15459 REGOLITH BRECCIA ST. 7 5854 g

INTRODUCTION: 15459 is a tough, glassy-matrix, glass ball-and glass shard-bearing regolith breccia. One large mare basalt clast in it has been dated as 3.3 b.y. old. 15459 is medium dark gray, blocky, and fractured (Fig. 2). It has fresh surfaces where it was broken off, zap pits elsewhere, and some vesicular splash glass coating as well as slickensides. Originally it was studied in a consortium headed by P. Gast.

The sample was collected on the northeast inner wall of Spur Crater, about 6 m southeast of the rim crest. It was taken from the center of a 30 x 30 x 15 cm rock (Fig. 1) that the CDR said looked as if it had "layering in it." A large fractured block lay immediately adjacent to it on the southeast (Fig. 1), and both it and 15459 were buried from one-third to one-half their height.

PETROLOGY: 15459 is a tough indurated breccia with small light-colored clasts dominant (Fig. 2). There is actually a diversity of clast types, including mare basalts, plutonic norites, impact melts, and numerous types of glass balls, shards, and schlieren (Figs. 3, 4). Light clasts appear to range from anorthosites or plagioclase to leucobasalts with pale green mafic minerals. Less abundant are gray lithic clasts and mafic mineral fragments. The glasses include black, green, and orange types. The matrix is dense and glassy, and thin glass veins and selvages on clasts are common.

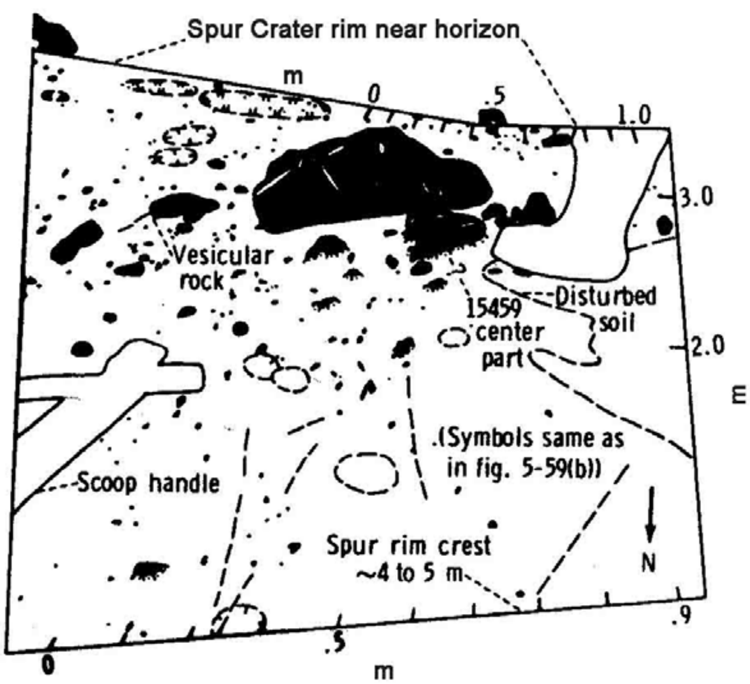


Figure 1. Presampling sample environment sketch map.

McKay and Wentworth (1983) found the sample to be compact, with a high fracture porosity, rare agglutinates, and common spheres, and with abundant shock features. Wentworth and McKay (1974) found its bulk density to be quite high, 2.84 g/cc. McKay et al. (1974) reported an I_s/FeO of 17-27 (25 in Korotev, 1984 unpublished), a submature index. According to Nagle (1982), 15459 shows the combination of characteristics expected in a rock produced by subcrater lithification, and its fabric is lineated rather than foliated.

Ridley (1975, 1977) briefly described the matrix and the glasses. The matrix contains numerous spherical glass particles of varied types, including Apollo 15 Green Glass, other mare types, and KREEP, for which Ridley (1977) provided group averages (Table 1). There are no glasses equivalent to the local quartz-normative basalts, nor to "highland basalt," and in fact highland glasses other than KREEP are rare. The glass group abundances are similar to those of soils around Spur Crater, as is the bulk composition, suggesting that 15459 is an indurated local soil.

