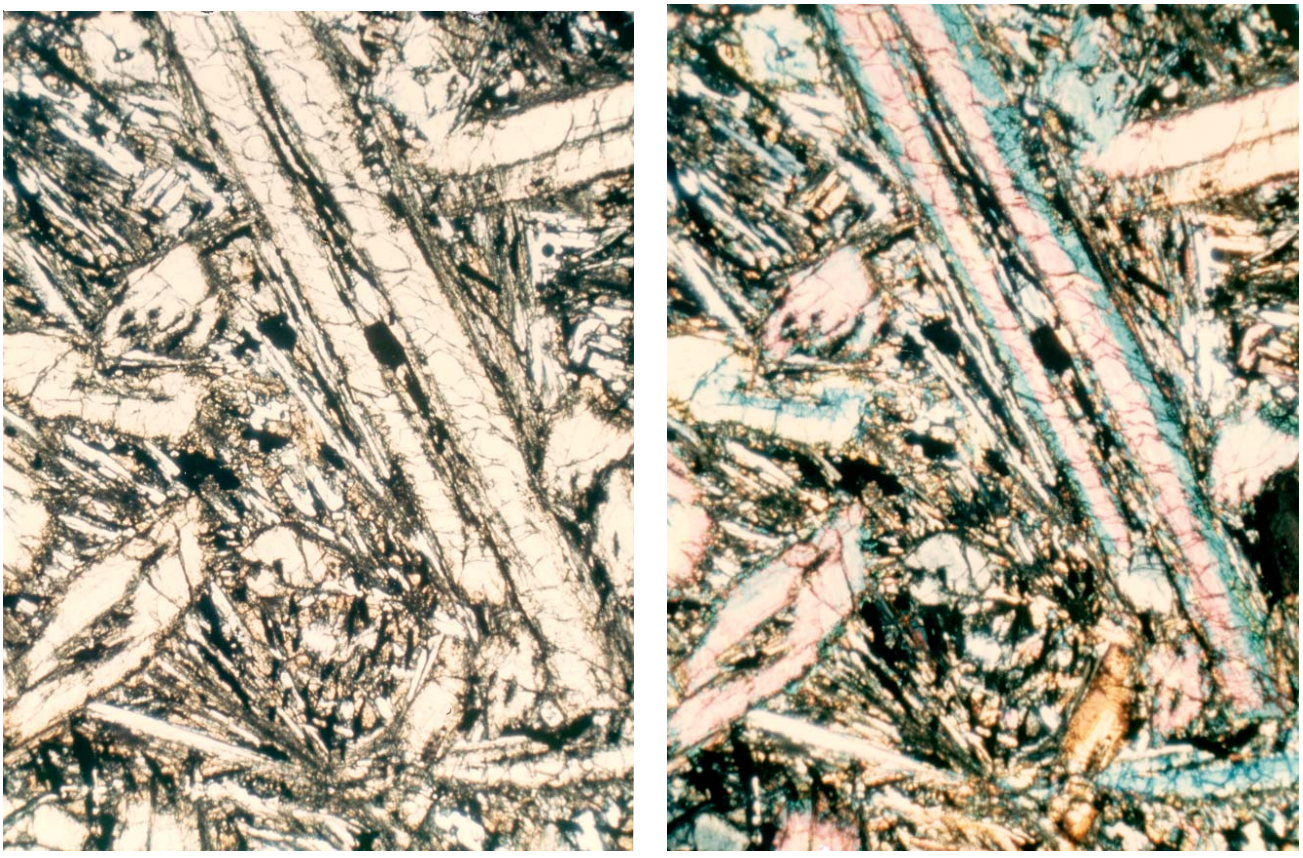


Figure 3: Transmitted-light and crossed-nicols of thin sections 12053,75 (top) and 12053,91 (bottom) showing chemically zoned, hollow, pyroxene phenocrysts (elongate and in cross section) set in variolitic groundmass.



