15555

DRAFT

Olivine Basalt

9614 grams

Figure 1: Photo of S1 surface of 15555, illustrating large zap pit and vuggy nature of rock. NASA photo no. S71-43954. Scale is in cm.

Introduction

Lunar sample 15555 (called "Great Scott", after the collector Dave Scott) is one of the largest samples returned from the moon and is representative of the basaltic samples found on the mare surface at Apollo 15. It contains olivine and pyroxene phenocrysts and is olivine normative in composition (Rhodes and Hubbard 1973). The bulk composition of 15555 is thought to represent that of a primitive volcanic liquid and has been used for various experimental studies related to the origin of lunar basalts (e.g. Walker et al. 1977).

15555 has a large zap pit (~1 cm) on the S1 face, various penetrating fractures and a few percent vugs (figure 1). It has a subophitic, basaltic texture (figure 3) and there is little evidence for shock in the minerals.

Ryder (1985) carefully reviewed all aspects of 15555. It is one of the most allocated and most studied samples

Mineralogical Mode of 15555

	Longhi et al. 1972	McGee et al. 1977	Heuer et al. 1972	Nord et al. 1973
Olivine	12.1	5-12	20	20
Pyroxene	52.4	52-65	40	40
Plagioclase	30.4	25-30	35	35
Opaques	2.7	5		
Mesostasis	2.3	0.2-0.4	5	5
Silica		0.3-2		

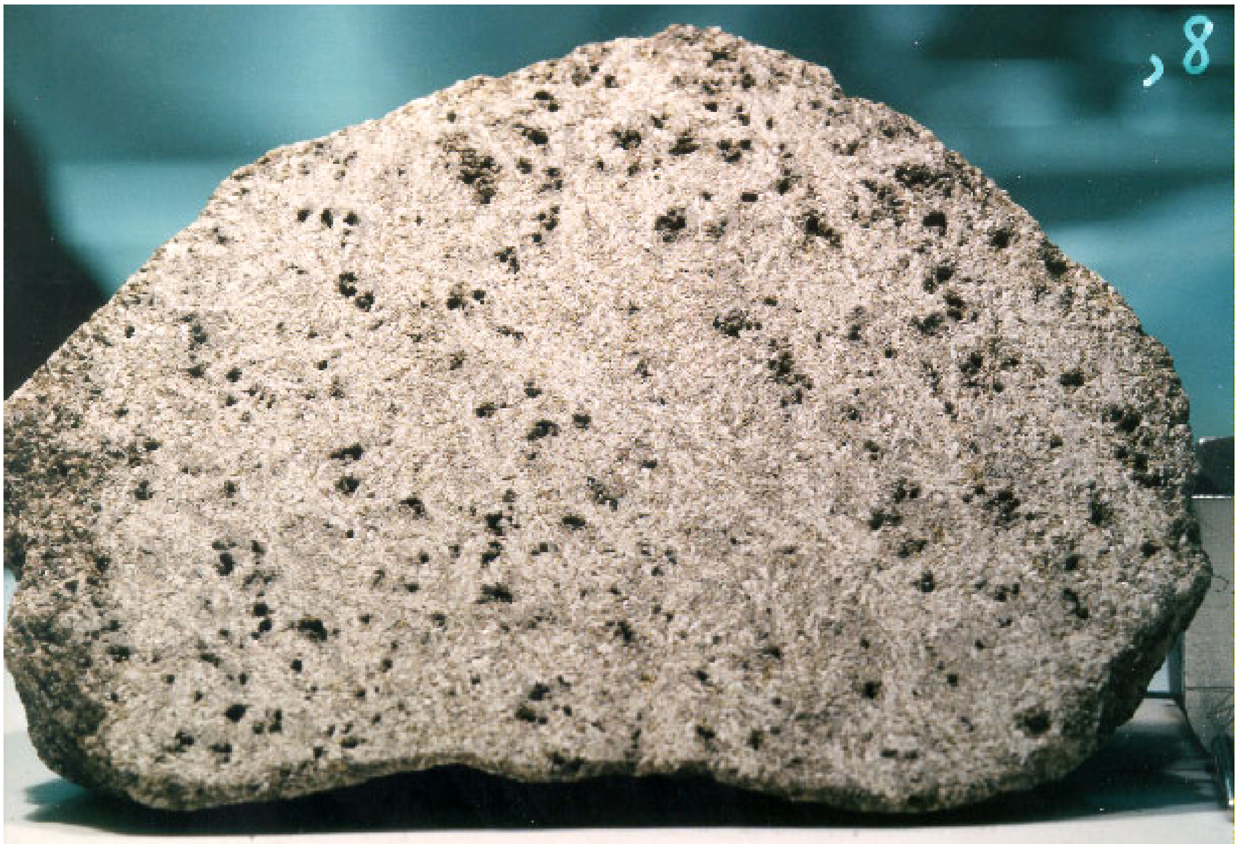

Figure 2: Closeup photo of sawn surface illustrating texture and vuggy nature of 15555,838. Sample is 3 x 5 inches. Photo # S93-045961.

from the moon and it has often been used in public displays.

Petrography

Lunar sample 15555 is a coarse-grained, porphyritic rock with rounded olivine phenocrysts (1 mm) and subhedral zoned pyroxene phenocrysts (0.5-2 mm) set in a matrix of poikilitic plagioclase (up to 3 mm). Interstices between plagioclase megacrysts are filled with minor opaque minerals, silica, glass and pore space. Inclusions of small euhedral chromite crystals occur in olivine and pyroxene. Inclusions of olivine and pyroxene are found in plagioclase. Ni-Fe metal is rare. Small vugs are about 2-4 % (figure 2).

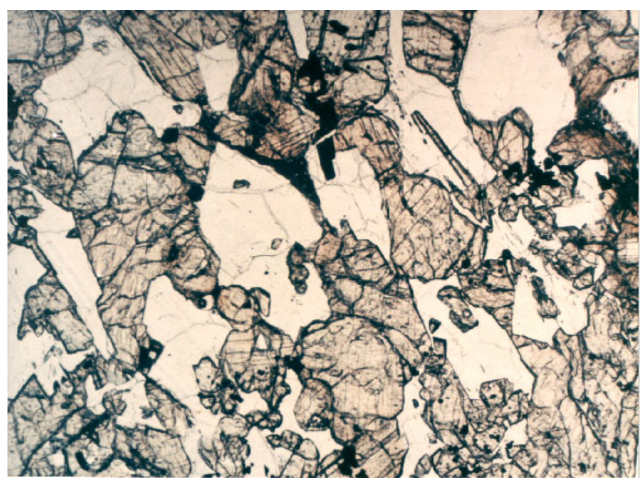

Figure 3: Photomicrograph of thin section of 15555. Scale is 2.5 mm across.

