15545
Olivine-normative Basalt
746.6 grams

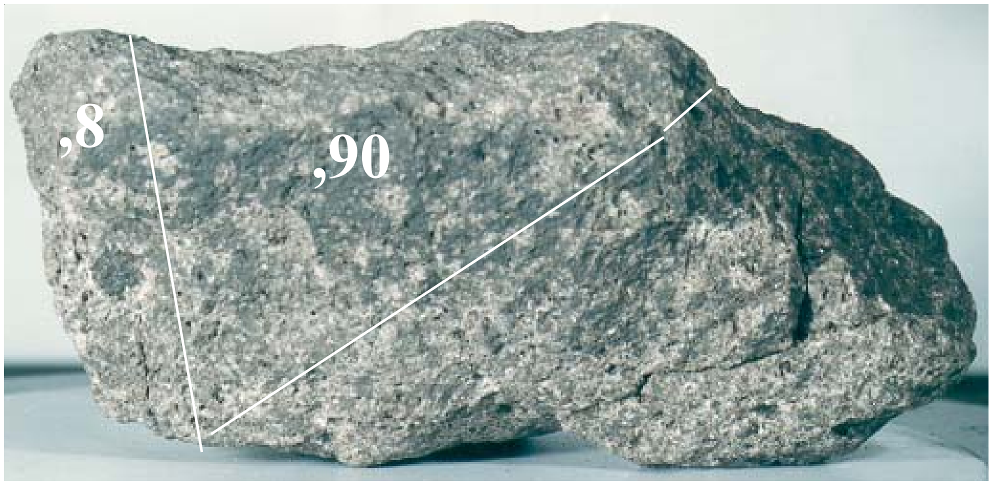


Figure 1: Photo of N1 surface of 15545 showing micrometeorite and patina covered surface. Sample is about 10 cm long. NASA S71-46618. Note the large (~6 mm) residual glass lining from a large micrometeorite crater on the left end. Location of saw cuts is approximate.

Introduction
Lunar samples 15545 was collected from near the edge of Hadley Rille in an area called The Terrace (see picture in 15595). The lunar regolith was thin in this area, with abundant rock samples (basalts) exposed (Swann et al. 1971). It appears to be another piece of the same lava flow as 15535. The age of this sample has not been determined, although whole-rock isotopic data are determined.

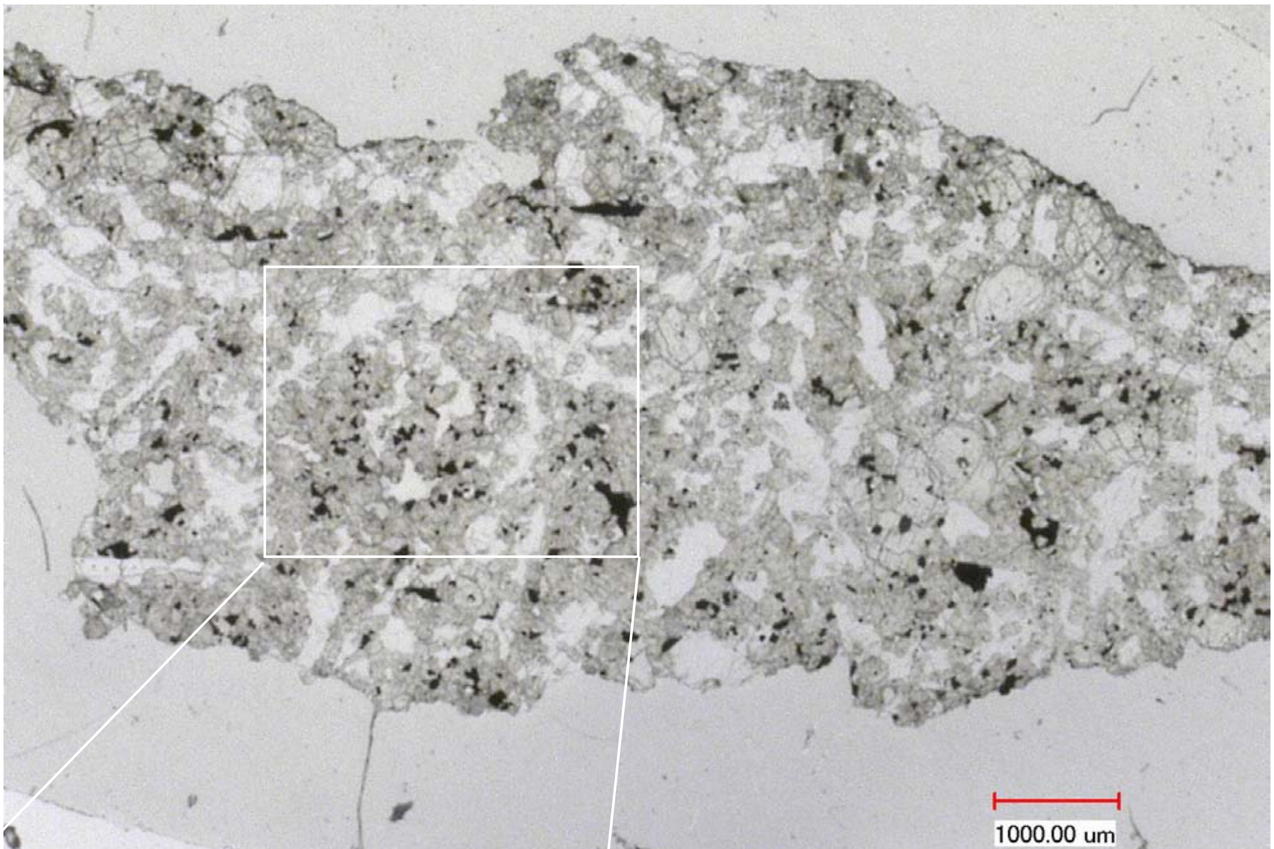
This potato-shaped rock has the remains of very large glass lining from micrometeorite impacts (figures 1 and 12) as well as prominent patina from glass splashes.