Fig. 2a

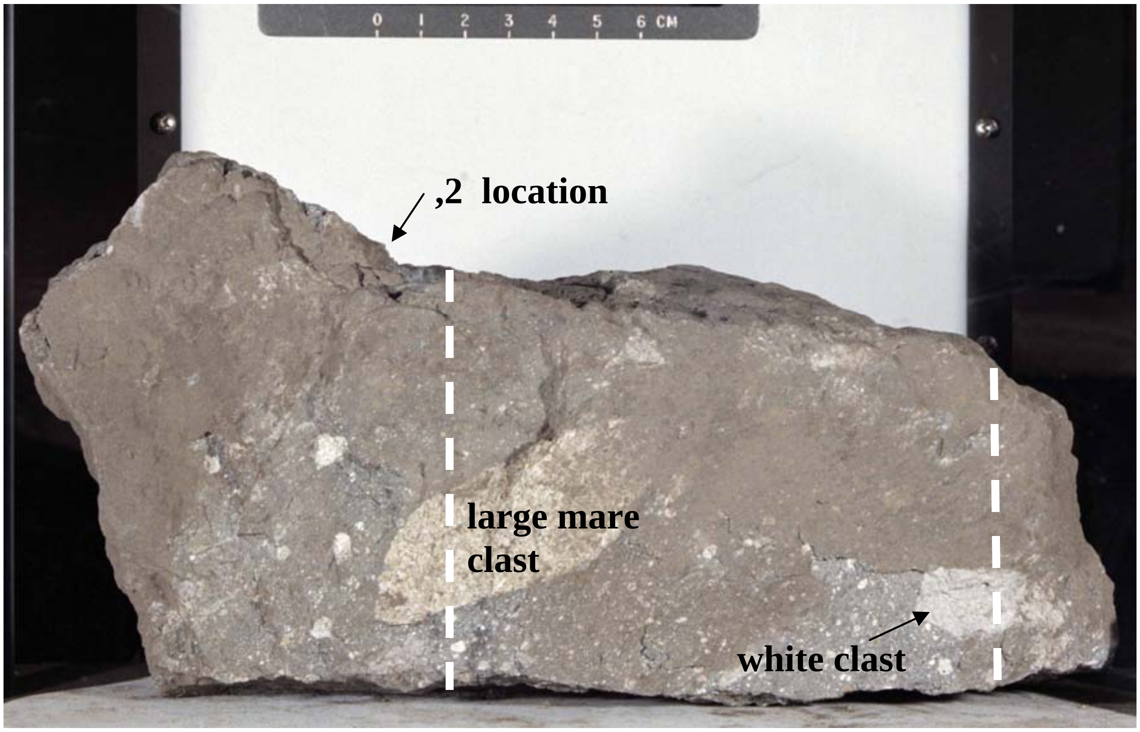


Fig. 2b

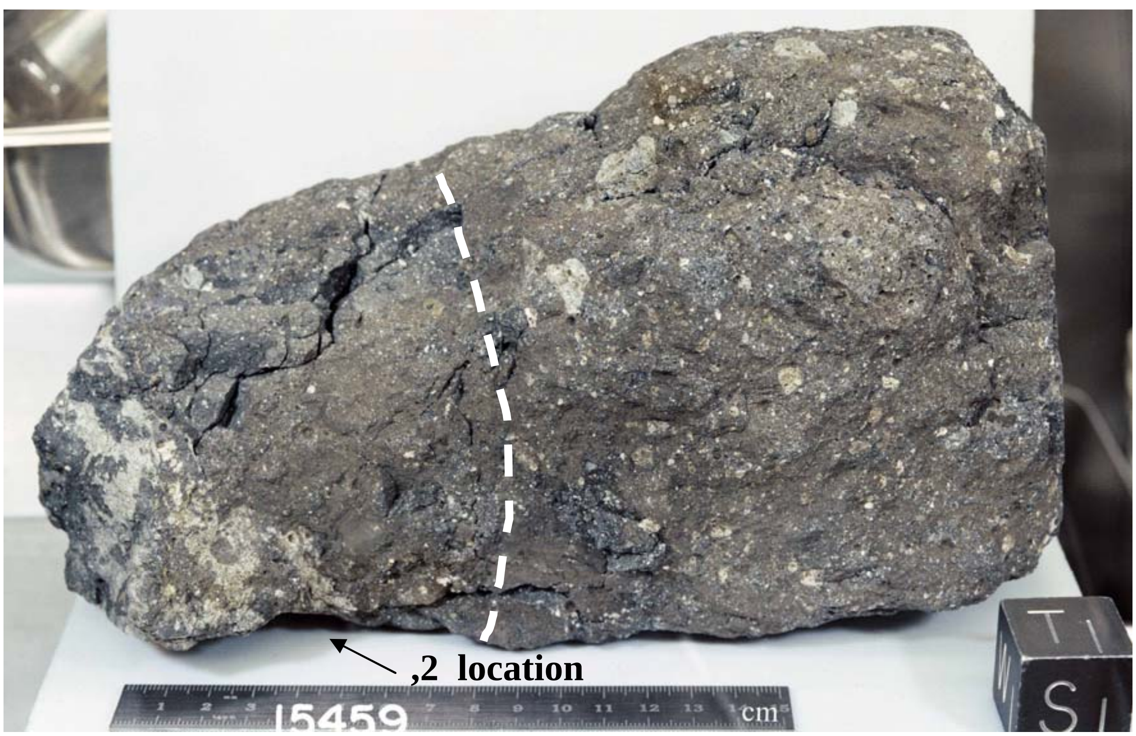


Fig. 2c

Figure 2. (a) 15459,0 presawing; S-71-44176 (b) presawing, showing approximate locations of subsequent sawcuts; S-71-44181 (c) first post-sawcut, showing approximate location of section sawcut. S-75-32550

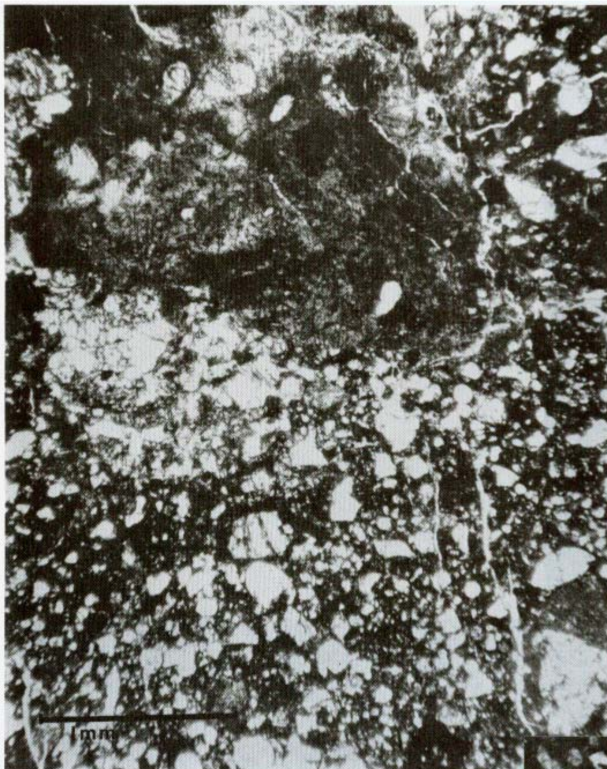


Fig. 3a

Fig. 3b

Figure 3. Photomicrographs of matrix in 15459, 14, transmitted light.

Fig. 4a

Fig. 4b

Fig. 4c

Fig. 4d

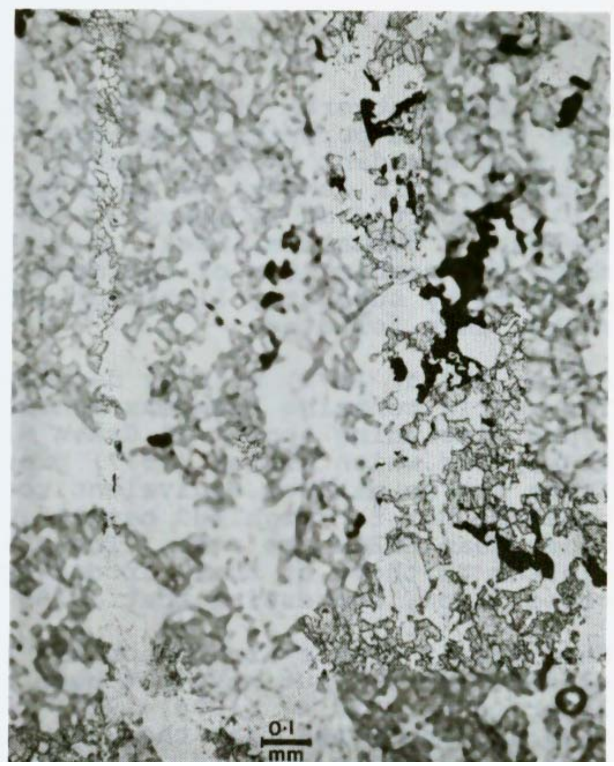


Fig. 4e

Figure 4. Photomicrographs of clasts
(a) 15459,124, large basalt, transmitted light;
(b) as (a), crossed polarizers;
(c) 15459,14 crushed basalt zone, transmitted light;
(d) 15459,125, poikilitic impact melt clast, transmitted light;
(e) 15459,125, matrix (right) and coarse norite (left), transmitted light.

Mare basalt clasts are common and include the prominent large clast (Fig. 2), but have not been much described in the literature. Ridley (1976, 1977) reported some data, referring to gabbros, and noted that they are similar to, but coarser grained than, local mare basalts. The pyroxene diagram shown in Ridley (1977) (Fig. 5) is of data from the large basalt clast, and shows pigeonite cores zoned to augite rims. Ridley (1976, 1977) also reported zoned olivine (Fo_{61-55}), plagioclase, spinel, and ilmenite in mare gabbros. The thin sections of the large clast show a coarse, pyroxene-rich mare basalt, sheared but not ground up (Fig. 4a,b). This large basalt has a chemistry (below) consistent with its being more mafic than typical mare basalts, and it is perhaps a pyroxene cumulate. It is the mare basalt which has been dated as 3.3 b.y. old (below). Other clasts of basalt are crushed (Fig. 4c). The "smeared" light zone, referred "anorthositic" are almost certainly the to in data packs as crushed basalts in the thin sections: chip ,2 (from which the thin sections which show cm-sized zones of crushed basalt were made) is from this zone (Fig. 2) and macroscopically the zone can be seen to contain laths of ilmenite. These crushed basalts do not appear to contain much olivine, but do contain cristobalite and patches of glassy mesostasis up to 1 mm across.

TABLE 1. Average glass compositions in 15459 matrix.

	1	2	3	4	5	6	7	8	9
SiO_2	45.24	45.43	49.52	46.40	44.11	35.38	37.64	42.93	43.95
TiO_2	0.34	0.42	1.37	0.85	0.05	13.64	12.04	3.11	2.79
Al_2O_3	7.53	7.72	17.08	19.47	30.90	7.26	8.46	8.89	8.96
Cr_2O_3	0.45	0.43	0.19	0.17	0.03	0.64	0.48	0.46	0.46
FeO	19.51	19.61	9.37	8.34	3.53	21.42	19.93	21.72	21.10
MgO	17.55	17.49	9.07	12.49	3.51	12.10	10.49	12.37	12.30
CaO	8.23	8.34	10.65	11.39	17.23	7.66	8.81	8.68	9.02
Na_2O	0.13	0.12	0.63	0.53	0.13	0.52	0.54	0.39	0.27
K_2O	0.01	~0.01	0.50	0.18	0.01	0.14	0.13	0.08	0.05
Total	98.98	99.57	98.38	99.82	99.49	98.76	98.52	98.63	98.90

1, Green glass. 2, Average green glass composition in three Apollo 15 soils (Reid *et al.* 1972). 3, Medium-K kreep. 4, Low-K kreep. 5, 'Anorthositic' component. 6, High-Ti mare basalt. 7, 'Mare 4' glasses in Apollo 15 soils (Reid *et al.* 1972). 8, Mare glasses. 9, 'Mare 3' glasses in Apollo 15 soils (Reid *et al.* 1972).

