15455

DRAFT

Breccia with Shocked Norite

937.2 grams

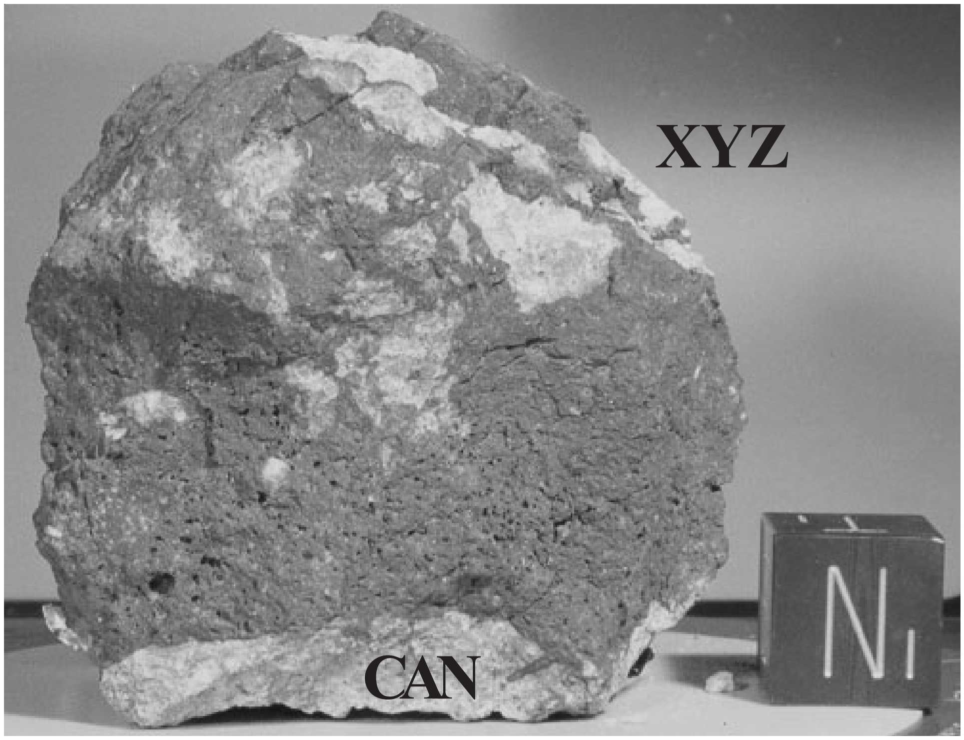


Figure 1: Photo of 15455 showing vesicular impact melt rock containing white clasts. Cube is 1 inch. NASA S71-43889. The large white clast (CAN) along the bottom was the main focus of research, but note the aditional white clasts (XYZ). This side had a few micrometeorite craters.

Introduction

The large, shocked, norite clast in 15455 is one of the oldest lunar materials that have been identified (~4.5 b.y.). It is surrounded and intruded by dark breccia matrix with an age about 3.9 b.y. 15455 is similar to 15445, both found on the rim of Spur Crater. It has micrometeorite craters on several surfaces and a cosmic ray exposure age about 200 m.y. Together, these two breccia samples, and the nearby boulder, are thought to represent ejecta from the Imbrium Basin (Ryder and Wood 1977, Ryder and Bower 1977 and Hertogen et al. 1977).

15455 was returned as one large piece (figures 1, 2, 3) and 22 small fragments (1-3 grams each). 15455 has been the subject of several coordinated consortia studies led by Lee Silver (1970s), John Wood (1970s) and the Norite Consortium led by Larry Nyquist (1980s). The results have previously been summarized in the catalog by Ryder (1985). Although there have been numerous studies of this important rock, it deserves more detailed investigation.