Petrography
Ryder (1985) gives the only petrographic description of 15545. Relict olivine phenocrysts have corroded borders in 15545. The matrix has small olivine and pyroxene crystals embedded in poikilitic plagioclase (figure 2). Opaques occur in clusters. The mafic minerals are highly zoned (figure 3). Kushiro (1972) reported pyroxene composition, Roedder and Weiblen (1972) studied melt inclusions, Engelhardt (1979) reported the paragensis from shape of ilmenite grains and Taylor and McCallister (1972) used Zr partioning to determined the cooling rate. Interior vugs and voids are visible in figure 9.

Chemistry
15545 has been analysed by several labs (table 1). The composition of 15545 plots right in the middle of the range for olivine-normative basalts (figure 6). The rare-earth-element pattern is identical to other Apollo 15 basalts (they have a very narrow range).

Mineralogical Mode for 15545

	Sample Catalog Butler 1971	Rhodes and Hubbard 1973	Papike et al. 1976
Olivine	11	3.7	8.6
Pyroxene	50	67.3	61.4
Plagioclase	30	24	23.5
Ilmenite	3	1.7	6
Spinel	3.1	1.6	
Silica	1.5		0.5
Mesostasis	0.5	0.3	



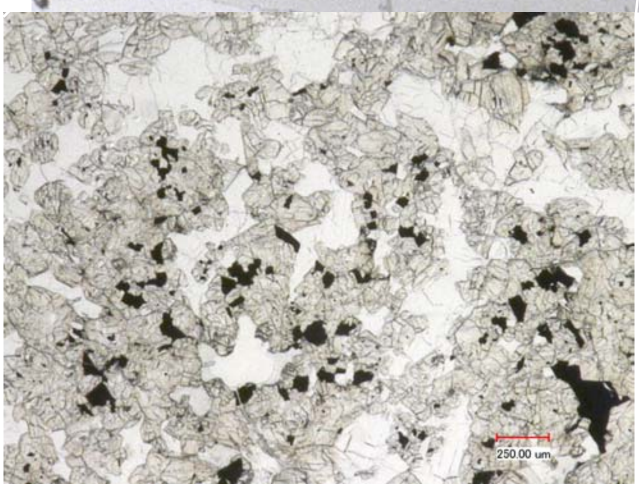


Figure 2a: Photomicrographs of thin section 15545,6 by C Meyer @ 30 and 100 x.

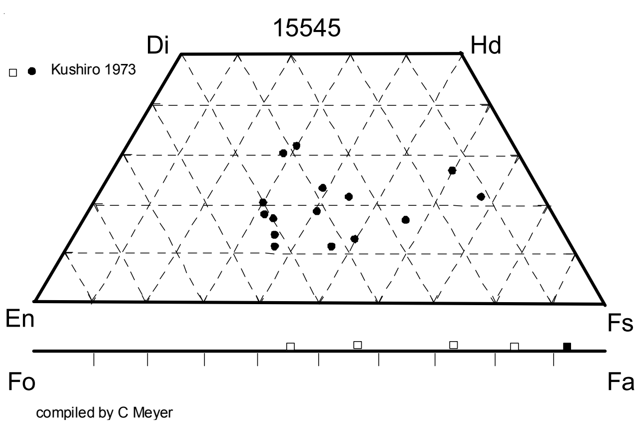


Figure 3: Pyroxene and olivine composition of 15545.

Radiogenic age dating

Compston et al. (1972) and Nyquist et al. (1972, 1973) determined the Rb, Sr isotopic composition of the whole rock sample, but did not give an age. Snyder et al. (1998) determined the Nd, Sm. The age is presumably the same as other Apollo 15 basalts (about 3.3 b.y.) (Papanastassiou and Wasserburg 1973), and from this one can calculate the initial Sr and Nd ratios.

Other Studies

Mizutani and Newbigging (1973) determined seismic velocities for lunar lava flows using a piece of 15545 (figure 7).

Processing

In 1971, the end (,8) was sawn off and cut up for initial allocations (figure 8). In 1995, the main mass was subdivided (figure 9 and 10). 15545,87 makes a very nice public display at Space Camp Canada in Quebec (figure 12). There are 11 thin sections.