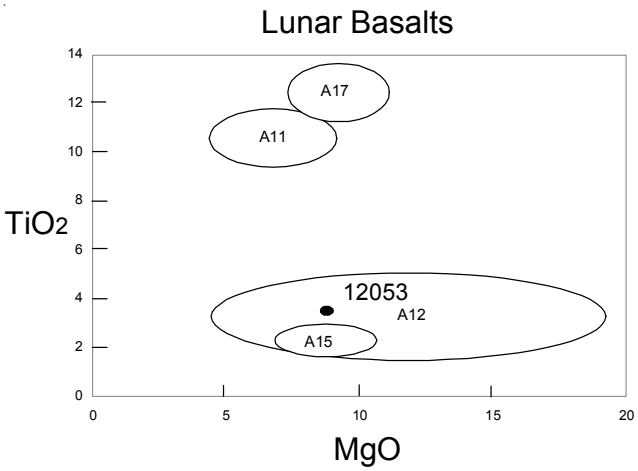


Figure 4: Composition of 12053 compared with that of other lunar basalts.

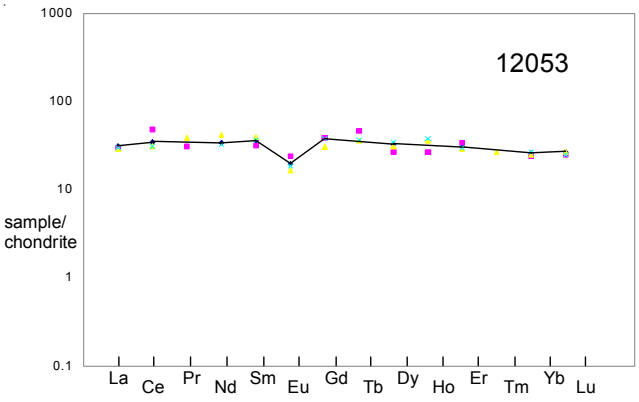


Figure 5: Comparison of rare-earth-element data for 12053 obtained by isotope dilution mass spectroscopy (line, Hubbard and Gast 1971, Wiesmann et al. 1975) with that obtained by neutron activation analysis (Morrison et al 1971, Wanke et al. 1971 and Haskin et al. 1971).

Plagioclase: Gay et al. (1971) find that plagioclase in 12053 is rather sodic ($An_{70} - An_{78}$).

Chemistry

Many investigators have determined the chemical compositions of these rocks (12052, 12053 and 12055)(table 1).

Radiogenic age dating

Horn et al. (1975b) dated 12053 by whole rock Ar/Ar plateau age as 3.17 ± 0.06 b.y.

Cosmogenic isotopes and exposure ages

Burnett et al. (1975) determined an exposure age of 130 ± 20 m.y. by $^{81}Kr/^{83}Kr$. Hintenberger et al. (1971) determined exposure ages for 12053 using ^{3}He (77 m.y.), ^{21}Ne (87 m.y.) and ^{38}Ar (83 m.y.).

Processing

12053 was cut with a circular saw (figure 6). Several slabs and short columns were produced. 12055,95 is on public display at the National Geographic Society in Washington DC (figure 7).

List of Photo #s for 12053

S69-60621 – 60642 B & W mug

S69-60956	
S70-36968	processing
S70-35473	TS B & W
S70-49837 – 49840	TS color
S70-49541 – 49542	TS color
S70-49564 – 49565	TS color
S73-17984	display

Mineralogical Mode for 12053

	Neal et al. 1994	Papike et al. 1976
Olivine	- -	2
Pyroxene	67.1	68.8
Plagioclase	21.1	20.3
Opaques		8.3
Ilmenite	3.9	
Chromite +Usp	1.6	
mesostasis	4.6	0.6
"silica"	0.2	

Summary of Age Data for 12053

	Ar/Ar
Horn et al. 1975b	3.17 ± 0.06 b.y.