Dalton and Hollister (1974) determined the crystallization sequence of 15555 by carefully studying the mineral zoning. At 1 atmosphere, Kesson (1975) determined experimentally that olivine crystallized at 1283 deg.C, followed by spinel at 1227 deg.C, pyroxene at 1154 deg.C and plagioclase at 1138 deg.C.

Walker et al. (1977) and Taylor et al. (1977) determined the cooling rate of 15555 (5 degC/day) by modeling the diffusion of Fe in olivine phenocrysts, while Bianco and Taylor (1977) determined a cooling rate (at time of olivine nucleation) of 12-24 degC/day from the number density of olivine crystals (grains/mm^2).

Kesson (1975) and Walker et al. (1977) performed high-pressure experiments on 15555 composition to obtain the pressure-temperature relation for multiply saturated phases. In this way, they obtained estimates of the

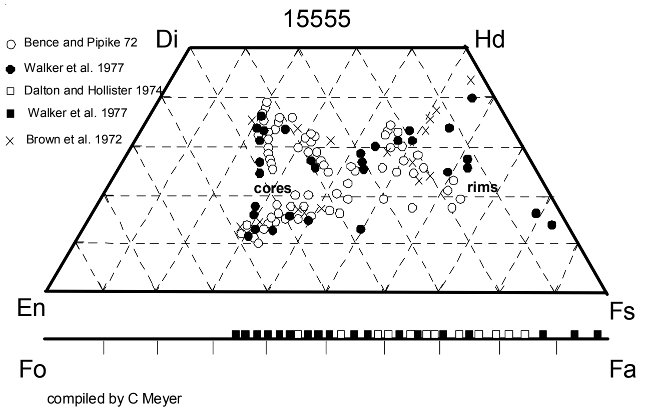

Figure 4: Pyroxene and olivine compositions for 15555.

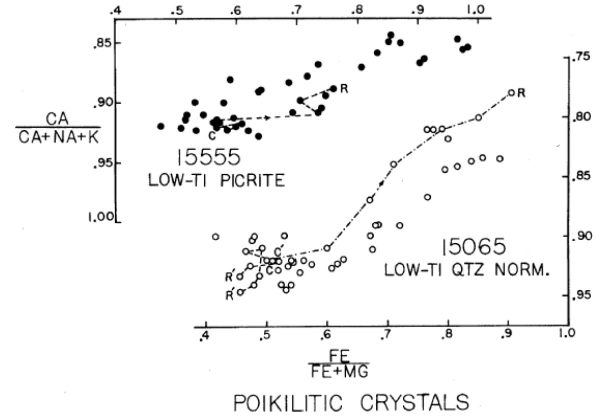

Figure 6: Fe/Mg zoning in poililitic plagioclase in 15555 and 15065 (from Longhi et al. 1976).

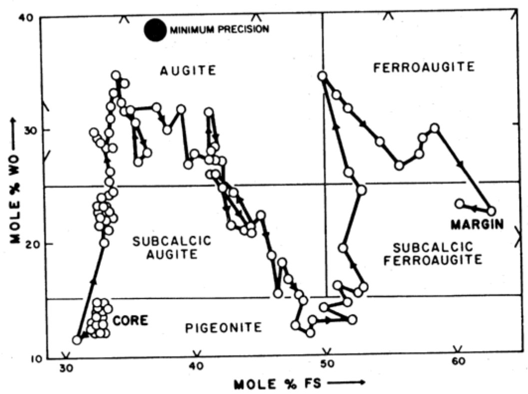

Figure 5: Chemical zoning of pyroxene in 15555 from Mason et al. (1972).

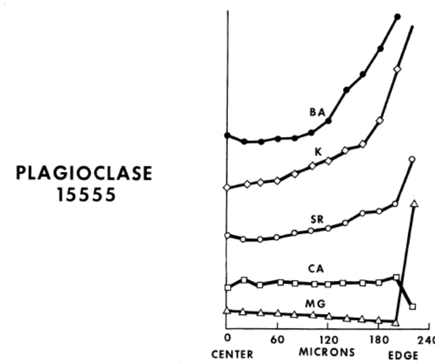

Figure 7: Variation of minor elements in large plagioclase crystal in 15555 as determined by ion microprobe (Meyer et al. 1974).

depth of origin for this composition of 240 km and 100-150 km respectively. However, it would be remarkably good fortune if a lunar basalt sample was representative of a true primary magma, because limited accumulation of olivine and/or opaques would greatly alter the liquid composition, and hence the phase diagram. Lunar basalts have very low viscosity. Never the less, the composition of 15555 (and or 15016) was chosen for experiments, because it was highest in Mg, and thus, most likely to be the primitive end member.

Mineralogy

Olivine: Bell and Mao (1972), Brown et al. (1972), Longhi et al. (1972), Walker et al. (1977) and Taylor et al (1977) studied the zoning in olivine phenocrysts. Dalton and Hollister (1974) reported two kinds of olivine; large (1mm), normal-zoned olivine phenocrysts with Fo_{67-29} and small (0.1mm) euhedral inclusions in plagioclase with Fo_{49-16}.

Pyroxene: Pyroxene compositions are given in plots by Brown et al. (1972), Bence and Papike (1972) and Walker et al. (1977). Coexisting, intergrown augite and pigeonite zone to a common focus and then the outer portions of pyroxene crystals zone to be extremely Fe-rich (figure 4). Mason et al. (1972) presented a traverse of the zoning in a complex pyroxene in 15555 (figure 5). Boyd (1972) found pyroxene cores had sector-zoned mantles of more Ca-rich pyroxene. Heuer et al. (1972), Nord et al. (1973) and Papike et al. (1972) studied microscopic exsolution.