Average abundances:	15459	A-15 soil
Green glass	43%	34%
Low-K kreep	13%	15%
Medium K kreep	20%	22%
'Anorthosite'	2%	
Mare	22% (High-Ti 2%)	22%

The other large clast (Fig. 2) is pale colored and fine-grained. There is some doubt as to its characteristics, because the chip taken for thin sections was not photographed, and the thin sections contain a poikilitic impact melt, a coarse norite, and matrix. The poikilitic impact melt dominates the relevant thin sections (Fig. 4d) and a later thin section specifically from the clast is a poikilitic impact melt. This clast type has been described by Ridley (1976, 1977) and Ridley and Adams (1976), in which it is described as poikiloblastic, and is also depicted by Reid et al. (1977). The clast contains unzoned, 1 mm-sized, orthopyroxene oikocrysts containing thin exsolution lamellae of augite. Pyroxene analyses (Fig. 6) are given in Ridley (1977) (some of the analyses appear to be erroneously listed by Ridley as cols. 11 and 12 instead of cols. 9 and 10), and are consistent with the compositions given by Reid et al. (1977) of $En_{71}Wo_{55}$ for oikocrysts. The oikocrysts contain chadacrysts of plagioclase (An_{92}) and olivine (Fo_{70}). There are also ilmenites (4% MgO), rare Al-Ti chromites, olivine fragments, and plagioclase clasts (cores homogeneous An_{92}, thin rims An_{69}). From a variety of px-ol "thermometers" Ridley (1977) and Ridley and Adams (1977) calculated equilibration temperatures close to solidus temperatures, hence prefer a metamorphic interpretation (however, the characteristics and textures are very similar to some of the Apollo 17 "melt-sheet" rocks). The x-ray diffraction data of Takeda (1973) is probably from this poikilitic clast (see below).

The coarse norite (Fig. 4e) contains exsolved and inverted pigeonites and plagioclases up to 1 mm across. According to Ridley (1976) the plagioclase is An_{88-92}, and to Ridley (1977) the pyroxene is $\sim En_{60}Wo_{10}$ in bulk composition (Fig. 6) (again, note the apparent switching of cols. 9 and 10 with 11 and 12 in Table 4 of Ridley, 1977). Takeda (1973) studied this clast by microprobe and x-ray diffraction, concluding that the pyroxene is inverted pigeonite, estimating a bulk composition of $En_{57}Wo_{10}$ from microprobe data. However, he noted that probe analyses of the pyroxene taken for x-ray diffraction are more magnesian ($En_{68}Wo_9$ bulk). Ridley (1977) referred to the x-ray diffraction data as being from the poikilitic clast, and this is probably correct (despite Takeda's 1973 disavowal) because ,38 from which the grains were taken was mainly the poikilitic clast. The situation is quite confusing, because both the chemical data and the isotopic data (below) for fragments from the white clast appear to be unlike other poikilitic impact melts such as the Apollo 17 "melt-sheet" samples, and would be more compatible with a pristine noritic lithology.

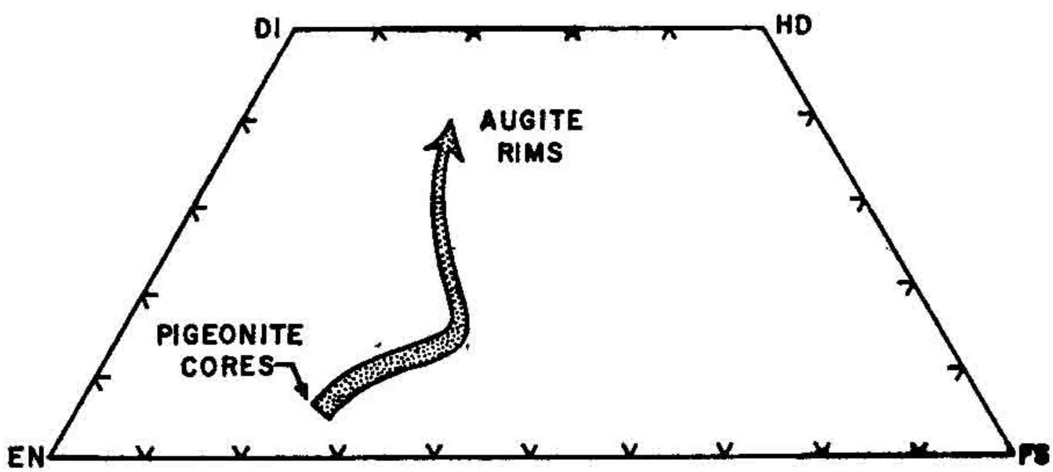
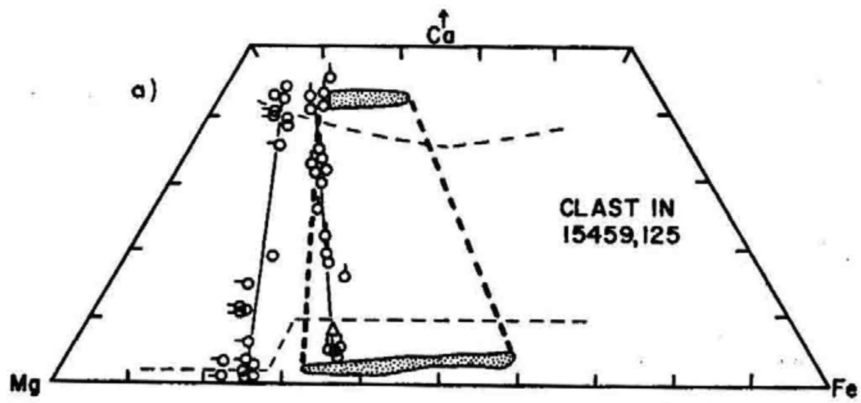
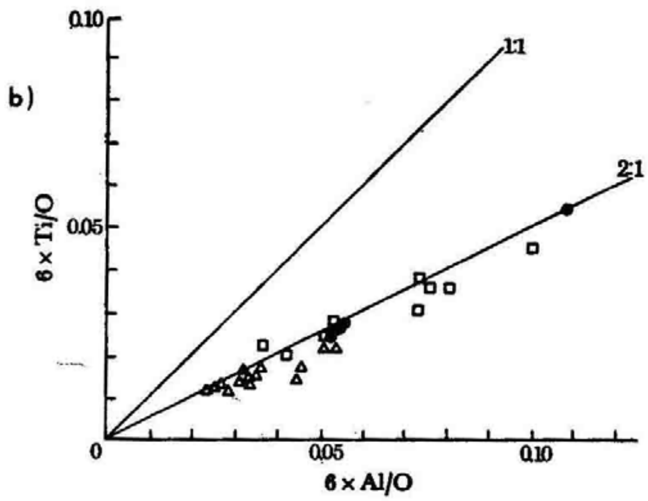


Figure 5. Zoning trends in pyroxenes in basalt 15459,124
(Ridley 1977).



Composition of pyroxenes in clasts in breccia 15459. Solid lines are tie lines between coexisting Ca-rich and Ca-poor pyroxenes. Shaded areas are range in composition of exsolved pyroxenes in Apollo 16 breccias. Dashed lines are coexisting pyroxenes from the Skaergaard Intrusion. Circles with vertical bar are inverted pigeonites from a plutonic norite clast. Intermediate compositions represent analyses where the microprobe beam was unable to resolve host and lamellae. Triangle represents bulk analyses of inverted pigeonite. Circles with horizontal bars are exsolved orthopyroxene oikocrysts in a poikiloblastic clast. Circles represent coexisting orthopyroxene and augite chadacrysts in the same clast.