Petrography

Wilshire, Morrison and Brett (1972, original Apollo 15 catalog), James (1977) and Ryder and Bower (1977) describe 15455 as an impact melt rock with significant clasts of plutonic rock. The matrix is described as a fragment-laden melt that has surrounded and intruded the enclosed clasts. The dark breccia matrix that makes up the majority of 15455 is coherent and dense in places and vesicular in others (figure 4). It is composed of a seriate mix of plagioclase, olivine and minor pink-spinel fragments (xenoliths) surrounded by a very fine-grained igneous-textured groundmass. Pyroxene is rare in the matrix material (Ryder 1985). Spudis et al. (1991) analyzed the small mineral clasts found in the

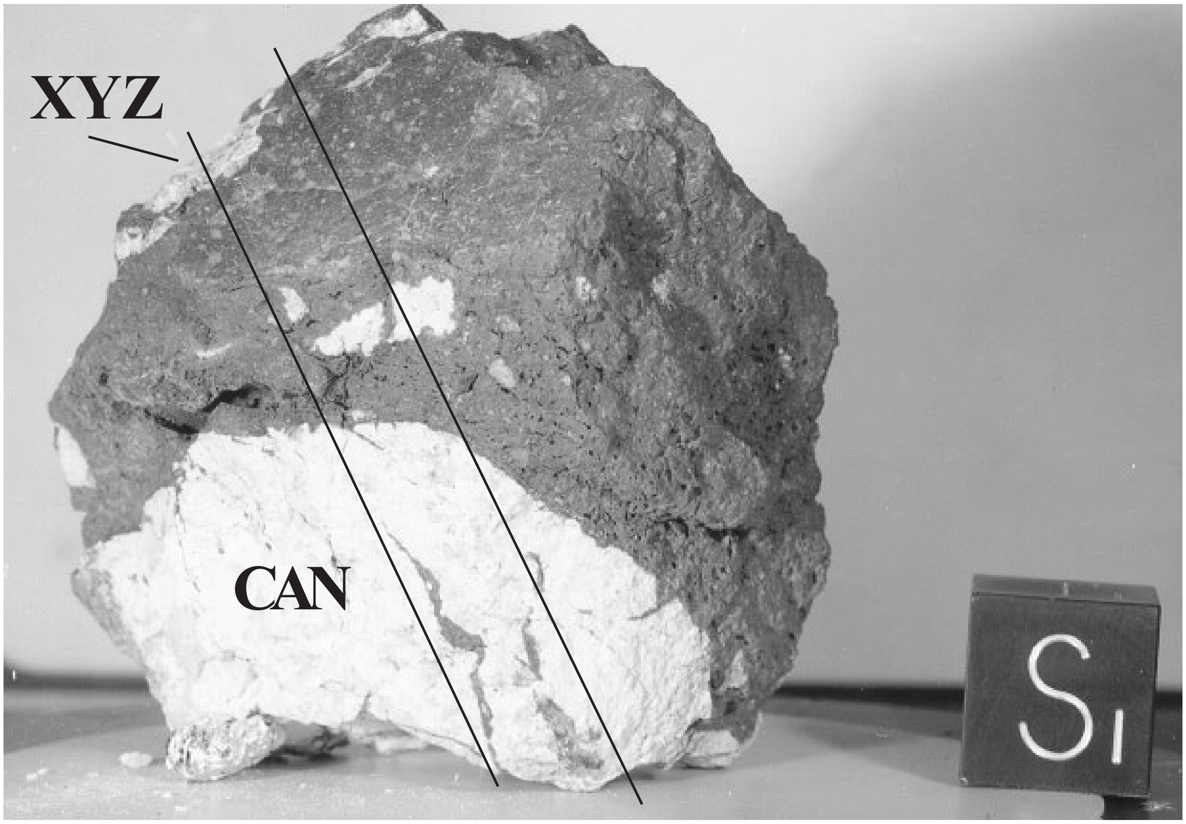


Figure 2: Photo of 15455 showing large cataclastic anorthositic norite clast (CAN) and approximate location of saw cuts. NASA S71-46588. Cube is 1 inch.