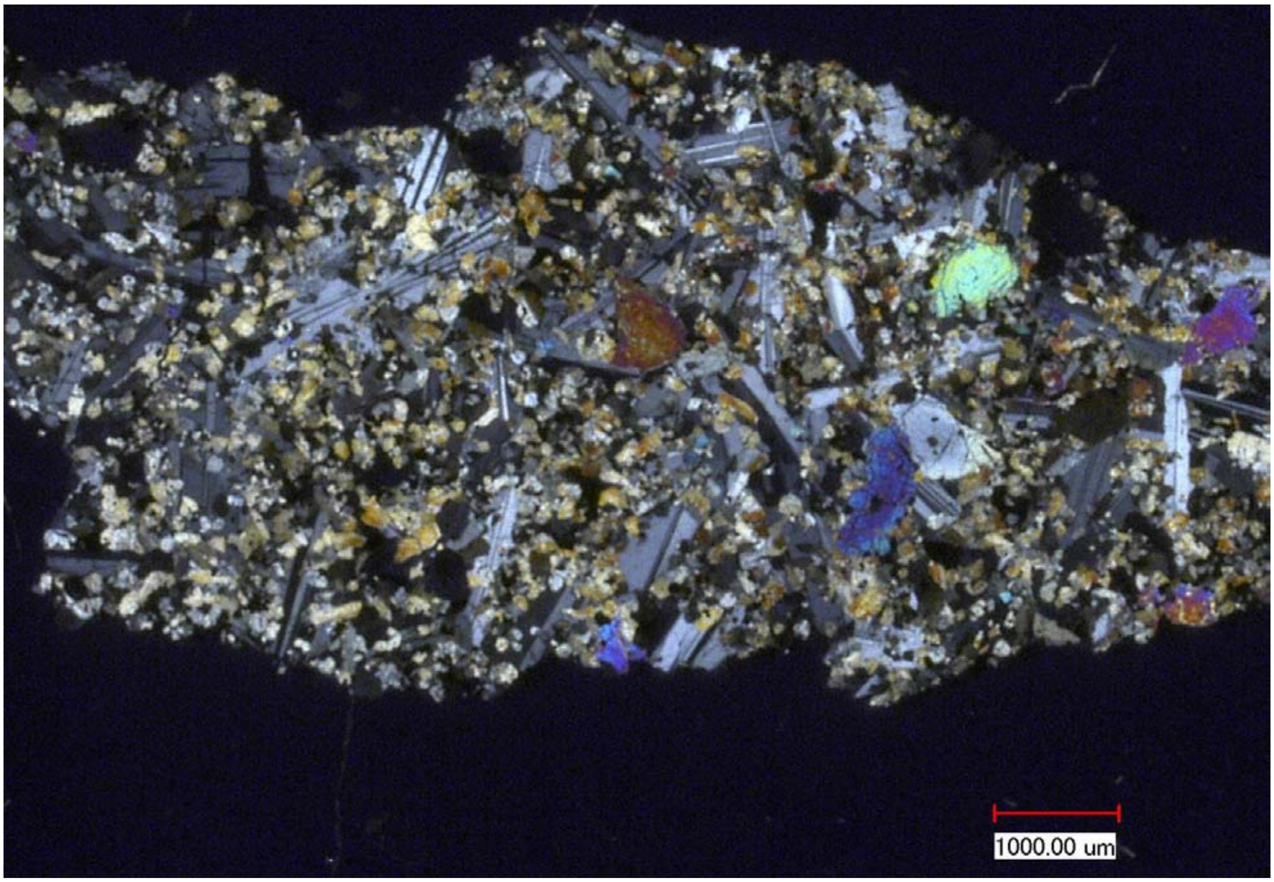


Figure 2b: Photomicrographs of thin section 15545,6 by C Meyer @ 30 x (crossed polarizers).

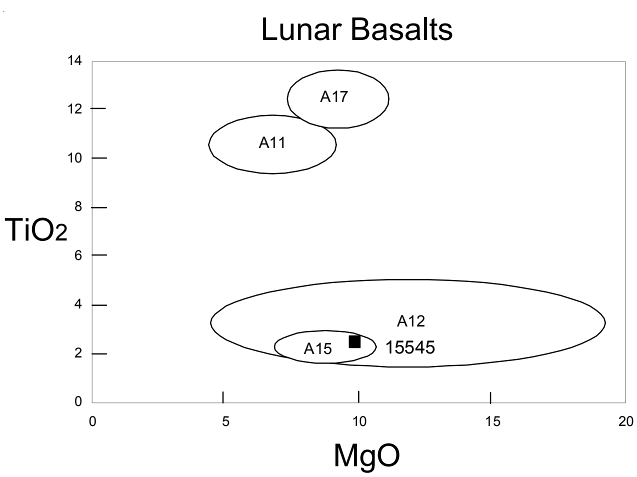
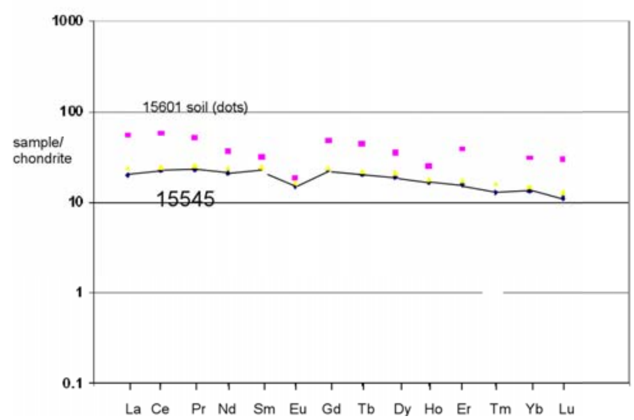


Figure 4: Chemical composition of 15545 compared with that of other lunar basalts.