Ti-Al relations in pyroxenes plotted in figure a. Note the close adherence to Al : Ti = 2 : 1 line indicating the presence of $R^{2+}TiAl_2O_6$ component. △, exsolved inverted pigeonites in plutonic norite; □, exsolved orthopyroxene oikocrysts; ●, coexisting orthopyroxene-augite chadacrysts in a poikiloblastic clast.

Figure 6. Pyroxenes in 15459,125 (Ridley 1977).

Ridley (1976, 1977) also referred to another type of light-colored clast ("coarse norite with intergranular texture" or "diabasic-textured KREEP norite") which has zoned plagioclases and pyroxenes. The pyroxene zones from orthopyroxene (up to 4% Al_2O_3) to ferropigeonite, and plagioclase from An_{86-78}. They also contain Ti-Al chromites, Cr-Al ulvospinel, ilmenite, and rare armalcolite. Pyroxene compositional relationships are shown in Figure 8. This clasts(s) is evidently an Apollo 15 KREEP basalt.

McDougall et al. (1973) noted that glass spheres in 15459 are commonly shattered or heavily fractured, an apparent record of in situ shock or stress. The crystalline components show no evidence of post-breccia formation shock. From the preservation of solar flare tracks in olivine, they concluded that 15459 has never been above a temperature of ~400°C.

The only other published petrographic data on 15459 are by Muller et al. (1973) and Wenk et al. (1973), who found b- and c-type antiphase domains in a plagioclase grain, which is unidentified except for being $An_{94.7}$ and 0.5 mm across.

<u>CHEMISTRY</u>: Allocations for chemical analyses of the matrix and of the two larger clasts were made, and published data is listed in Tables 2-4. Rare earths are shown in Figure 9. In most cases there is little specific discussion of the analyses, even to the extent of what the analysis was of. Table 4 also lists an analysis of a second white clast analyzed by S.R. Taylor et al. (1973). In addition to the listed data, Janghorbani et al. (1973) also analyzed specifically for oxygen in the three lithologies (matrix 46.1%, basalt 43.0%, poikilitic melt 42.6%). Friedman et al. (1972) combined their two clast allocations (,30 and ,37) together for analysis, finding 22 ppm C; they also analyzed this combination for hydrogen (8 ppm), and found 38 ppm hydrogen in the matrix.

The matrix is aluminous and elevated in rare-earths compared with mare basalts and anorthositic lithologies. It corresponds roughly with low-K Fra Mauro which is a common glass composition within 15459 and Apollo 15 soils.

The mare basalt is much more magnesian than local large samples of mare basalt. Its rare-earth pattern is similar to other Apollo 15 mare basalts, both olivine and quartz-normative. The major element data are not complete enough to demonstrate whether the sample belongs to one of those two groups or to yet another. Wolf and Anders (1980) noted that it has "suspiciously high Ir, Re, Au and Ge contents, due either to its slight (<4%) contamination with matrix or to its mafic character." Hence they excluded the siderophile data from consideration with basalts in general.

The poikilitic clast chemistry is generally consistent with its mineralogy, including an Mg' of 75. The Ir content of 2.2 ppb suggests a meteoritic contribution. The rare-earth pattern, however, is quite unusual in having a positive Eu anomaly, and it is much flatter than a KREEP pattern. The other light clast analyzed by S.R. Taylor et al. (1973) has a pattern more like KREEP, but at low enough abundances to eliminate any significant Eu anomaly.

<u>STABLE ISOTOPES</u>: Friedman et al. (1972) reported hydrogen and carbon isotopic analyses for matrix and for a combination of the mare and poikilitic melt clasts (Table 5).

<u>RADIOGENIC ISOTOPES AND GEOCHRONOLOGY</u>: Stettler et al. (1973) determined a ^{40}Ar-^{39}Ar age of 3.33 ± 0.06 b.y. from the intermediate temperature release (Fig. 10). The release shows a high temperature drop-off. This age is the same as other Apollo 15 mare basalts.

TABLE 15459-2. Matrix

		,98	,74	,100	,99	,98	,0	,98	,97	,70	,1	,226
Wt %	SiO2				45.8				46.6			
	TiO2	0.9107			2.0a			0.911	1.02			1.11
	Al2O3				17.8				17.2			17.0
	FeO				11.0,11.1b			9.4	11.2			11.6
	MgO				11.8			10.0	11.4			12.3
	CaO							11.2	11.6			10.8
	Na2O				0.35			0.42	0.36,0.41			0.42
	K2O	0.1534					0.165	0.1530	0.16			
	P2O5									0.15		
(ppm)	Sc		23.0		21,20							22.0
	V		96.0									69
	Cr		2150		1800,1830				1900			2080
	Mn				1190				1000			1220
	Co		42.0		45,41							48.5
	Ni		232									213
	Rb		3.4			3.76		3.76	2.92			
	Sr		108			129.5		130				130
	Y		63.0						46.0			
	Zr	215	294.0		220c				240			220
	Nb		19.0						15.6			
	Hf	5.4	6.2		5.69,5.35				4.5			5.6
	Ba		230					157	160			157
	Th		3.71				2.9		2.52			2.4
	U	0.771	0.87				0.70	0.771	0.62	0.69		0.68
	Pb		3.3						3.5			
	La		19.0					14.7	15.0			14.2
	Ce		51.0					37.0	41.0			38
	Pr		6.5						5.3			
	Nd		27.0					22.9	20.9			21
	Sm		8.7					6.60	5.6			6.71
	Eu		1.18		1.1,1.3			1.15	0.83			1.08
	Gd		11.5						7.1			
	Tb		1.74		0.97				1.14			1.35
	Dy		10.8					9.14	7.3			
	Ho		2.68						1.83			
	Er		7.7					5.62	5.1			
	Tm		1.2						0.78			
	Yb		7.2					5.08	4.7			5.02
	Lu							0.858	0.73			0.696
	Li											
	Be											
	B											
	C			50							85	
	N											
	S											
	F									82		
	Cl									17		
	Br									0.387		
	Cu		4.4									
	Zn											
(ppb)	I									660		
	At											
	Ga		4100									
	Ge											
	As											
	Se											
	Mo											
	Tc											
	Ru											
	Rh											
	Pd											
	Ag											
	Cd											
	In											
	Sn		90						210			
	Sb											
	Te											
	Cs		150						130			180
	Ta				880,1100							680
	W								120			
	Re											
	Os											
	Ir											5.5
	Pt											
	Au											1.3
	Hg											
	Tl											
	Bi											
		(1)	(2)	(3)	(4)	(5)	(6)	(7),(13)	(8)	(9)	(10)	(14)

References for Tables 15459-2 through 15459-4

References and methods, Tables 2 to 4:

(1) Church et al. (1972); ID/MS
(2) S.R. Taylor et al. (1972, 1973); Spark source emission spec.
(3) Friedman et al. (1972); Combustion
(4) Janghorbani et al. (1973), Chyi and Ehmann (1973), Garg and Ehmann (1976); NAA
(5) Nyquist et al. (1972, 1973); ID/MS
(6) Keith et al. (1972); Gamma ray spec.
(7) Hubbard et al. (1973); ID/MS
(8) S.R. Taylor et al. (1973)
(9) Jovanovic and Reed (1975)
(10) Moore et al. (1972)
(11) Ganapathy et al. (1973); RNAA
(12) Stettler et al. (1973); MS
(13) Wiesmann and Hubbard (1975); ID/MS
(14) Korotev (1984 unpublished); INAA

Notes:

(a) authors reservations on accuracy.
(b) reactor NAA
(c) corrected value from Garg and Ehmann (1976)
(d) corrected value from Higuchi et al. (1975)