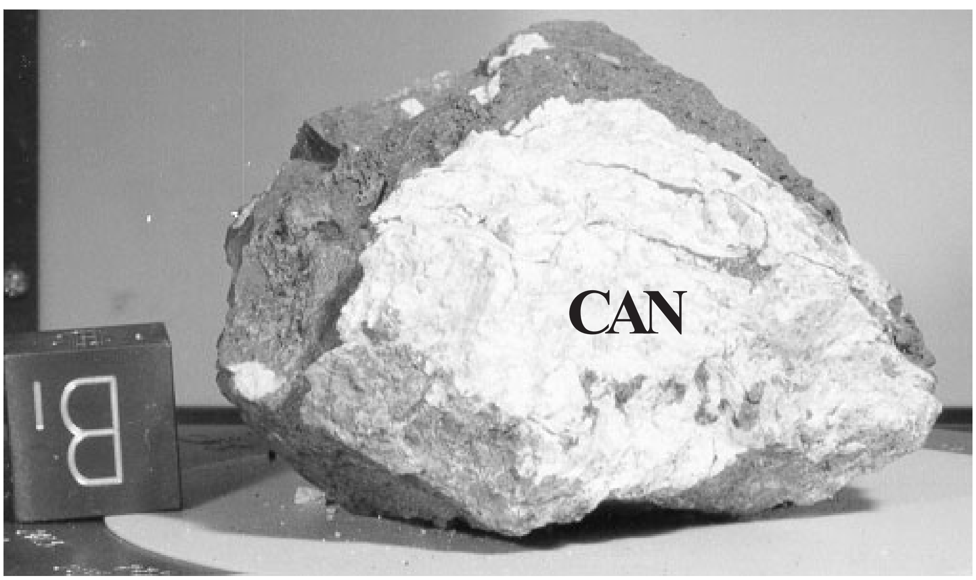


Figure 3: Photo of bottom of 15455 showing cataclastic anorthositic norite clast (CAN). Cube is 1 inch. NASA S71-46585.

breccia matrix, finding that they could be related to norites and troctolites, but not to basalts nor to ferroan anorthosites. James (1977) described rounded xenocrysts in the matrix of 15455 with spherulitic devitrified maskylynite (figure 5) indicating a shock history more extreme than was experienced by the large norite clast. Christie et al. (1973) found no glass in the matrix, which they described as a dark, non-porous, annealed microbreccia.