5Figure 7: Normalized rare-earth-element diagram for 15545 (data by Wiesmann and Hubbard 1975 and Ryder and Shuraytz 2001).

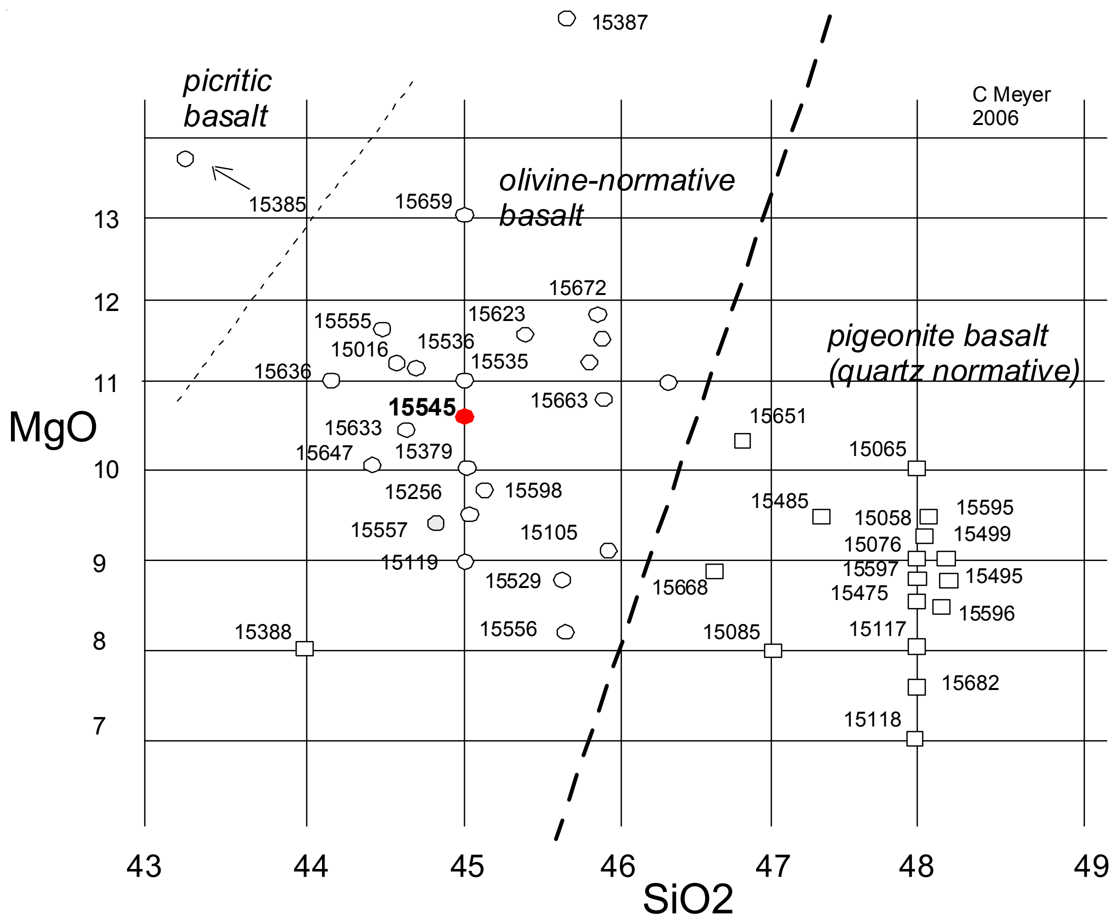


Figure 6: The big picture

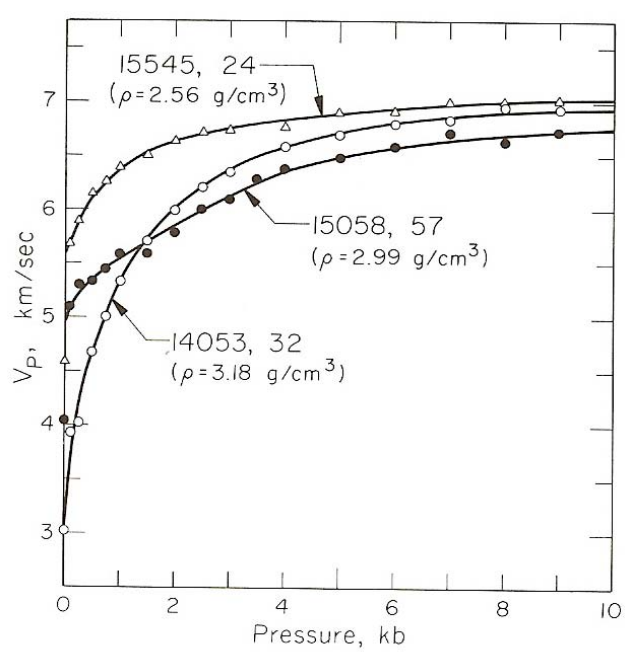


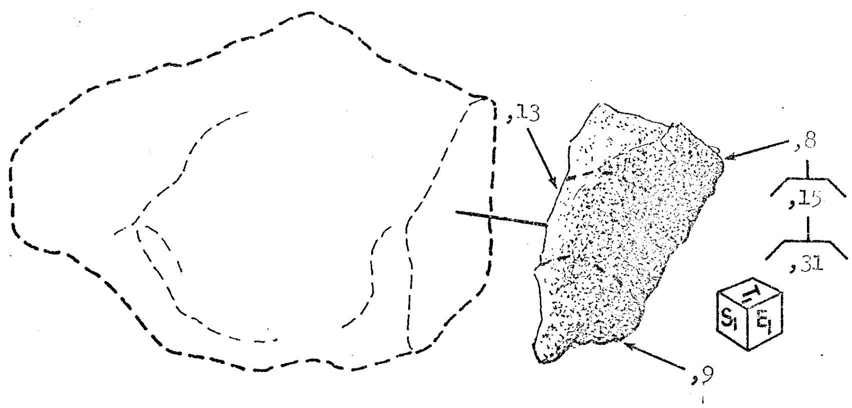
Figure 7: 15545 was used to determine important physical properties of lunar basalt (Mizutani and Newbigging 1973).

Table 1. Chemical composition of 15545.

			Hubbard73																
reference	Rhodes73		Wiesmann75		Maxwell72		Chappel73		Wolf79		Ryder2001				Hughes73			Neal2001	
weight			Rhodes73													O'Kelley72			
SiO2 %	45.02	(d)			45.72	(c)	44.89	(d)			45	(d)							
TiO2	2.33	(d)	2.35	(a)	2.4	(c)	2.49	(d)			2.31	(d)							
Al2O3	8.77	(d)			8.3	(c)	8.71	(d)			8.65	(d)							
FeO	22.02	(d)			21.99	(c)	22.43	(d)			22.14	(d)	22.3	(g)					
MnO	0.3	(d)			0.3	(c)	0.31	(d)			0.282	(d)							
MgO	10.36	(d)	7.36	(a)	10.39	(c)	10.08	(d)			10.51	(d)							
CaO	9.89	(d)			9.62	(c)	9.95	(d)			9.65	(d)							
Na2O	0.21	(d)	0.28	(a)	0.28	(c)	0.45	(d)			0.223	(d)	0.254	(g)					
K2O	0.03	(d)	0.047	(a)	0.04	(c)	0.04	(d)			0.044	(d)				0.041	(b)		
P2O5	0.05	(d)			0.11	(c)	0.07	(d)			0.064	(d)							
S %	0.07	(d)					0.05	(d)							0.075	0.078	(g)		
sum																			
Sc ppm					42	(e)							42	(g)				43.9	(h)
V					168	(e)												308	(h)
Cr					4310	(e)	3700	(d)			4484	(d)	4430	(g)				6444	(h)
Co					21	(e)							54.7	(g)				61.5	(h)
Ni					69	(e)			51	(f)	51	(d)	78	(g)				70.4	(h)
Cu					370	(e)					4	(d)						14.3	(h)
Zn					23	(e)			0.99	(f)								19.7	(h)
Ga							3	(d)										3.6	(h)
Ge ppb									3.76	(f)									
As																			
Se									117	(f)					160	190	(g)		