Table 1a. Chemical composition of 12053.

reference	LSPET70		Gast70		Hubbard71		Weismann75			Willis71		Willis72	O'Kelly71		Morrison71			
weight	879 g				202 mg		202 mg	167 mg					879 g					
SiO2 %										46.21	(c)							
TiO2			3.5	(b)						3.32	(c)				2.67	(e)		
Al2O3										10.14	(c)				11.34	(e)		
FeO										19.77	(c)				18.4	(e)		
MnO										0.28	(c)				0.28	(e)		
MgO										8.17	(c)				8.12	(e)		
CaO			10.6	(b)						11.01	(c)				9.66	(e)		
Na2O			0.31		0.27					0.26	(c)				0.26	(e)		
K2O	0.061	(a)	0.07	(b)	0.07	(b)	0.07	0.067	(b)	0.065	(c)		0.064	(a)	0.06	(e)		
P2O5										0.14	(c)							
S %										0.08	(c)							
sum																		
Sc ppm										50	(d)				46	(e)	42	(f)
V										148	(d)				170	(e)	140	(f)
Cr										3350	(c)				2200	(e)		
Co										30	(d)				36	(e)	36	(f)
Ni										10					39	(e)	42	(f)
Cu										26					24	(e)		
Zn										1.2					2.1	(e)		
Ga															2.9	(e)		
Ge ppb																		
As															0.02	(e)		
Se																		
Rb			1.24	(b)	1.24	(b)	1.24	1.19	(b)	1.1							1.2	(f)
Sr			130	(b)	130	(b)	130	116	(b)	111		114					120	(f)
Y										52		44.2					54	(f)
Zr										138		133			120	(e)	110	(f)
Nb										10		8.2					9.4	(f)
Mo															0.3	(e)		
Ru																		
Rh																		
Pd ppb																		
Ag ppb																		
Cd ppb																		
In ppb																		
Sn ppb																		
Sb ppb															8	(e)		
Te ppb																		
Cs ppm																	0.07	(f)
Ba			84.4	(b)	84.4	(b)	84.4		(b)	86					86	(e)	89	(f)
La			7.26	(b)	7.32	(b)	7.32		(b)						6.4	(e)	6.9	(f)
Ce			20.9	(b)	20.9	(b)	20.9		(b)						27	(e)	19	(f)
Pr																	3.5	(f)
Nd			15.3	(b)	15.3	(b)	15.3		(b)						17	(e)	19	(f)
Sm			5.25	(b)	5.25	(b)	5.25		(b)						5.4	(e)	5.9	(f)
Eu			1.1	(b)	1.1	(b)	1.1		(b)						0.96	(e)	0.93	(f)
Gd															6.7	(e)	6	(f)
Tb															1.3	(e)	1.3	(f)
Dy			8.01	(b)	8.01	(b)	8.01		(b)								7.5	(f)
Ho															1.8	(e)	2	(f)
Er			4.88	(b)	4.88	(b)	4.88		(b)								4.6	(f)
Tm															0.53	(e)	0.66	(f)
Yb			4.71	(b)	4.71	(b)	4.19		(b)	3.8	(d)				5.9	(e)	4.1	(f)
Lu			0.662	(b)	0.667	(b)	0.667		(b)						0.61	(e)	0.67	(f)
Hf							0.2		(b)						3.4	(e)	3.3	(f)
Ta															0.6	(e)		
W ppb															160	(e)		
Re ppb																		
Os ppb																		
Ir ppb																		
Pt ppb																		
Au ppb																		
Th ppm	0.89	(a)											1.06	(a)	0.82	(e)		
U ppm	0.25	(a)											0.28	(a)	0.24	(e)		