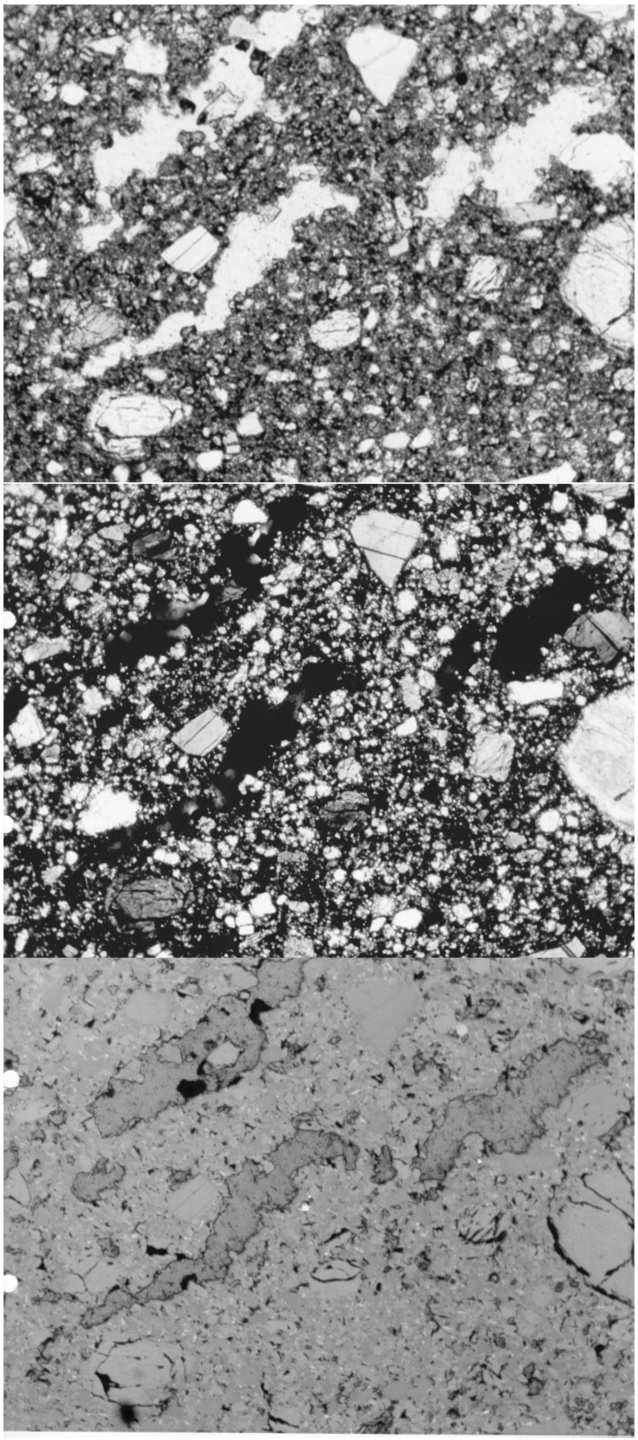


Figure 4: Three views of thin section 15455,162 - transmitted light, cross-polarized light and reflected light. NASA S71- 27693-27695. Field of view 1.3 mm. This represents the impact-melt breccia lithology and shows the elongate vugs.

Reid et al. (1977) found that the matrix material in 15455 had approximately the same composition as "LKFM" – a cluster of glass compositions found at several Apollo sites.

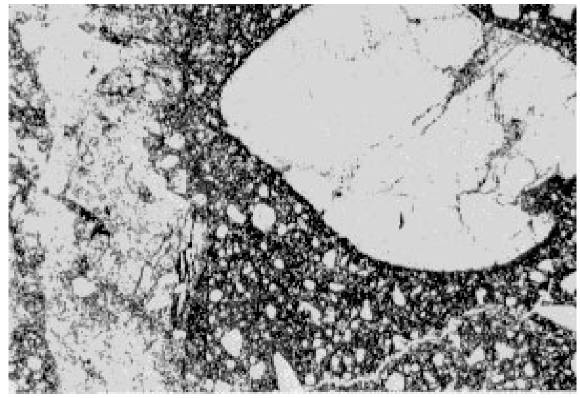


Figure 5: Photomicrograph of thin section of 15455 showing sharp contact of matrix with norite clast (left) with rounded fragment of spherulitic devitrified maskelynite included in matrix (from James 1977). Plane polarized light. Field of view 2.2 mm.

15455 contains several clasts, but only two have been studied:

Significant Clasts

CAN ***Cataclastic Anorthositic Norite:*** – The largest clast (about 200 grams, seen on S1-B1 end) is pristine norite with about 70% plagioclase, 30% orthopyroxene and trace augite (figure 7). The 15455 norite also contains a variety of accessory minerals: silica, armalcolite, chromite, ilmenite, rutile, a phosphate, zircon, baddelyite, Fe-metal and troilite (Ryder and Bower 1977).

The original grain size of this norite (CAN) was quite large (1-3 mm), but the grains are significantly fractured as if crushed and granulated while in place (Phinney et al. 1977, James 1977). Cross-cutting veins of dark matrix material cut through the white, norite material (figures 2, 22, 25-27). There is a "chill margin" surrounding this large clast (figure 6).

CAN has been the subject of the Norite Consortium led by Larry Nyquist (see Shih et al. 1993) and has been found to be extremely old (see below).

This large white clast may itself be composed of more than one material (not well established). Observations (by Wilshire and Morrison) made during the original preliminary examination were that "plagioclase ranges from 60% to more than 95% and the variation in proportion to pyroxene suggest an original layering". This is supported by the initial trace element analysis

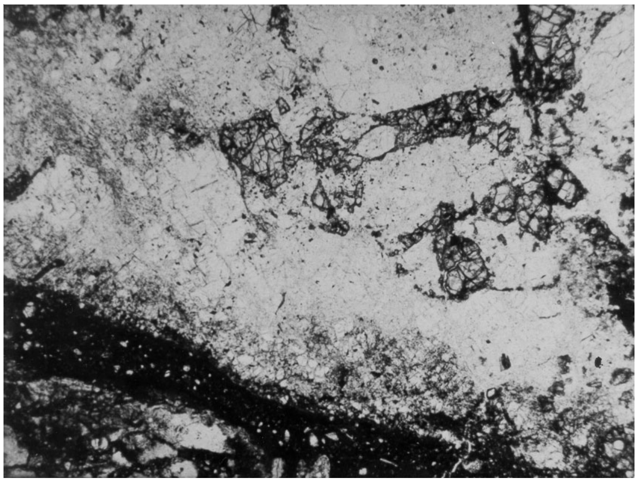


Figure 6: Photomicrograph of thin section of 15455 cataclastic anorthositic norite clast (CAN) showing relic coarse igneous texture. NASA S71-51729. Scale about 2 mm across.