Plagioclase: The cores of large plagioclase crystals are relatively unzoned (An_{94-91}) but the rims approach An_{78}. Longhi et al. (1976) studied the change in FeO/MgO from center to rim (figure 6) and Meyer et al. (1974) studied zoning of trace elements in 15555 (figure 7). Schnetzler et al. (1973) and Brunfelt et al. (1972) determined the trace element content of plagioclase separates.

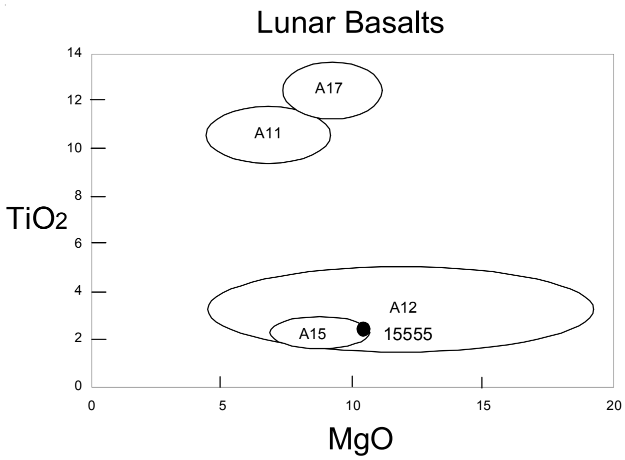

Figure 8: Composition of mare basalts, including 15555.

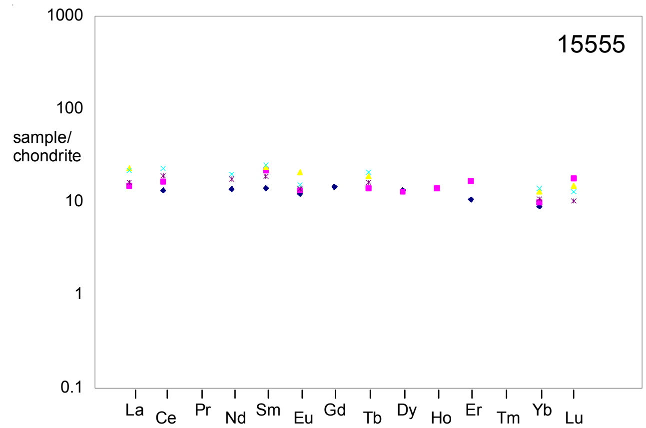

Figure 9: Normalized rare-earth-element diagram for 15555 (data from table 1a,b,c). Note the variation.

Spinel: Dalton and Hollister (1974) found that chromite inclusions in olivine had ulvöspinel overgrowths. The spinels in 15555 have also been studied by Haggerty et al. (1972) and El Goresy et al. (1976). Some chromite has been reduced to form exsolution of ilmenite plus Fe metal.

Silica: Heuer et al. (1972) identify silica found in the mesostasis as cristobalite.

Phase Y: Brown et al. (1972) and Peckett et al. (1972) reported a Zr-Ti-Fe phase ("phase Y") in the mesostasis which Andersen and Hinthorne (1973) were able to date by ion microprobe.

Chemistry

The chemical composition of 15555 is given in tables 1 and 2. The lack of agreement is due to the relatively large crystal size and the small amounts distributed for analysis (see complaints lodged by Mason et al. 1972 and Rhodes and Hubbard 1973). Even Ryder and Schuraytz (2001) found significant variation in 4 gram duplicate splits.

15555 is found to be typical of Apollo 15 basalts (figure 8). It is thought to be the primitive end member of the olivine-normative Apollo 15 suite (Chappell and Green 1973), and therefore suitable for high-pressure melting experiments. The rare-earth-element pattern is flat (figure 9).

Radiogenic age dating

15555 proved to be a good sample to resolve analytical techniques and inter-laboratory comparisons and was apparently allocated (by CAPTEM) to each laboratory for that purpose. Argon 39/40 plateau ages were obtained by Alexander et al. (1971), Husain et al. (1971), Podosek et al. (1971) and York (1972). The most dependable ages were those obtained on plagioclase separates (figure 10).

Chappell et al. (1971), Wasserburg and Papanastassiou (1971), Murthy et al. (1971), Cliff et al. (1972) and Birck et al. (1975) determined internal mineral isochrons by the Rb/Sr method (figures 11-14). These results are discussed in Papanastassiou and Wasserburg (1973).

Tatsumoto et al. (1972) found that U/Pb data for 15555 lie on a discordia line from 4.65 to 3.3 b.y., while Tera and Wasserburg found that the whole rock data lie on a discordia line from 3.3 and 4.42 (*magic point*, see figure 15). Andersen and Hinthorne (1973) dated U-rich, Y-Zr phases by ion microprobe.

Lugmair (1975) and Unruh et al. (1984) present Sm-Nd and Lu-Hf whole rock data and Nyquist et al. (1991) have dated 15555 by Sm-Nd internal isochron (figure 16). Nyquist et al. also heated the sample to 790 deg C and 990 deg C for 170 hours to see what disturbance there was to age dating (see table).

Lee et al. (1977) reported Hf/W and $^{182}W/^{184}W$.

It seems clear that this sample should be dated every few years, by whatever new technique, or new laboratory, that comes along, and that the data needs to be compared by CAPTEM, to understand precision

Table 1a. Chemical composition of 15555.