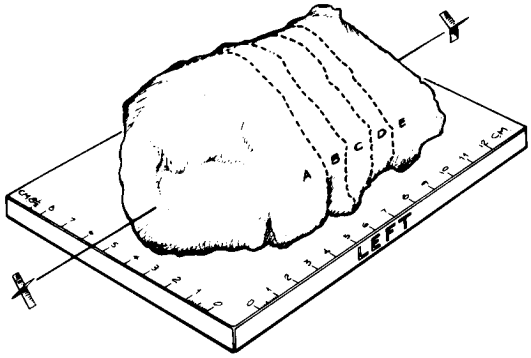
technique (a) radiation counting, (b) IDMS, (c) XRF, (d) emission spec., (e) INAA, (f) ms

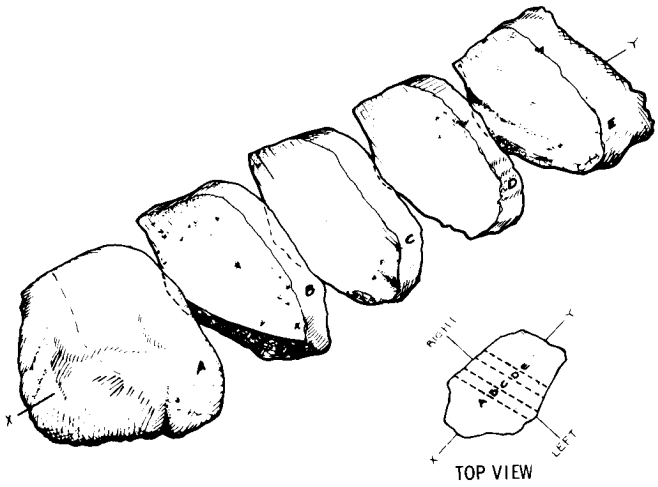
Table 1b. Chemical composition of 12053.

reference	Wanke71		Haskin71		Neal2001	
weight						
SiO2 %	47.28	(e)				
TiO2	3.67	(e)				
Al2O3	10.18	(e)				
FeO	20.07	(e)				
MnO	0.29	(e)				
MgO	8.06	(e)				
CaO	9.38	(e)				
Na2O	0.3	(e)				
K2O	0.06	(e)				
P2O5						
S %						
sum						
Sc ppm	56.4	(e)			54	(g)
V					167	(g)
Cr	3480	(e)			3312	(g)
Co	39.1	(e)			42	(g)
Ni	28	(e)			18.6	(g)
Cu	7.1	(e)			16	(g)
Zn					23	(g)
Ga	4.1	(e)			3.6	(g)
Ge ppb	100	(e)				
As	0.01	(e)				
Se						
Rb	1.7	(e)			1.31	(g)
Sr	140	(e)			116	(g)
Y					43	(g)
Zr					149	(g)
Nb					9.8	(g)
Mo					0.52	(g)
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb						
In ppb						
Sn ppb	0.86	(e)				
Sb ppb					50	(g)
Te ppb						
Cs ppm	0.1	(e)			0.06	(g)
Ba	100	(e)			71	(g)
La	7.07	(e)	7.13	(e)	6.41	(g)
Ce	30	(e)	19	(e)	18.9	(g)
Pr	2.8	(e)			2.66	(g)
Nd			15	(e)	14.2	(g)
Sm	4.7	(e)	5.51	(e)	4.92	(g)
Eu	1.34	(e)	1.05	(e)	0.97	(g)
Gd	7.6	(e)	7.53	(e)	7	(g)
Tb	1.73	(e)	1.33	(e)	1.21	(g)
Dy	6.53	(e)	8.44	(e)	7.45	(g)
Ho	1.49	(e)	2.1	(e)	1.61	(g)
Er	5.4	(e)	4.8	(e)	4.44	(g)
Tm					0.59	(g)
Yb	3.92	(e)	4.36	(e)	4.23	(g)
Lu	0.62	(e)	0.614	(e)	0.55	(g)
Hf	4	(e)			3.55	(g)
Ta	0.45	(e)			0.49	(g)
W ppb	120	(e)			120	(g)
Re ppb						
Os ppb						
Ir ppb	*0.24*	(e)				
Pt ppb	*2.2*	(e)				
Au ppb						
Th ppm	0.87	(e)			0.81	(g)
U ppm	0.242	(e)			0.26	(g)
technique	*(e) INAA, (g) ICP-MS*					