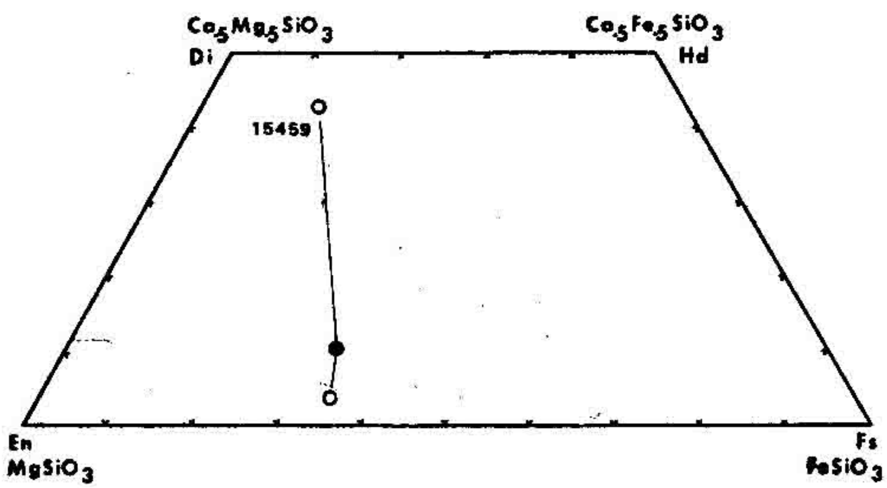


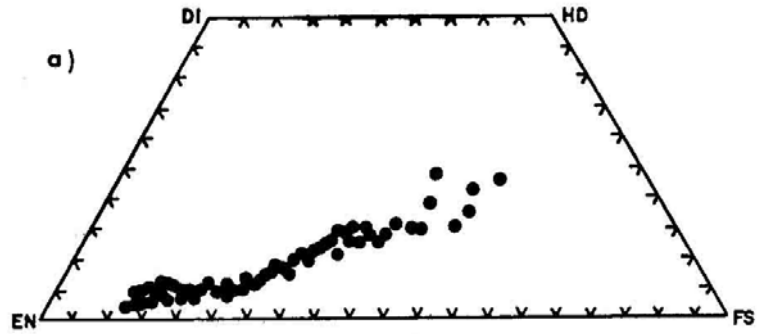
Figure 7. Pyroxenes in norite clast in 15459,125 (Takeda 1973).

Nyquist et al. (1972, 1973) reported whole rock Rb-Sr isotopic data for matrix (,98), mare basalt (,31), and the poikilitic clast (,38) (Table 6). The mare basalt data are consistent with a pyroxene-rich Apollo 15 mare basalt of 3.3 b.y. age. The light clast shows a very low $^{87}Sr/^{86}Sr$ ratio for its alumina content, quite different from most KREEP-rich impact melts.

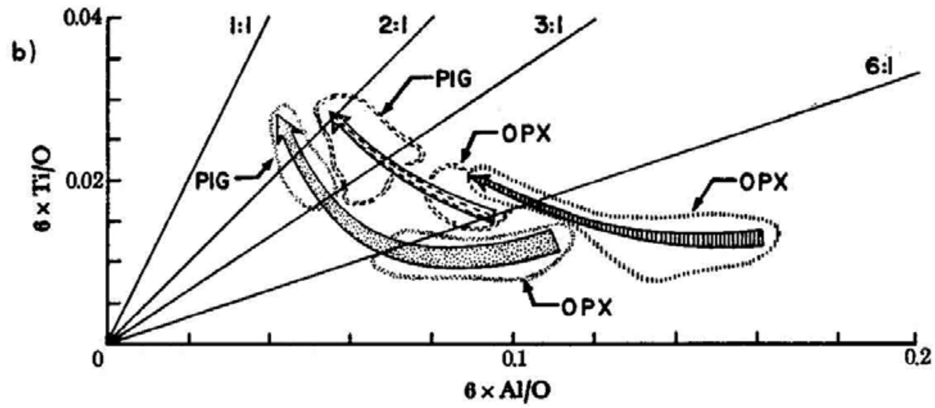
TABLE 15459-3. Large mare clast

		,29	,28	,32	,31
WT %	SiO_2	51.1			
	TiO_2				2.0
	Al_2O_3	5.3			
	FeO	18.7b			
	MgO	24.2			17.3
	CaO			7.7	7.6
	Na_2O				0.19
	K_2O			0.0380	0.0389
	P_2O_5				
(ppm)	Sc	43			
	V				
	Cr	750			
	Mn	2050			
	Co	69	84		
	Ni				
	Rb		0.20		0.697
	Sr				54.9
	Y				
	Zr	48.6			
	Nb				
	Hf	1.17			
	Ba				46.7
	Th				
	U		0.107		0.16
	Pb				
	La				5.13
	Ce				14.2
	Pr				
	Nd				10.2
	Sm				3.25
	Eu	0.67			0.611
	Gd				4.40
	Tb	2.0			
	Dy				4.72
	Ho				
	Er				2.92
	Tm				
	Yb				2.21
	Lu				0.321
	Li				4.2
	Be				
	B				
	C				
	N				
	S				
	F				
	Cl				
	Br		0.033		
	Cu				
	Zn		0.93		
(ppb)	I				
	At				
	Ga				
	Ge		23		
	As				
	Se		66		
	Mo				
	Tc				
	Ru				
	Rh				
	Pd				
	Ag		0.34		
	Cd		3.2		
	In		0.85		
	Sn				
	Sb		0.042		
	Te		1.8		
	Cs		19d		
	Ta	990			
	W				
	Re		0.0105		
	Os				
	Ir		0.090		
	Pt				
	Au		0.081		
	Hg				
	Tl		0.08		
	Bi		0.39		
		(4)	(11)	(12)	(13)

For references and methods, see Table 15459-2.



Variation in composition of pyroxenes in a diabasic-textured kreep norite clast 15459, 19. Note the continuity of pyroxene compositions from cores of aluminous bronzite to rims of intermediate pigeonite.



Ti-Al relations in pyroxenes plotted in figure a. Note the core bronzites have Al:Ti > 6:1, indicating the presence of $R^{2+}Al_2SiO_6$ component reflecting high alumina activity in the basalt melt. During crystallization the Al:Ti ratios approach 2 and in some crystals <2, suggesting the presence of divalent Cr or trivalent Ti.

Figure 8. Pyroxenes in "diabasic-textured KREEP norite" in 15459,19 (Ridley 1977).

<u>EXPOSURE AND TRACKS</u>: Stettler et al. (1973) determined a ^{38}Ar exposure age of 520 m.y. for the mare basalt sample. There is always a possibility that this basalt retains a record of exposure prior to incorporation into the breccia (see below). Keith et al. (1972) provided data on cosmogenic radionuclides (^{26}Al, ^{22}Na, ^{54}Mn, ^{66}Co, and ^{46}So). The ^{26}Al is saturated (Keith et al. 1972, Yokoyama et al. 1972), indicating an exposure of more than ~2 m.y. Track densities (Bhattacharya et al. 1975) for interior chips are in the range (6-20) x 10^6 cm^{-2}, indicating a surface exposure age of less than 10 to 30 m.y.

McDougall et al. (1973) studied solar flare tracks in 15459, finding evidence for solar flare irradiation prior to breccia formation for the mare clast. The preservation of tracks in matrix olivines and their high densities in matrix plagioclases preclude heating above 400°C during the formation of the breccia.