reference	Chappel 72		Schnetzler 72		Brunfelt 72		Ganapathy 73		Rhodes 73		Cuttitta 73		Fruchter 73		Janghorbani 73		
weight															1.5 g	1.8 g	
SiO2 %	43.82	(a)	45	(c)					44.24	(a)	45.21	(f)			45.14	44.1	(d)
TiO2	2.63	(a)	1.6	(c)	2.03	(d)			2.26	(a)	1.73	(f)	2.25	(d)	2.33	2.86	(d)
Al2O3	7.45	(a)	9.37	(c)					8.48	(a)	10.32	(f)	8.5	(d)	9.45	8.5	(d)
FeO	24.58	(a)	21.18	(c)	22.13	(d)			22.47	(a)	20.16	(f)	23.16	(d)	20.97	22.4	(d)
MnO	0.32	(a)	0.26	(c)	0.3	(d)			0.29	(a)	0.25	(f)			0.26	0.27	(d)
MgO	10.96	(a)	12.22	(c)					11.19	(a)	11.2	(f)			11.77	10.11	(d)
CaO	9.22	(a)	9.25	(c)	10.35	(d)			9.45	(a)	9.96	(f)					
Na2O	0.24	(a)	0.26	(c)	0.28	(d)			0.24	(a)	0.35	(f)	0.26	(d)	0.39	0.39	(d)
K2O	0.04	(a)	0.03	(c)					0.03	(a)	0.05	(f)					
P2O5	0.07	(a)	0.07	(c)					0.06	(a)	0.05	(f)					
S %	0.06	(a)							0.05	(a)							
sum																	
Sc ppm					38.4	(d)					40	(f)	40	(d)		38	(d)
V					244	(d)					240	(f)					
Cr	4036	(a)	3216	(c)	4820	(d)					4516	(f)	4100	(d)		3580	(d)
Co					61.8	(d)					87	(f)	50	(d)		55	(d)
Ni					90	(d)			42	(a)	96	(f)					
Cu					6.6	(d)					0.13	(f)					
Zn					1.3	(d)	0.78	(e)									
Ga					2.9	(d)					4.6						
Ge ppb							8.5	(e)									
As					<0.05	(d)											
Se					0.085	(d)	0.156	(e)									
Rb	0.68	(b)	0.445	(b)	0.75	(d)	0.65	(e)	0.6	(b)	1.1						
Sr	89.7	(b)	84.4	(b)	84	(d)			92	(b)	93						
Y									23	(a)	23						
Zr			57.3	(b)					76	(a)	58						
Nb									4.3	(a)	17						
Mo																	
Ru																	
Rh																	
Pd ppb																	
Ag ppb					<7	(d)	1	(e)									
Cd ppb							2.1	(e)									
In ppb					2	(d)	0.55	(e)									
Sn ppb																	
Sb ppb							0.067	(e)									
Te ppb							3.4	(e)									
Cs ppm					0.026	(d)	0.03	(e)									
Ba			32.2	(b)	47	(d)					30						
La					3.5	(d)							5.4	(d)			
Ce			8.06	(b)	10	(d)											
Pr																	
Nd			6.26	(b)													
Sm			2.09	(b)	3.2	(d)							3.5	(d)			
Eu			0.688	(b)	0.75	(d)							1.18	(d)		1	(d)
Gd			2.9	(b)													
Tb					0.51	(d)							0.7	(d)		0.92	(d)
Dy			3.27	(b)	3.2	(d)											
Ho					0.78	(d)											
Er			1.7	(b)	2.7	(d)											
Tm																	
Yb			1.45	(b)	1.64	(d)					4.2		2.1	(d)			
Lu					0.43	(d)							0.37	(d)			
Hf					2.1	(d)							2.2	(d)			
Ta					0.29	(d)										1.45	(d)
W ppb					1200	(d)											
Re ppb							0.0013	(e)									
Os ppb																	
Ir ppb					<0.1	(d)	0.006	(e)									
Pt ppb																	
Au ppb					0.48	(d)	0.139	(e)									
Th ppm					0.3	(d)											
U ppm					0.14	(d)											

technique (a) XRF, (b) IDMS, (c) AA, colormetric, (d) INAA, (e) RNAA, (f) various, see paper

Table 1b. Chemical composition of 15555.

reference	Maxwell 72	Mason 72		Unruh 84	Birck 75		Kaplan 76	Gibson 75		Chyi and Ehmann 73			Longhi 72		Murthy 72	
weight		0.5 g														
SiO2 %	44.22	44.75	(f)										45.86	(f)		
TiO2	2.36	2.07	(f)										2.4	(f)		
Al2O3	7.54	8.67	(f)										8.29	(f)		
FeO	24.24	23.4	(f)										23.45	(f)		
MnO	0.29	0.3	(f)													
MgO	11.11	11.48	(f)										11.55	(f)		
CaO	9.18	9.14	(f)										9.24	(f)		
Na2O	0.29	0.24	(f)										0.34	(f)		
K2O	0.04	0.05	(f)		0.039	(b)							0.09	(f)	0.042	(b)
P2O5	0.06	0.05	(f)													
S %	0.07		(f)				0.065	0.0855	(f)							
sum																
Sc ppm	49		(f)													
V	240		(f)													
Cr		4174	(f)													
Co	59		(f)										4700	(f)		
Ni	86		(f)													
Cu	21		(f)													
Zn																
Ga																
Ge ppb																
As																
Se																
Rb					0.62	(b)									0.7	(b)
Sr	84				91	(b)									85.3	(b)
Y	25															
Zr	140									130	124	(d)				
Nb																
Mo																
Ru																
Rh																
Pd ppb																
Ag ppb																
Cd ppb																
In ppb																
Sn ppb																
Sb ppb																
Te ppb																
Cs ppm																
Ba	48														41.61	(b)
La																
Ce																
Pr																
Nd				7.518		(b)										
Sm				2.52		(b)										
Eu																
Gd																
Tb																
Dy																
Ho																
Er																
Tm																
Yb	4.3															
Lu				0.255		(b)										
Hf				2		(b)				3.2	3.26	(d)				
Ta																
W ppb																
Re ppb																
Os ppb																
Ir ppb																
Pt ppb																
Au ppb																
Th ppm																
U ppm																

technique (a) XRF, (b) IDMS, (c) AA, colormetric, (d) INAA, (e) RNAA, (f) various, see paper

Table 1c. Chemical composition of 15555.