THE CUTTING OF LUNAR ROCK NO. 12053

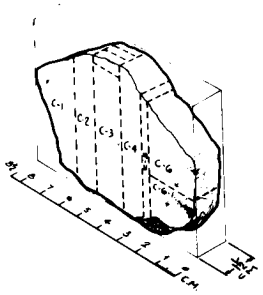
DRAWING COMPLETED MARCH 23, 1970



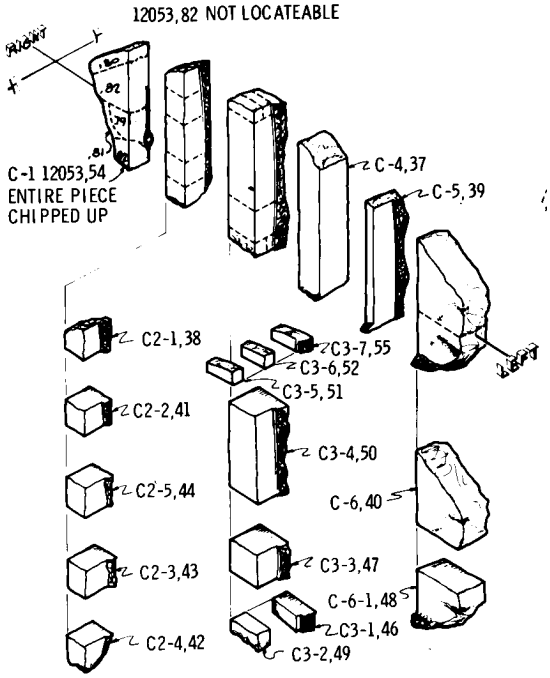


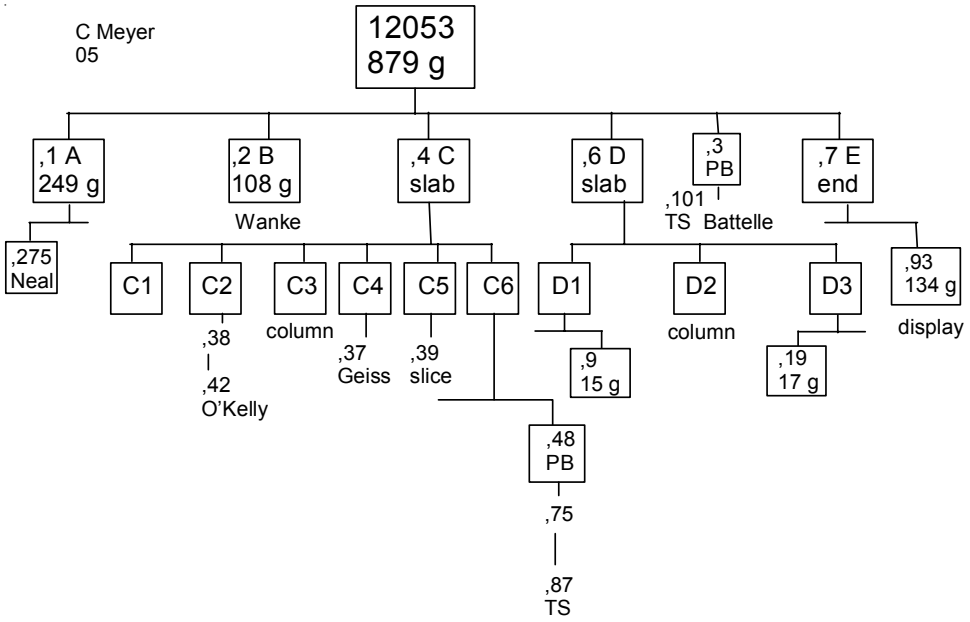
THE CUTTING OF SLICE 'C' NO. 12053,4

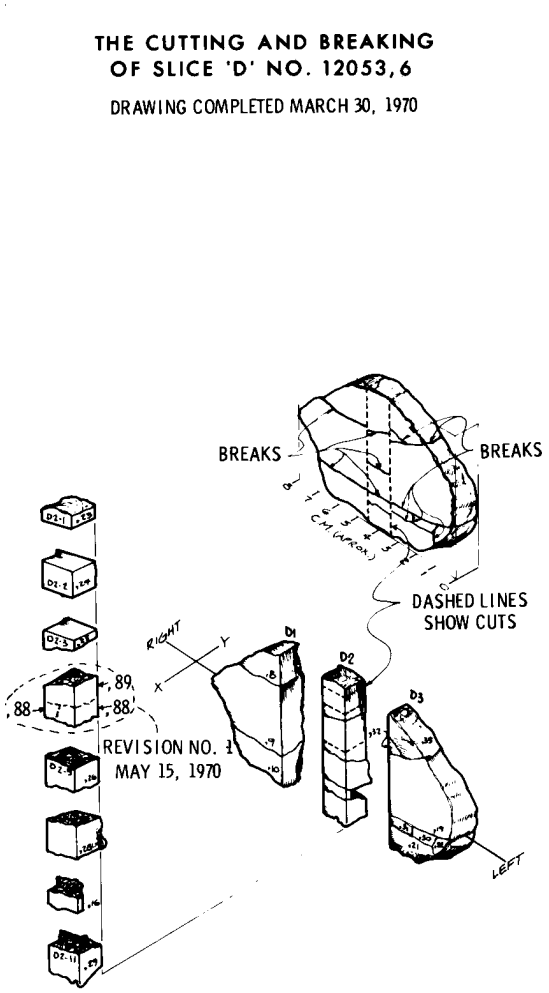
DRAWING COMPLETED MARCH 26, 1970



NOTE: SMALL CHIPS OF
12053,82 NOT LOCATEABLE