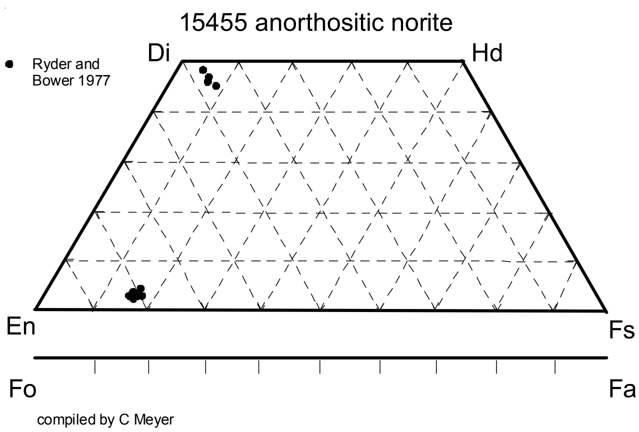


Figure 7: Pyroxene composition of large cataclastic anorthositic norite clast (CAN). Replotted from data by Ryder and Bower (1977).

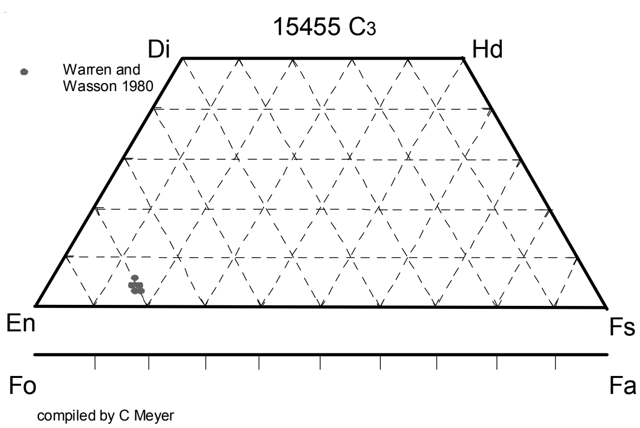


Figure 8: Pyroxene composition of norite clast C3 (replotted from Warren and Wasson 1980).

Mineralogical Mode of 15455 CAN

	PET	Ryder and Bower 1977	Warren and Wasson 1980
Orthopyroxene	25 %	30	24
Plagioclase	75	70	75

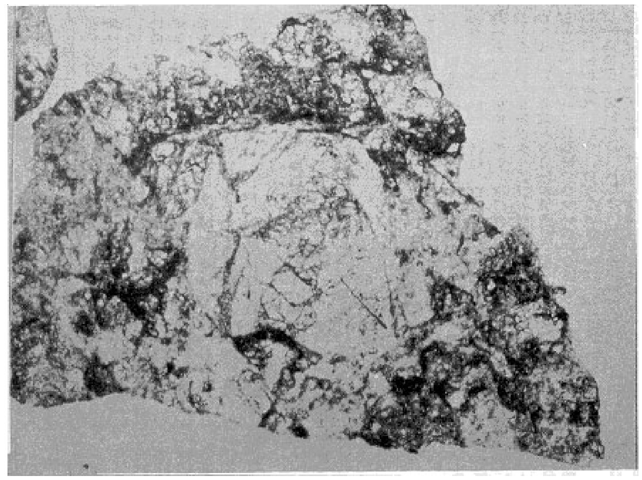


Figure 9: Thin section photo of cataclastic troctolitic anorthosite clast (CTA) in 15455,169 (from Ryder 1985). Field of view is 3 mm.