		duplicate										
reference	Ryder 2001			Ryder 2001			Ryder 2001			Chappel 73		
weight	4.014	4.001										
SiO2 %	44.5	45	(a)				43.7	44.8	(c)	44.75	43.82	(a)
TiO2	2.3	2.02	(a)				2.45	2.06	(c)	2.05	2.63	(a)
Al2O3	8.21	9.16	(a)				8.3	8.6	(c)	9.01	7.45	(a)
FeO	22.75	21.49	(a)	23	21.3	(b)	22.6	22	(c)	21.68	24.58	(a)
MnO	0.282	0.275	(a)				0.28	0.28	(c)	0.3	0.32	(a)
MgO	11.16	11.32	(a)				11.1	11.2	(c)	11.39	10.96	(a)
CaO	9.22	9.47	(a)				9.2	9.5	(c)	9.62	9.22	(a)
Na2O	0.228	0.234	(a)	0.24	0.259	(b)	0.22	0.26	(c)	0.27	0.24	(a)
K2O	0.042	0.036	(a)				0.04	0.04	(c)	0.04	0.04	(a)
P2O5	0.065	0.053	(a)				0.1	0.1	(c)	0.06	0.07	(a)
S %										0.04	0.06	(a)
sum												
Sc ppm				41.4	39.1	(b)						
V												
Cr	4592	4620	(a)	4600	4460	(b)	4387	3451	(c)	3968	4037	(a)
Co				57.4	55.4	(b)						
Ni	62	67	(a)	64	62	(b)						
Cu	6	3	(a)									
Zn												
Ga										2.7		(a)
Ge ppb												
As												
Se												
Rb	4	3	(a)							0.54	0.76	(a)
Sr	90	90	(a)	109	99	(b)				92.2	90.7	(a)
Y	23	20	(a)							18		(a)
Zr	88	70	(a)							69		(a)
Nb	12	8	(a)							5		(a)
Mo												
Ru												
Rh												
Pd ppb												
Ag ppb												
Cd ppb												
In ppb												
Sn ppb												
Sb ppb												
Te ppb												
Cs ppm												
Ba				47	39	(b)						
La				5.14	3.88	(b)						
Ce				13.8	11.6	(b)						
Pr												
Nd				9	8	(b)						
Sm				3.64	2.78	(b)						
Eu				0.86	0.78	(b)						
Gd												
Tb				0.77	0.6	(b)						
Dy												
Ho												
Er												
Tm												
Yb				2.28	1.77	(b)						
Lu				0.31	0.25	(b)						
Hf				2.8	2.03	(b)						
Ta				0.4	0.29	(b)						
W ppb												
Re ppb												
Os ppb												
Ir ppb												
Pt ppb												
Au ppb												
Th ppm				0.41	0.29	(b)						
U ppm												

technique (a) XRF, (b) INAA, (c) fused bead, elec. probe

Table 2. Additional trace element data for 15555

	Rb ppm	Sr ppm	U ppm	Th ppm	K %
Chappell et al. 1971	0.68	89.7			
	0.72	91.7			
Murthy et al. 1971	0.7	85.32			
	0.538	74.11			
Tatsumoto et al. 1972	0.874	92			0.0538
			0.1264	0.4596	
			0.1173	0.4296	
Mark et al. 1973	0.675				0.0313
Compston et al. 1972	0.63	89.9			

Other Studies on 15555

	topic
Boyd 1972	pyroxene zoning
Bell and Mao 1972	olivine zoning
Michel-Levy and Johann 1973	petrogaphy
Nord et al. 1973	HTEM , microstructure
Heuer et al. 1972	microstructure
Crawford 1973	plagioclase
Czank et al. 1973	crystallographic details, plagioclase
Wenk et al. 1973	crystallographic details, plagioclase
Wenk and Wild 1973	crystallographic details, plagioclase
Meyer et al. 1974	ion microprobe, plagioclase
Blank et al. 1982	proton microprobe, opaques
Brunfelt et al. 1973	trace element composition, plagioclase, pyroxene
Roedder and Weiblen 1972	immiscible melt inclusions
Weeks 1972	Mossbauer spectra
Burns et al. 1972, 1973	microscopic spectra
Huffman et al. 1972, 1974, 1975	Mossbauer spectra
Simmons et al. 1975	microcracks
Cukierman et al. 1973	recrystallization
Mark et al. 1973	age dating
Husain 1974	age dating
Friedman et al 1972	Pyrolysis, H, C isotopes
Eisenstraut et al. 1972	GC
Gibson et al 1975	Combustion
Kaplan et al. 1976	Combustion, S, C isotopes
DesMarais et al. 1978	Combustion, C isotopes
Allen et al 1973	INAA, Pb etc.
Rosholt 1974	Th isotopes
Fleischer et al. 1973	tracks
Megrue 1973	laser probe, rare gases
Fireman et al. 1972	solar wind rare gas
Collinson et al. 1972, 1973	magnetic data
Pearce et al. 1972, 1973	magnetic data
Dunn and Fuller 1972	magnetic data
Hargraves et al 1972	magnetic data
Nagata et al. 1972, 1973	magnetic data
Schwerer and Nagata 1976	magnetic data
Chung and Westphal 1973	dielectric data
Schwerer et al. 1973, 1974	electrical conductivity
Schwerer et al. 1973	Mossbaurer spectra
Tittmann et al. 1972	seismic wave velocity
Warren et al 1973	seismic wave velocity, pressure
Chung 1973	seismic wave velocity, pressure
Hemingway et al. 1973	specific heat
Adams and McCord 1972	reflectance spectra
Charrette and Adams 1975	reflectance spectra
Brito et al. 1973	thermoluminescence studies
Cukiermann et al. 1973	viscosity
Cukiermann and Uhlmann 1974	viscosity

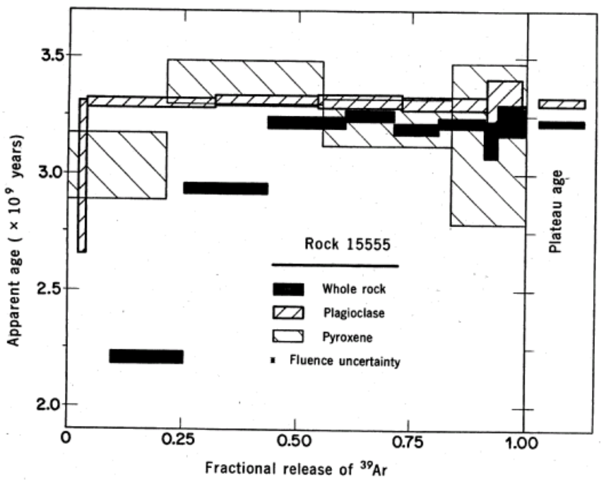

Figure 10: Argon 39/40 plateau ages for plagioclase and whole rock 15555 from Podosek et al. (1972).