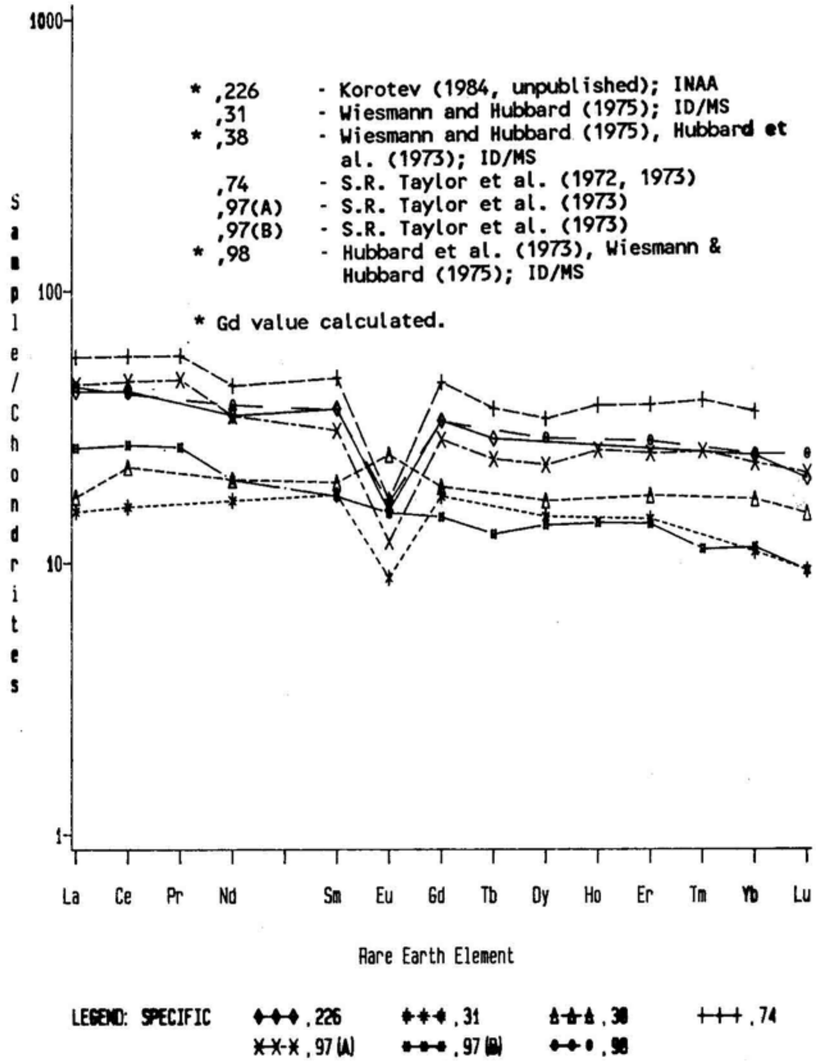


Figure 9. Rare earth elements in materials from 15459.

PHYSICAL PROPERTIES: Collinson et al. (1972, 1973) reported magnetic data, including the effects of demagnetization, for two matrix splits (Fig. 11). 15459,95 is different from crystalline rocks in that it has no strong soft component, and a high intensity (10 x 10^{-6} emu/g) of hard NRM, stable above 100 Oe. Iron is the carrier (thermal demagnetization experiments). 15459 has a strong viscous remanent magnetism. The overall data are not inconsistent with the NRM being acquired by thermoremanence in a weak lunar field, but the detailed history is complicated. Brecher (1975, 1976) listed 15459 as a sample with an NRM showing directional change under demagnetization which is rotational in a plane, compatible with her model of "textural remanence" (in this model, the magnetic characters are produced by partial alignment of grain magnetic moments, not any ancient fields).

TABLE 15459-4. White clasts.

		,36	,35	,38	,97
Wt %	SiO2	46.0			46.9
	TiO2	2.0a		1.7	0.32
	Al2O3	20.1			23.5
	FeO	7.9b			5.85
	MgO	14.6a		9.8	9.43
	CaO			12.5	13.7
	Na2O	0.38		0.73	0.41
	K2O			0.1046	0.08
	P2O5				
(ppm)	Sc	16			
	V				
	Cr	920			1640
	Mn	940			
	Co	19	20		
	Ni				
	Rb		0.27	1.69	0.78
	Sr			205.3	
	Y				30
	Zr	116c			
	Nb				
	Hf	2.97			1.6
	Ba			119.1	101
	Th				1.03
	U		0.420	0.35	0.29
	Pb				1.1
	La			5.80	8.8
	Ce			19.9	24.0
	Pr				3.0
	Nd			12.2	12.2
	Sm			3.60	3.2
	Eu	1.9		1.74	1.06
	Gd				3.7
	Tb	2.9			0.6
	Dy			5.37	4.4
	Ho				0.99
	Er			3.56	2.8
	Tm				0.34
	Yb			3.44	2.3
	Lu			0.523	0.32
	Li				
	Be				
	B				
	C				
	N				
	S				
	F				
	Cl				
	Br		0.048		
	Cu				
	Zn		2.1		
(ppb)	I				
	At				
	Ga				
	Ge		8.9		
	As				
	Se		50		
	Mo				
	Tc				
	Ru				
	Rh				
	Pd				
	Ag		0.48		
	Cd		7.8		
	In		0.63		
	Sn				120
	Sb		0.11		
	Te		6.4		
	Cs		100d		
	Ta	890			
	W				90
	Re		0.109		
	Os				
	Ir		2.2		
	Pt				
	Au		0.20		
	Hg				
	Tl		0.43		
	Bi		0.69		
		(4)	(11)	(13)(7)	(8)

For references and methods, see Table 15459-2.

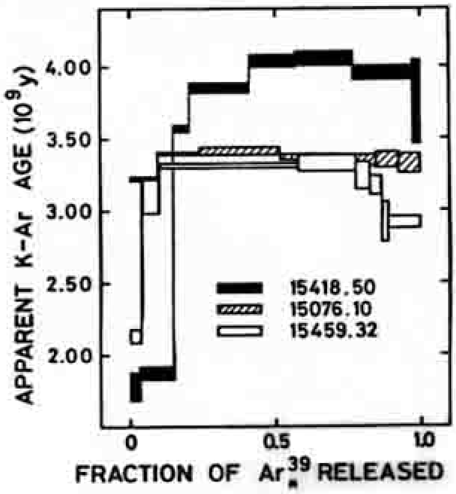


Figure 10. Ar release diagram (Stettler et al., 1973).