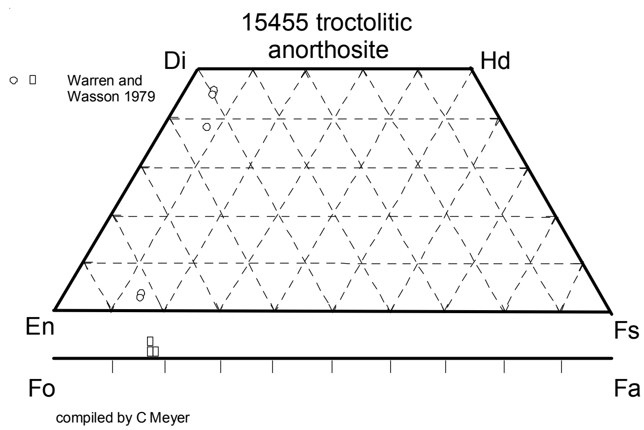


Figure 10: Pyroxene composition of egg-shaped, cataclastic troctolitic anorthosite clast (CTA) in 15455. Replotted from Warren and Wasson (1979).

Mineralogical Mode of 15455 CTA

	Warren and Wasson 1979	Norn	Ryder 1985
Olivine	22	29	25
Pyroxene	11	13	
Plagioclase	66	58	75

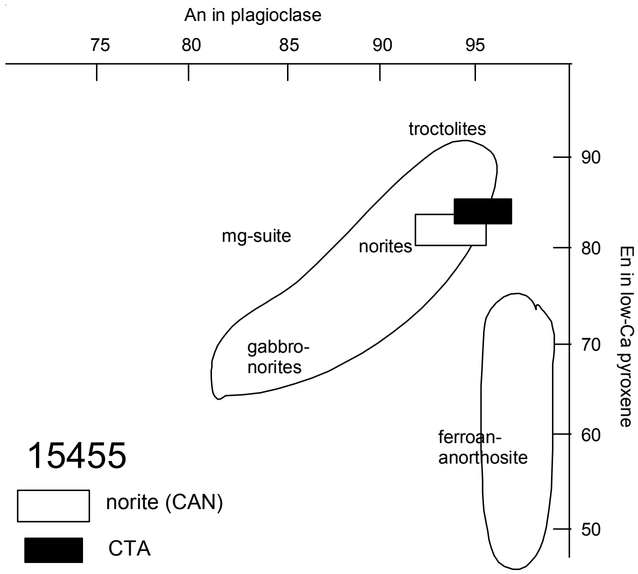


Figure 11: Plagioclase and pyroxene composition of largest clasts in 15455 (CAN and CTA). Data from Ryder and Bower (1977) and Warren and Wasson (1979).

of the white clast by Taylor et al. (1973) which is different from that by Philpotts (unpublished), Shih et al. (1993) and Warren and Wasson (1980) (Table 2 and figure 13). Warren and Wasson (1980) termed their split "c3", to distinguish it from the material "c1" originally studied by Taylor et al. (1973) and Ganapathy et al. (1973).

CTA *Cataclastic Troctolitic Anorthosite:* This egg-shaped white clast (~3 grams) was exposed during cutting slab (figures 26 and 27). Warren and Wasson (1979) found that this clast (termed "c2") had an "extreme cataclastic texture" while Ryder and Norman (1979) found it had a "feldspathic granulite texture". It has an extremely fine grain size (100 to 350 microns) with more olivine than pyroxene (hence term troctolitic). Ganapathy et al. (1973) and Warren and Wasson (1979) found it has low meteoritic siderophile content and was thus "chemically pristine". The REE pattern is not unlike that of the norite (figure 14).

XYZ *Complex:* This set of unstudied white clasts on W1 end is shown in figures 1 and 23.

C, D, E, F: Small white clasts exposed by saw cut (~1 gram ea.) as designated in catalog by Ryder (1985). D may be part of XYZ above (see figure 26). These clasts have not been studied and will prove to be difficult to extract in the glove box.