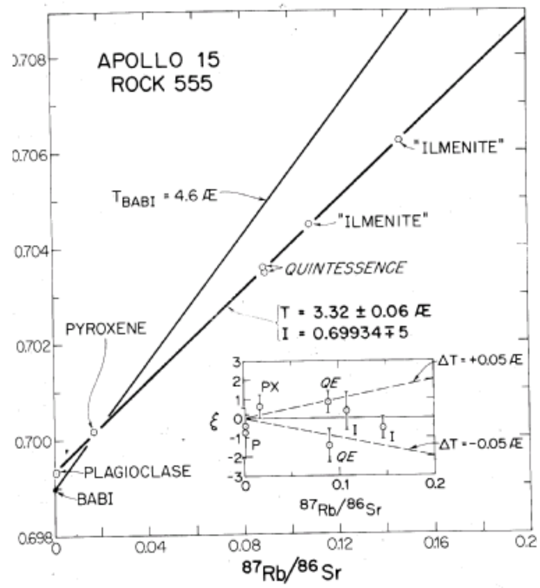

Figure 11: Rb/Sr internal mineral isochron for 15555 from Wasserburg and Papanastassiou (1971).

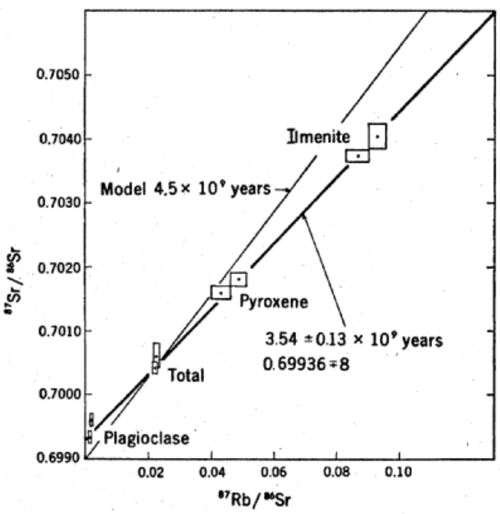

Figure 12: Rb/Sr internal mineral isochron for 15555 (from Chappell et al. 1971).

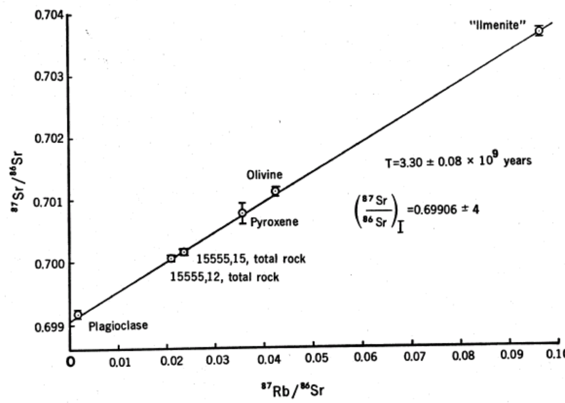

Figure 13: Rb/Sr internal mineral isochron for 15555 (from Murthy et al. 1971).

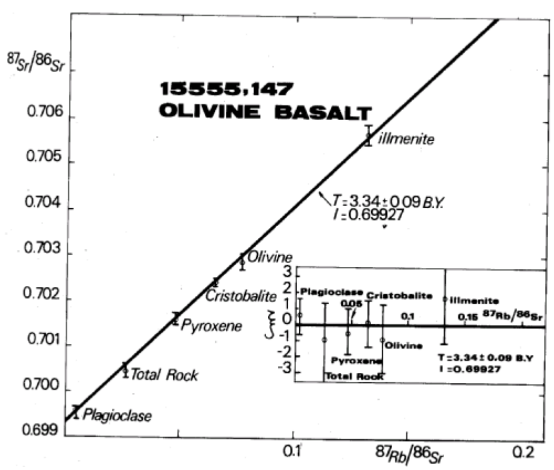

Figure 14: Rb/Sr internal mineral isochron for 15555 (from Birck et al. 1975).

and accuracy that are claimed. In this way, 15555, becomes a sort of control sample for geochronology.

Cosmogenic isotopes and exposure ages

Marti and Lightner (1971) determined the cosmic ray exposure age as 81 m.y. by ^{81}Kr . Podosek et al. (1971) and York et al. (1972) determined exposure ages of 90 m.y. and 76 m.y., respectively, by ^{38}Ar. This age in not associated with any local crater (Arvidson et al. 1975).

The lunar orientation and history of surface exposure is not well documented for 15555 and it has not often been allocated for depth profiles of cosmic ray, solar flare radionuclide studies *(however, see Fireman below)*. The large impact (figure 1) would have caused the rock to jump or role! Behrmann et al. (1972)

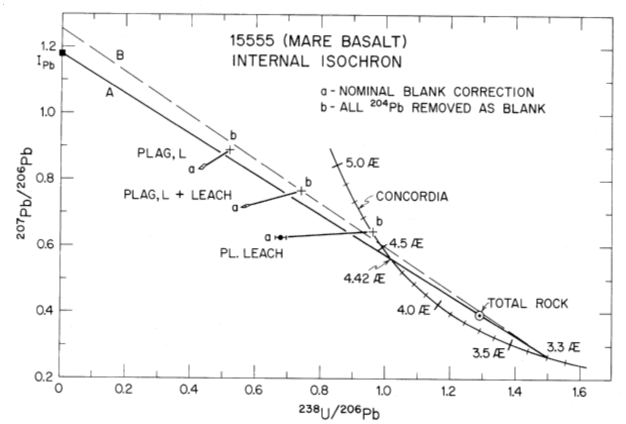

Figure 15: U-Pb data for leaches and "whole rock" splits. Line is drawn thru whole rock data and intersection at 3.3 (the age determined by Rb-Sr) (from Tera and Wasserburg 1971).

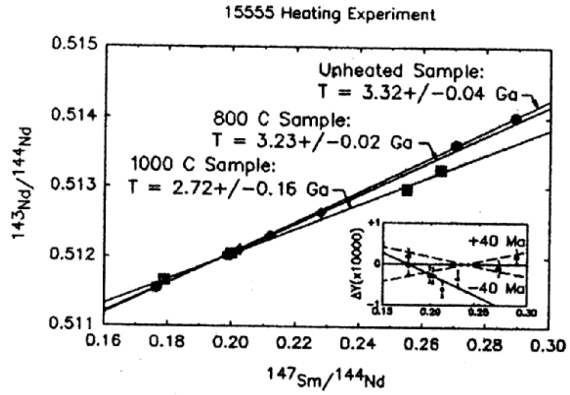

Figure 16: Sm-Nd internal mineral isochron for 15555 from Nyquist et al. (1991). Linear arrays are also determined for heat treated samples, but with lower ages!

determined a track age of 34 m.y. and calculated that the erosion rate was about 1 mm per m.y. On the other hand, Poupeau et al. (1972) also determined the track density and concluded that the sample had been buried beneath the regolith. Bhandari et al. (1972) determined the track density (and suntan age).