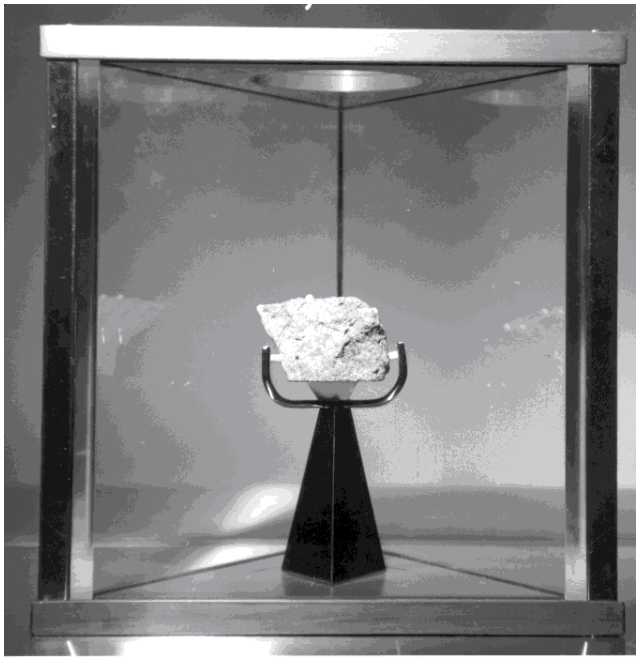


Figure 7: Display sample 12053,93. NASA #S73-17984.

Figure 6: Parts cut from slab D, 12053,6. Cubes are about 1 cm. NASA #S70-36968.

References for 12053

Baldridge W.S., Beaty D.W., Hill S.M.R. and Albee A.L. (1979) The petrology of the Apollo 12 pigeonite basalt suite. *Proc. 10th Lunar Planet. Sci. Conf.* 141-179.