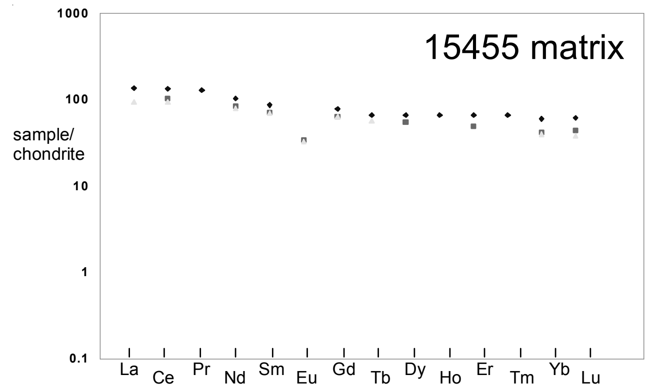


Figure 12: Normalized rare-earth-element composition diagram for matrix samples of 15455 (data by Taylor 1973, Philpotts (unpublished), and Lindstrom et al. 1988).

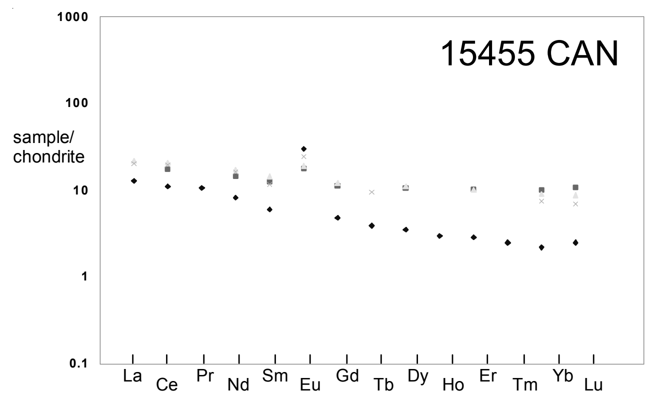


Figure 13: Normalized rare-earth-element diagram for the large white norite clast in 15455 (data from Taylor 1973, Philpotts (unpublished), Shih et al. 1993 and Warren and Wasson 1980 (C3).

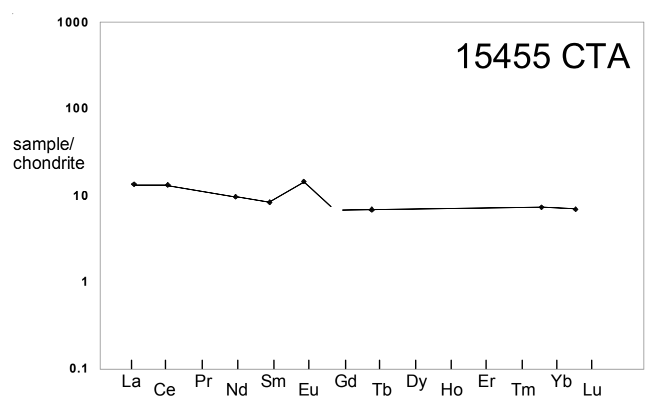


Figure 14: Normalized rare-earth-element diagram for egg-shapped troctolitic anorthosite clast (CTA) in 15455 (data by Warren and Wasson 1979).

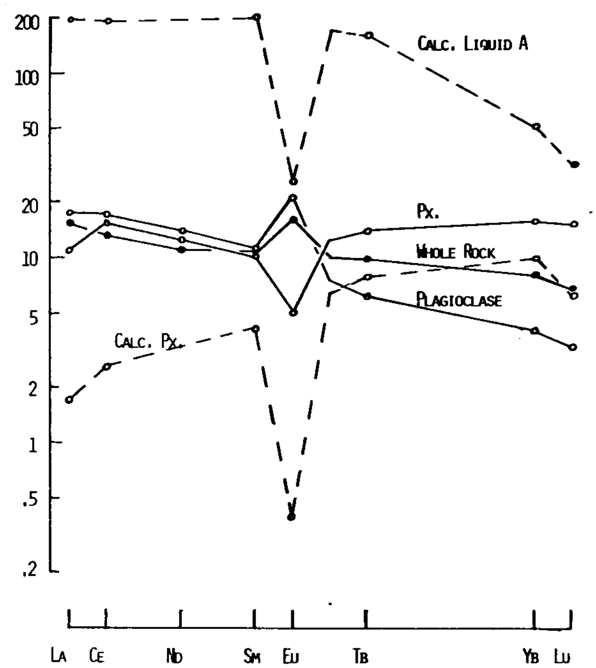


Figure 15: Trace element composition of 15455 (whole rock, plagioclase and pyroxene) and calculated composition of parent liquid (evolved). Blanchard and McKay 1980.