Other Studies

Lunar sample 15555 was allocated for many other studies, including physical properties, spectroscopy, thermoluminescence, isotopic analysis (C, S, Th, etc. see table). Supplemental data was collected on companion samples.

Marti and Lightner (1971), Mergue (1973) and Husain (1974) reported the content and isotopic ratios for rare gasses in 15555. Fireman et al. (1972) used measurements of ^{3}H (tritium), ^{37}Ar and ^{39}Ar from different depths in 15555 (and other Apollo samples) to determine the intensity of recent and long term solar flare activity.

Numerous experimental studies have been carried out on 15555 powder and/or synthetic mix *(but what composition should be used?)*. Humphries et al. (1972), Longhi et al. (1972), Kesson (1975) and Walker et al. (1977) determined the mineral phases present at various temperatures and pressures (figures 17 and 18). If, and only if, the composition is correct and the source region contains olivine, pyroxene and plagioclase, then the depth of origin (~200 km) can be concluded from these phase diagrams.

Summary of Age Data for 15555

	Rb/Sr	Ar/Ar	U/Pb	Pb/Pb	Sm/Nd
Chappell et al. 1971	3.54 ± 0.13 b.y.				
Wasserburg, Pap 1971	3.32 ± 0.06				
Alexander et al. 1971		3.33 ± 0.05			
Husain et al. 1971		3.28 ± 0.06			
Murthy et al. 1971	3.3 ± 0.08				
Podosek et al. 1971		3.22 ± 0.03			
plagioclase		**3.31 ± 0.03**			
York et al. 1972		3.31 ± 0.05			
Cliff et al. 1972	3.34				
Papanastassiou, W 1973	3.32 ± 0.04				
Birck et al. 1975	3.34 ± 0.09				
Tatsumoto et al. 1972			3.3 (and 4.65)		
Tera and Wasserburg 1974			3.3 (and 4.42)		
Andersen and Hinthorne 1973				*3.36 ± 0.06*	
				3.46 ± 0.09	
Nyquist et al. (1991)					3.32 ± 0.04
(heated)					*3.23 ± 0.02*

Caution: These ages have not been updated using new decay constants.

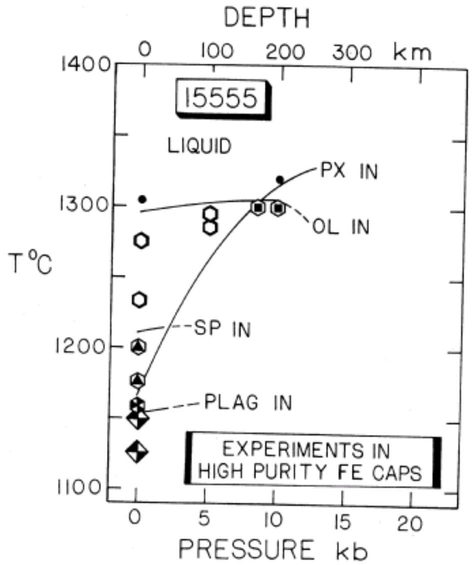

Figure 17: Experimental phase diagram for 15555 from Walker et al. (1977).

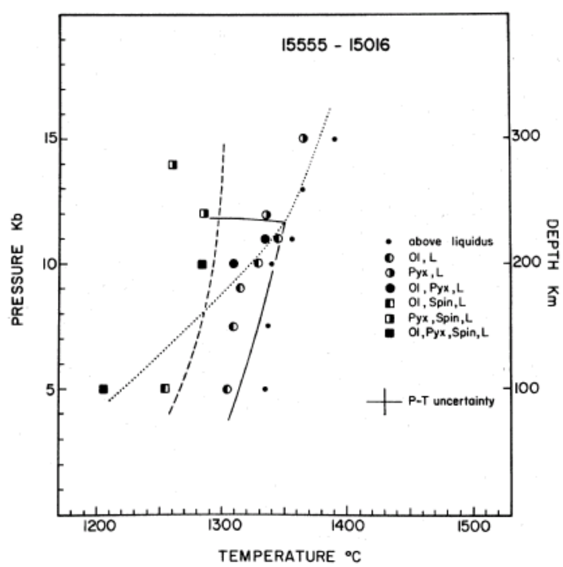

Figure 18: Experimental phase diagram for 15555 by Kesson (1975).

Processing

Two slabs, cut at right angles, were made from this rock for allocations (figures 19-21). Slab ,46 is illustrated in figure 21. Slab ,57 was cut from ,48 and used for many allocations.

This large rock has been used to prepare 13 lunar sample displays, one of which is illustrated in figure 22. These are located in Edmonton, Geneva, Oakland, Yorba Linda, Denver, Washington D.C., Illinois, Kansas, Boston, Michigan, Philadelphia, Austin and Utah. Three thin sections of 15555 are also on display.

List of NASA photo #s for 15555

S71-43390-43394	color, dusty
S71-43952-43954	dust free
S71-51781-51795	TS
S71-52201	TS
S71-52213	TS
S71-57110	after slab cut, B&W
S71-57987	exploded parts, slab
S74-23072	TS
S74-31406-31413	,461 - ,463
S75-33416-33421	,56
S79-27098-27100	set of thin sections
S85-29591-29600	,791 - ,463
S90-37023	,160
S93-45953-45962	,838
S96-09087	,880
S97-16866	,880

,45 ,47

Figure 19: First saw cuts of 15555. Photo number S71-57110. Cube is 1 inch.

Figure 20: Sawing slab. Photo # S71-57094.