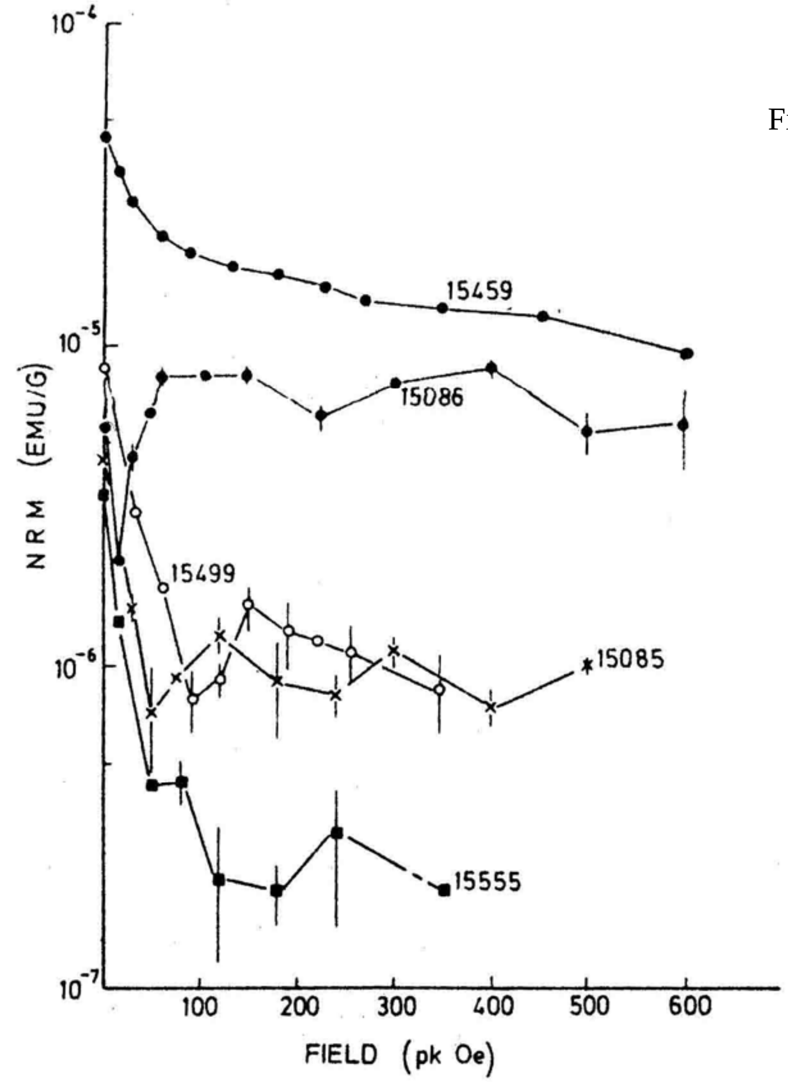
TABLE 15459-5. H and C isotopes

	δD	$\delta^{13}C$
,100 matrix	-200	-25
,30 + ,37 comb.	-346	-22

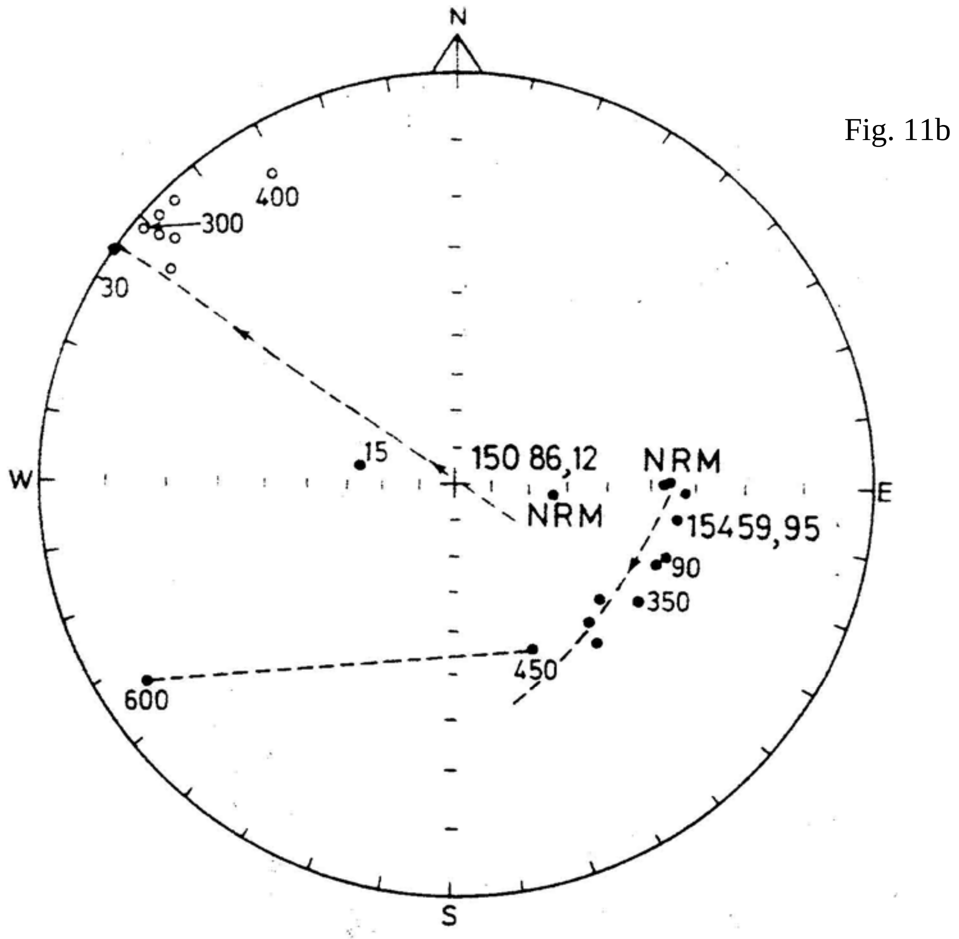
TABLE 15459-6. Rb-Sr isotopic data (Nyquist et al., 1973)

	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	T_{BABI} b.y.	T_{LUNI} b.y.
,98 matrix	3.76	129.5	0.0842 ± 10	0.70437 ± 14	4.37 ± .16	4.45 ± .16
,31 mare	0.697	54.9	0.0367 ± 6	0.70109 ± 6	3.80 ± .27	3.98 ± .27
,38 light clast	1.69	205.3	0.0239 ± 5	0.70067 ± 5	4.58 ± .24	4.86 ± .24

Fig. 11a



Alternating field demagnetization of Apollo 15 samples. Vertical bars indicate range of intensities obtained after repeated demagnetization.



A.F. demagnetization of samples 15459,95 and 15086,12. The directions of NRM are referred to arbitrary axes in the rocks.

Figure 11. Demagnetization of 15459 matrix samples (Collinson et al. 1973).

Tittman et al. (1972) reported a Rayleigh wave (V_R) velocity of <1.95 km/sec parallel to fractures--this is a high value approaching that of synthetic basalts. Perpendicular to fractures, the V_R is much lower and shows steps reflecting the crossing of fractures (Fig. 12).

Chung and Westphal (1973) reported a density of 2.76 gm/cc, and tabulated and diagrammed (Fig. 13) electrical data. The electrical properties are typical of those for feldspar-rich lunar basalts.

Adams and McCord (1972) measured diffuse reflection spectra (0.35-2.5 m) to determine the wavelength position of the two crystal-field absorption bands for pyroxenes. The data is similar to some Apollo 14 breccias, and shows that on average 15459 has less calcic pyroxene (i.e., less augite) than mare basalts.

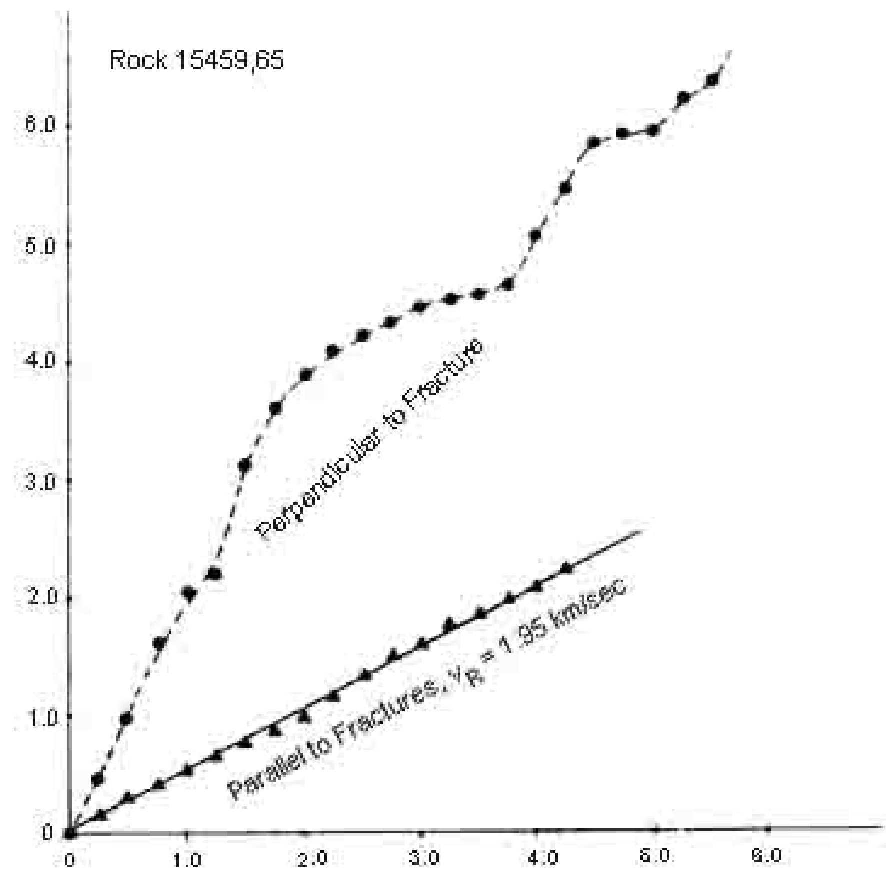
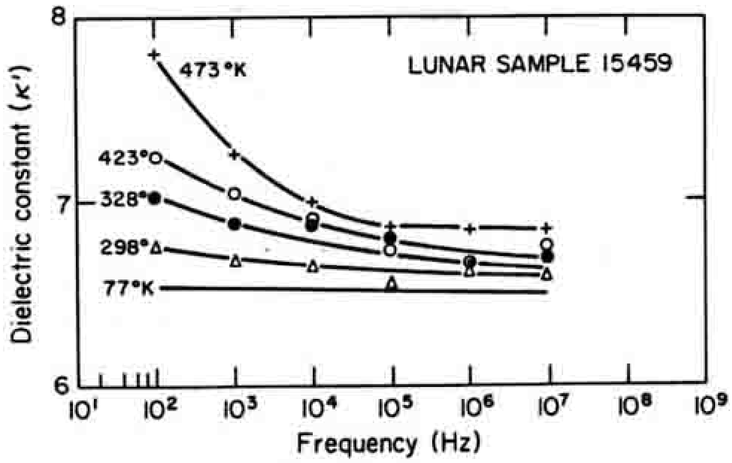
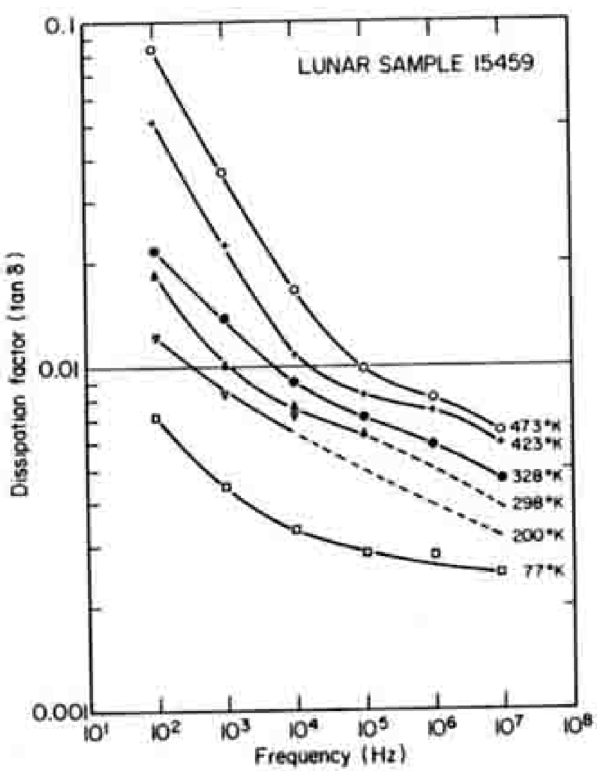