Rb			0.75	(a)			0.57	(d)	0.91	(f)	2	(d)						0.87	(h)
Sr			104	(a)	70	(e)	97.6	(d)			90	(d)	110	(g)				106.3	(h)
Y					33	(e)					24	(d)						29.3	(h)
Zr			96	(a)	190	(e)					81	(d)						89.2	(h)
Nb											9	(d)						6.31	(h)
Mo																		0.04	(h)
Ru																			
Rh																			
Pd ppb									<0.43	(f)									
Ag ppb									2.85	(f)					1.6	1.5	(g)		
Cd ppb									1.8	(f)									
In ppb									1.45	(f)									
Sn ppb									<40	(f)									
Sb ppb									1.31	(f)									
Te ppb									2.8	(f)									
Cs ppm					0.08	(e)			0.03	(f)								0.02	(h)
Ba			46.7	(a)	81	(e)							48	(g)				49.2	(h)
La			4.93	(a)	4.8	(e)							4.58	(g)				4.6	(h)
Ce			13.9	(a)	8.9	(e)							13.9	(g)				13.4	(h)
Pr																		2.02	(h)
Nd			9.92	(a)	7.6	(e)							9	(g)				9.3	(h)
Sm			3.29	(a)	3.3	(e)							3.3	(g)				3.41	(h)
Eu			0.895	(a)	0.74	(e)							0.87	(g)				0.83	(h)
Gd			4.48	(a)	4.5	(e)												4.44	(h)
Tb					0.65	(e)							0.74	(g)				0.73	(h)
Dy			4.68	(a)	5.2	(e)												4.57	(h)
Ho																		0.91	(h)
Er			2.67	(a)														2.46	(h)
Tm																		0.31	(h)
Yb			2.16	(a)	1.4	(e)							2.07	(g)				2.12	(h)
Lu			0.308	(a)	0.31	(e)							0.28	(g)				0.27	(h)
Hf			3	(a)	2.2	(e)							2.46	(g)				2.15	(h)
Ta					0.38	(e)							0.35	(g)				0.36	(h)
W ppb																		10	(h)
Re ppb									0	(f)					0.011	0.014	(g)		
Os ppb									<0.02	(f)					0.12	0.19	(g)		
Ir ppb									0.02	(f)					0.12	0.056	(g)		
Pt ppb																			
Au ppb									0.01	(f)					0.019	0.028	(g)		
Th ppm					0.2	(e)							0.4	(g)		0.43	(b)	0.41	(h)
U ppm			0.132	(a)	0.12	(e)			0.14	(f)						0.13	(b)	0.12	(h)