Burnett D.S., Monnin M., Seitz M., Walker R. and Yuhas D. (1971) Lunar astrology – U-Th distributions and fission-track dating of lunar samples. *Proc. 2nd Lunar Sci. Conf.* 1503-1519.

Dence M.R., Douglas J.A.V., Plant A.G. and Traill R.J. (1971) Mineralogy and petrology of some Apollo 12 samples. *Proc. Second Lunar Sci. Conf.* 285-299.

Gast P.W. and Hubbard N.J. (1970c) Rare earth abundances in soil and rocks from the Ocean of Storms. *Earth Planet. Sci. Lett.* **10**, 94-101.

Gay P., Brown M.G., Muir I.D., Bancroft G.M. and Williams PGL (1971) Mineralogical and petrographic investigations of some Apollo 12 samples. *Proc. Second Lunar Sci. Conf.* 377-392.

Haskin L.A., Helmke P.A., Allen R.O., Anderson M.R., Korotev R.L. and Zweifel K.A. (1971) Rare-earth elements in Apollo 12 lunar materials. *Proc. 2nd Lunar Sci. Conf.* 1307-1317.

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.

Horn P., Kirsten T. and Jessberger E.K. (1975b) Are there Apollo 12 basalts younger than 3.1 b.y. Unsuccessful search for A12 mare basalts with crystallization ages below 3.1 b.y. *Meteoritics* **10**, 417-418.

Hubbard N.J. and Gast P.W. (1971) Chemical composition and origin of nonmare lunar basalts. *Proc. 2nd Lunar Sci. Conf.* 999-1020.

James O.B. and Wright T.L. (1972) Apollo 11 and 12 mare basalts and gabbros: Classification, compositional variations and possible petrogenetic relations. *Geol. Soc. Am. Bull.* **83**, 2357-2382.

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

Morrison G.H., Gerard J.T., Potter N.M., Gangadharam E.V., Rothenberg A.M. and Burdo R.A. (1971) Elemental abundances of lunar soil and rocks from Apollo 12. *Proc. 2nd Lunar Sci. Conf.* 1169-1185.

Neal C.R., Hacker M.D., Snyder G.A., Taylor L.A., Liu Y.-G. and Schmitt R.A. (1994a) Basalt generation at the Apollo 12 site, Part 1: New data, classification and re-evaluation. *Meteoritics* **29**, 334-348.

Neal C.R., Hacker M.D., Snyder G.A., Taylor L.A., Liu Y.-G. and Schmitt R.A. (1994b) Basalt generation at the Apollo 12 site, Part 2: Source heterogeneity, multiple melts and crustal contamination. *Meteoritics* **29,** 349-361.

O'Kelley G.D., Eldridge J.S., Schonfeld E. and Bell P.R. (1971a) Abundances of the primordial radionuclides K, Th, and U in Apollo 12 luanr samples by nondestructive gamma-ray spectroscopy: implications for the origin of lunar soils. *Proc. Second Lunar Sci. Conf.* 1159-1168.

O'Kelley G.D., Eldridge J.S., Schonfeld E. and Bell P.R. (1971b) Cosmogenic radionuclide concentrations and exposure ages of lunar samples from Apollo 12. *Proc. Second Lunar Sci. Conf.* 1747-1755.

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.

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

Warner J. (1970) Apollo 12 Lunar Sample Information. NASA TR R-353. JSC (catalog)

Wiesmann H. and Hubbard N.J. (1975) A compilation of the Lunar Sample Data Generated by the Gast, Nyquist and Hubbard Lunar Sample PI-Ships. Unpublished. JSC

Willis J.P., Ahrens L.H., Danchin R.V., Erlank A.J., Gurney J.J., Hofmeyr P.K., McCarthy T.S. and Orren M.J. (1971) Some inter-element relationships between lunar rocks and fines, and stony meteorites. *Proc. 2nd Lunar Sci. Conf.* 1123-1138.