Figure 12. V_R data for 15459 matrix
(Tittman et al. 1972).



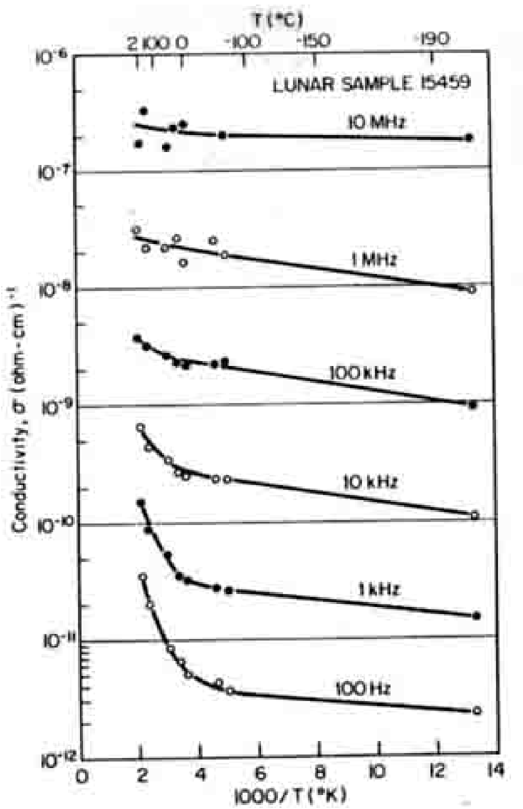
Dielectric constant of sample 15459,62 as a function of frequency and temperature.

Fig. 13a



Dielectric losses in sample 15459,62 as a function of frequency and temperature.

Fig. 13b



Electrical conductivity of sample 15459,62 as a function of frequency and temperature.

Fig. 13c

Figure 13. Electrical functions for 15459 matrix (Chung and Westphal 1973).

PROCESSING AND SUBDIVISIONS: Several small pieces were removed from 15459, including samples from the large mare basalt clast and the other large pale clast (Fig. 2). One piece ,6 (159.8 g) was removed from the west end and later was encapsulated for exhibition. A small piece was sawn off the west end and subdivided (Figs. 2, 14) and this cut was through the white clast. A later cut removed the west end (Fig. 2), which was numbered ,184 (1276 g) and placed in remote storage, and one of the other large pieces (,173, 85.6 g) removed in this operation also went for exhibition purposes. The main piece ,0 now has a mass of 3744 g.

Thin sections ,3; ,4, and ,13-,21 were made from ,2 (see Fig. 2). Thin sections ,122; ,124 and; ,224 sample the large mare basalt. Thin sections ,123 and ,125-,127 sample chips purportedly from the large white clast, contain matrix, poikilitic melt and (at least ,125) coarse norite. ,225 sampled the same white clast and appears to be of the poikilitic impact melt.

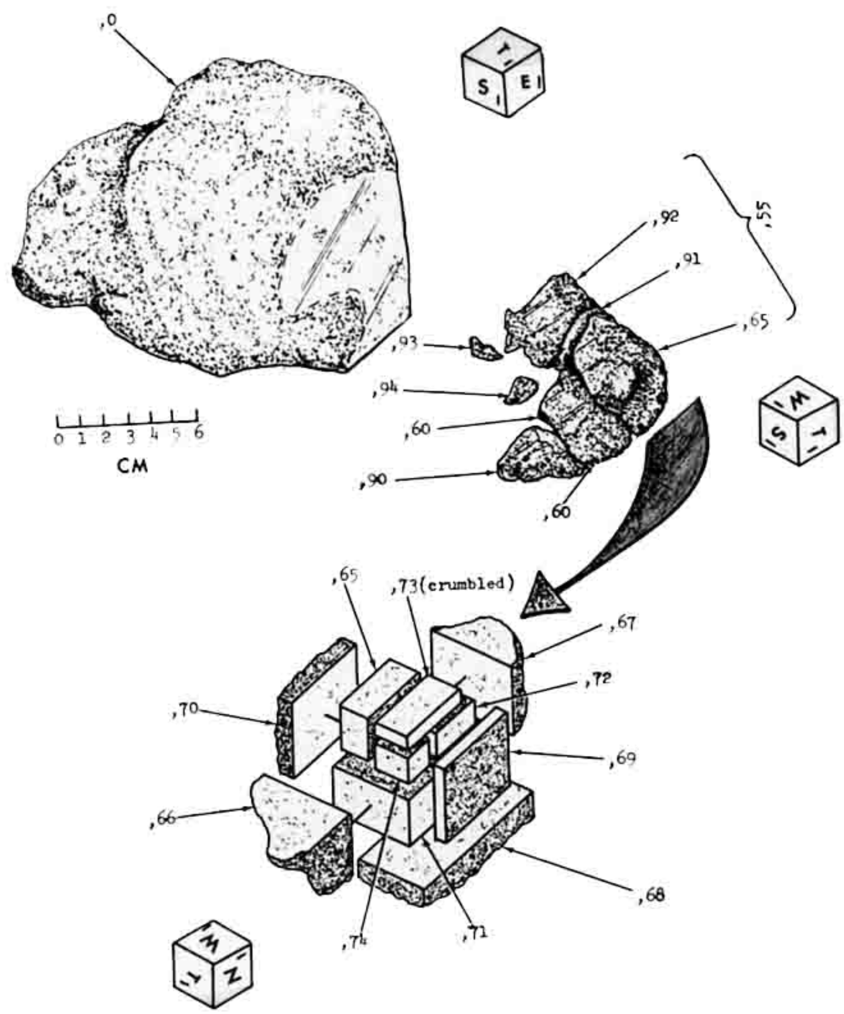


Figure 14. Initial sawing of 15459; several large chips had already been removed.