technique: (a) IDMS, (b) radiation counting, (c) conventional, (d) XRF, (e) optical emssion, (f) RNAA, (g) INAA, (h) ICP-MS

Figure 8: Sawing the end off 15545 in 1971. NASA S71-60997. Cube is 1 inch.



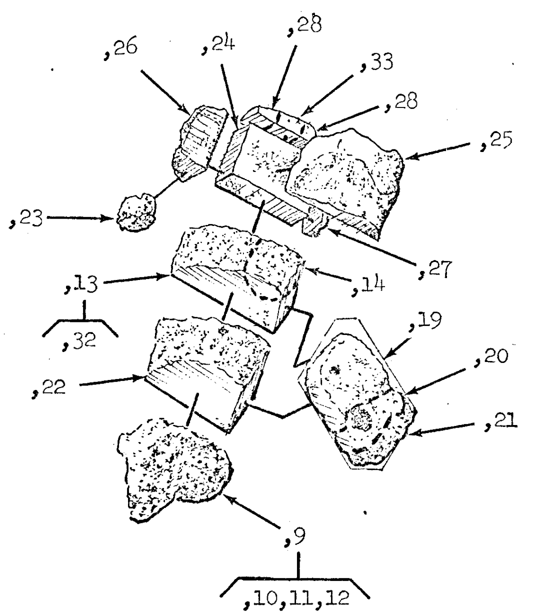


Figure 9: Sawn surfaces of 15545. NASA S96-01622. Cube is 1 cm.

Figure 10: Saw cut through 15545,0 in 1995. NASA S96-01619. Cube is 1 cm.