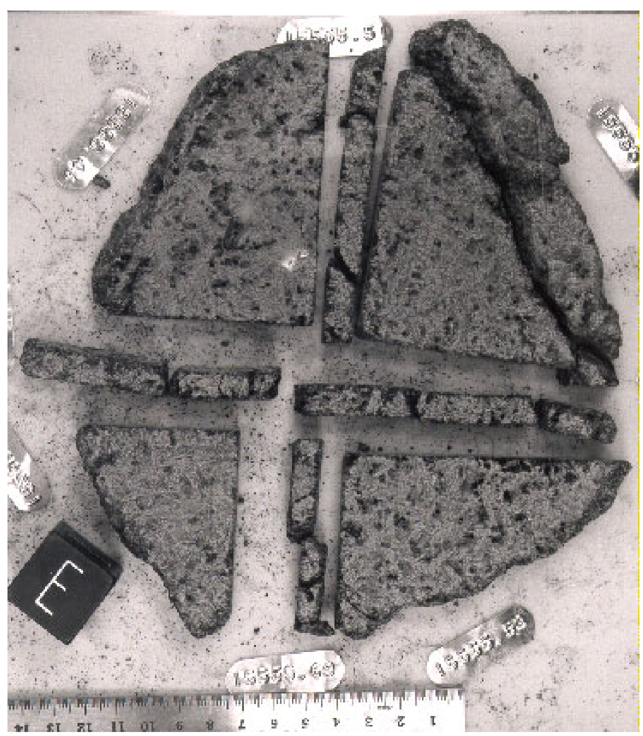

*Figure 21: Parts diagram for slab 15555,46.
Photo # S71-57987. Cube is 1 inch.*

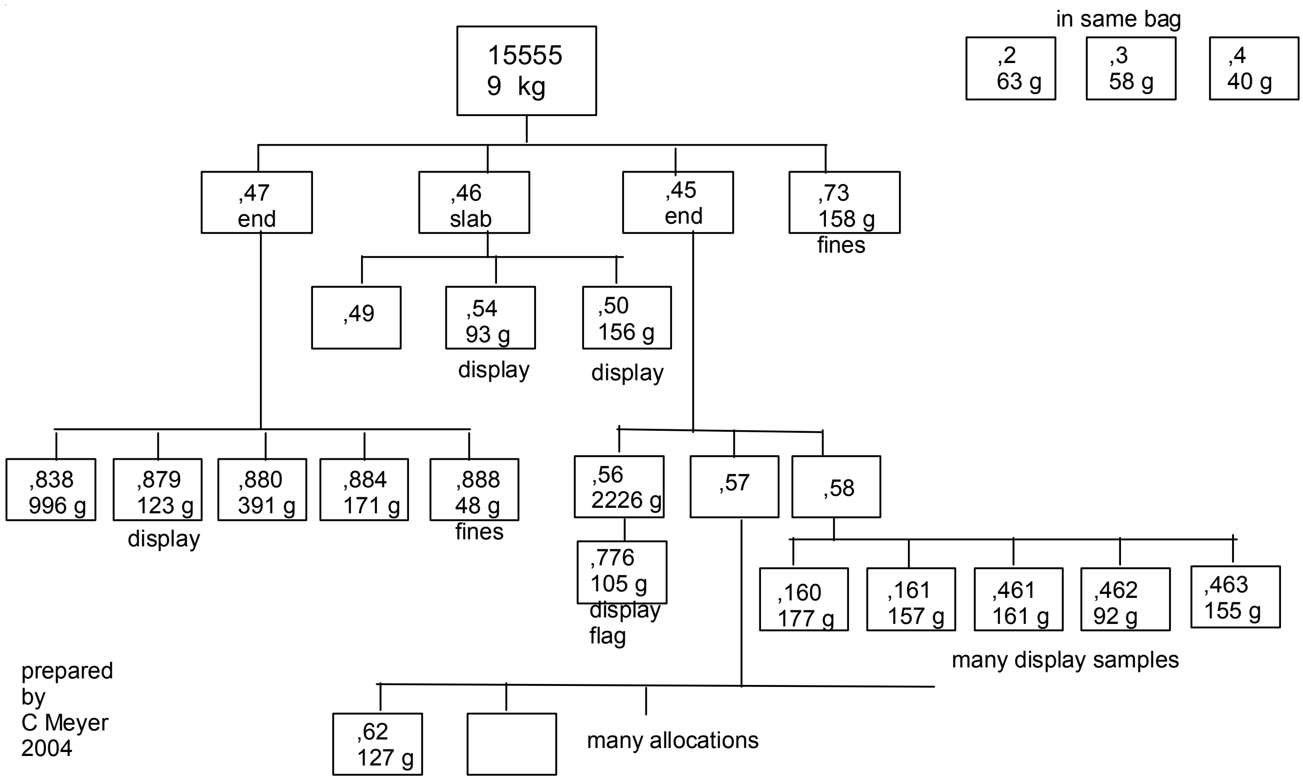

Figure 22: Display case with 15555,160. Case is made from optical glass and filled with dry nitrogen.

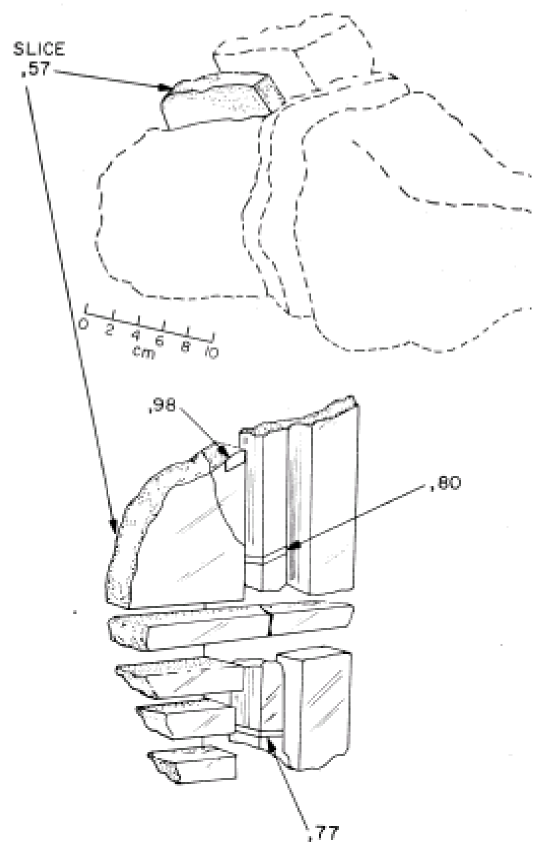

Figure 23: Location of samples studied by Fireman et al. (1972) in second slab (,57) cut from 15555,45.