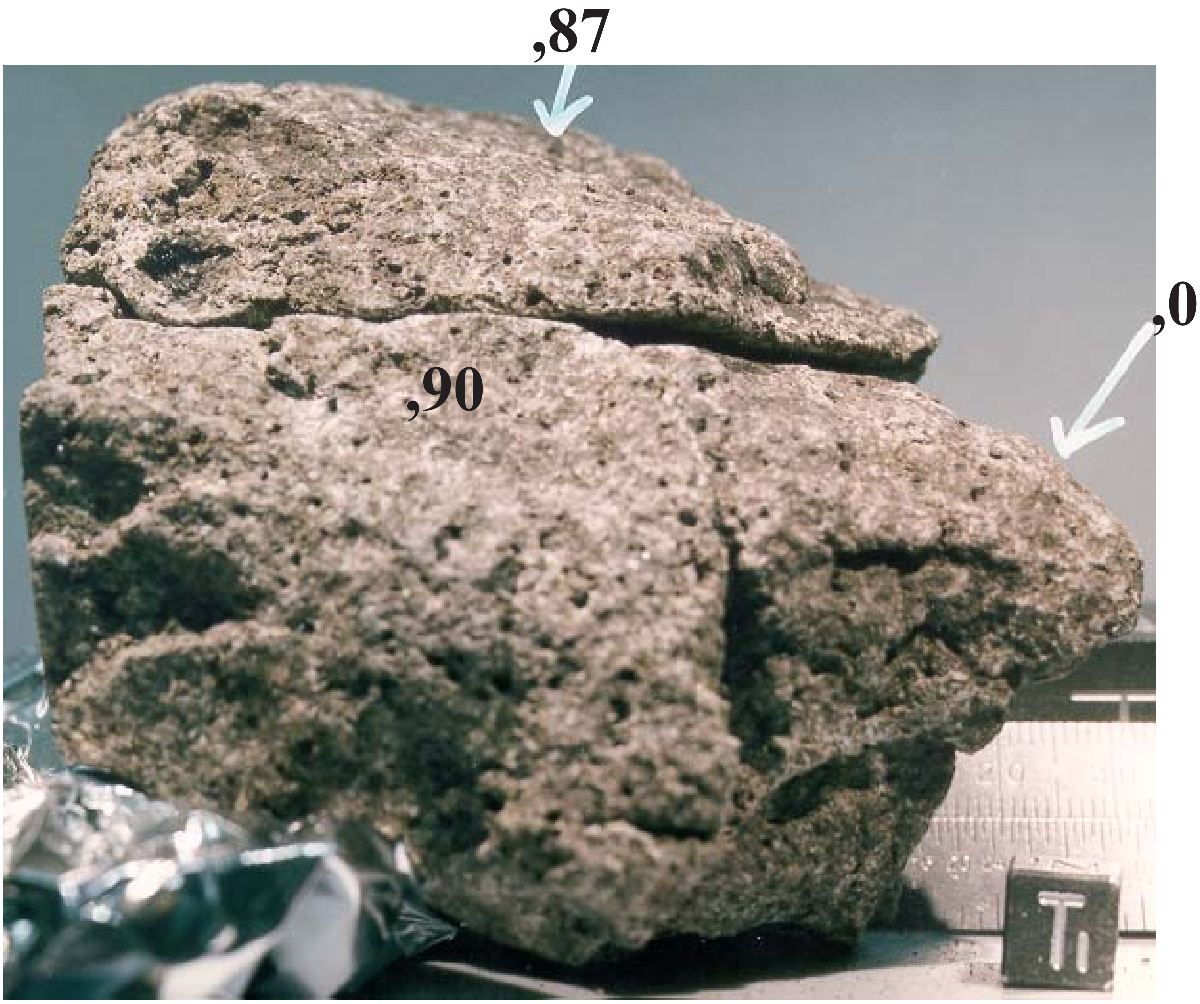


Figure 11: Subdivison of 15545 done in 1995. NASA S96-01626. Cube is 1 cm.

References for 15545

Butler P. (1971) Lunar Sample Catalog, Apollo 15. Curators' Office, MSC 03209

Chappell B.W. and Green D.H. (1973) Chemical compositions and petrogenetic relationships in Apollo 15 mare basalts. *Earth Planet. Sci. Lett.* **18**, 237-246.

Church S.E., Bansal B.M. and Wiesmann H. (1972) The distribution of K, Ti, Zr, U, and Hf in Apollo 14 and 15 materials. *In* **The Apollo 15 Lunar Samples**, 210-213.

Compston W., de Laeter J.R. and Vernon M.J. (1972) Strontium isotope geochemistry of Apollo 15 basalts. *In* **The Apollo 15 Lunar Samples**, 347-351.

Eldridge J.S., O'Kelley G.D. and Northcutt K.J. (1972) Concentrations of cosmogenic radionuclides in Apollo 15 rocks and soils. *In* **The Apollo 15 Lunar Samples,** 357-359.

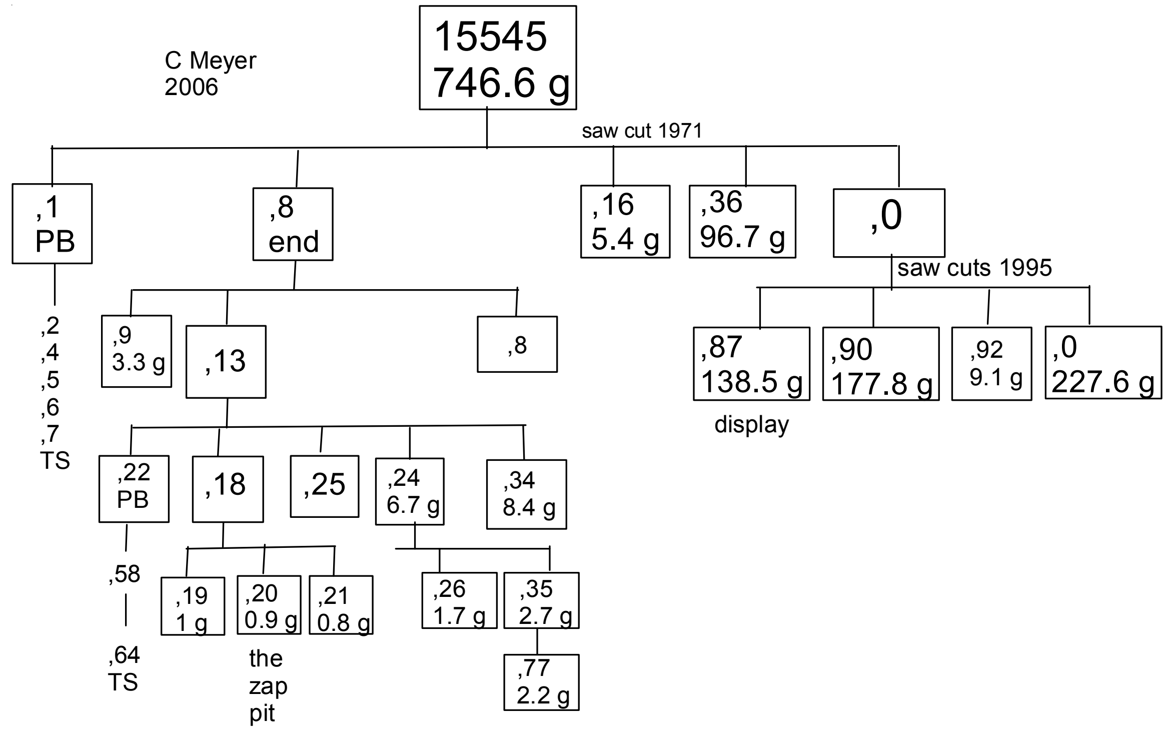
Fruchter J.S., Stoeser J.W., Lindstrom M.M. and Goles G.G. (1973) Apollo 15 clastic materials and their relationship to local geologic features. *Proc. 4th Lunar Sci. Conf.* 1227-1237.

Hubbard N.J., Rhodes J.M., Gast P.W., Bansal B.M., Shih C.-Y., Wiesmann H. and Nyquist L.E. (1973b) Lunar rock types: The role of plagioclase in non-mare and highland rock types. *Proc. 4th Lunar Sci. Conf.* 1297-1312.

Kushiro I. (1972) Petrology of some Apollo 15 basalts. *In* **The Apollo 15 Lunar Samples**, 128-130.

Lofgren G.E., Donaldson C.H. and Usselman T.M. (1975) Geology, petrology and crystallization of Apollo 15 quartz-normative basalts. *Proc. 6th Lunar Sci. Conf.* 79-99.

LSPET (1972a) The Apollo 15 lunar samples: A preliminary description. Science 175, 363-375.



LSPET (1972b) Preliminary examination of lunar samples. Apollo 15 Preliminary Science Report. NASA SP-289, 6-1—6-28.

Maxwell J.A., Bouvier J.-L. and Wiik H.B. (1972) Chemical composition of some Apollo 15 lunar samples. *In* **The Apollo 15 Lunar Samples**, 233-238.

Mizutani H. and Newbigging D. (1973) Elastic wave velocities of Apollo 14, 15 and 16 rocks. *Proc. 4th Lunar Sci. Conf.* 2601-2609.

Neal C.R. (2001) Interior of the moon: The presence of garnet in the primitive deep lunar mantle. *J. Geophys. Res.* **106**, 27865-27885.

Nyquist L.E., Hubbard N.J., Gast P.W., Bansal B.M., Wiesmann H. and Jahn B-M. (1973) Rb-Sr systematics for chemically defined Apollo 15 and 16 materials. *Proc. 4th Lunar Sci. Conf.* 1823-1846.

O'Kelley G.D., Eldridge J.S. and Northcutt K.J. (1972a) Abundances of primordial radioelements K, Th, and U in Apollo 15 samples, as determined by non-destructive gamma-ray spectrometry. *In* **The Apollo 15 Lunar Samples,** 244-246.

Papanastassiou D.A. and Wasserburg G.J. (1973) Rb-Sr ages and initial strontium in basalts from Apollo 15. *Earth Planet. Sci. Lett.* **17**, 324-337.

Figure 12: Photo of display sample prepared from 15545,87 including the residual glass lining from a large micrometeorite impact. NASA S96-01629.

Rhodes J.M. and Hubbard N.J. (1973) Chemistry, classification, and petrogenesis of Apollo 15 mare basalts. *Proc. 4th Lunar Sci. Conf.* 1127-1148.

Roedder E. and Weiblen P.W. (1972a) Petrographic features and petrologic significance of melt inclusions in Apollo 14 and 15 rocks. *Proc. 3rd Lunar Sci. Conf.* 251-279.

Ryder G. (1985) Catalog of Apollo 15 Rocks (three volumes). Curatoial Branch Pub. # 72, JSC#20787

Ryder G. and Schuraytz B.C. (2001) Chemical variations of the large Apollo 15 olivine-normative mare basalt rock samples. *J. Geophys. Res.* **106**, E1, 1435-1451.

Snyder G.A., Borg L.E., Taylor L.A., Nyquist L.E. and Halliday A.N. (1998) Volcanism in the Hadley-Apennine region of the Moon: Geochronology, Nd-Sr isotopic systematics and depths of melting (abs#1141). *Lunar Planet. Sci.* **XXIX**, Lunar Planetary Institute, Houston.

Swann G.A., Hait M.H., Schaber G.C., Freeman V.L., Ulrich G.E., Wolfe E.W., Reed V.S. and Sutton R.L. (1971b) Preliminary description of Apollo 15 sample environments. U.S.G.S. Interagency report: 36. pp219 with maps

Swann G.A., Bailey N.G., Batson R.M., Freeman V.L., Hait M.H., Head J.W., Holt H.E., Howard K.A., Irwin J.B., Larson K.B., Muehlberger W.R., Reed V.S., Rennilson J.J., Schaber G.G., Scott D.R., Silver L.T., Sutton R.L., Ulrich G.E., Wilshire H.G. and Wolfe E.W. (1972) 5. Preliminary Geologic Investigation of the Apollo 15 landing site. In Apollo 15 Preliminary Science Rpt. NASA SP-289. pages 5-1-112.

Taylor L.A. and McCallister R.H. (1972a) Opaque mineralogy of Apollo 15 rocks: Experimental investigations of elemental partioning and subsolidus reduction. *In* **The Apollo 15 Lunar Samples**, 169-173.

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