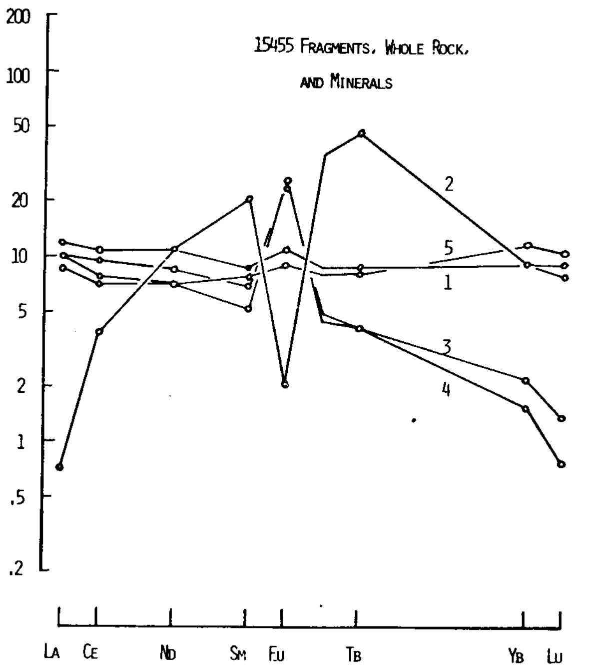


Figure 16: Trace element composition of 15455 (fragments 1 to 5) from Blanchard and McKay 1980.

Mineralogy

Olivine: Ryder and Bower (1977) and Spudis et al. (1991) find olivine ranges in composition Fo_{90-75} in the matrix but Fo_{82} in CTA (figure 10).

Plagioclase: Ryder and Bower (1977) showed plagioclase was An_{96-83} in the matrix, but that it was An_{96-92} in clasts CAN and CTA (figure 11).

Metallic iron: Hewins and Goldstein (1975) reported metal in norite clast with up to 10% Co.

Chemistry

Tables 1, 2 and 3 give the chemical composition of the matrix, and two largest clasts: the "norite" (CAN) and the "troctolite" (CTA).

Blanchard and McKay (1980) reported whole rock and mineral composition data for the cataclastic anorthositic norite clast (CAN) and determined that the parent liquid was already highly "evolved" when it formed (figure 15). Philpotts (unpublished), Shih et al. (1993) and Warren and Wasson (1980) analyzed the norite clast (CAN) finding similar results, but different from that of Taylor et al. (1973) (figure 13).

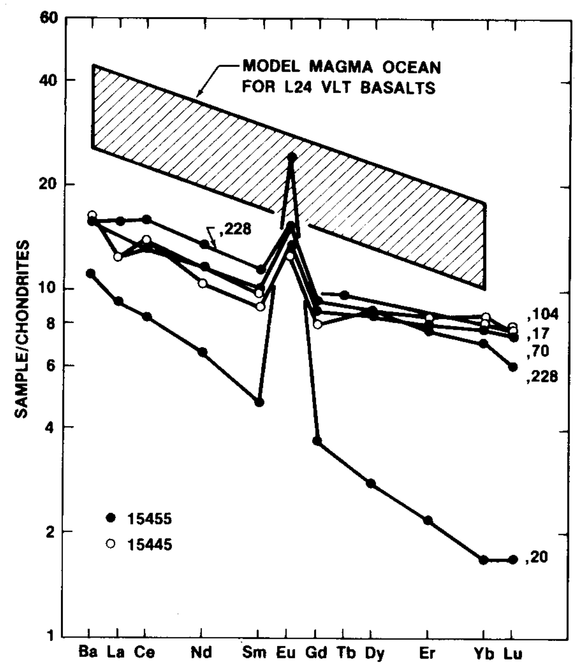


Figure 17: Comparison of 15455 norite and 15445 norites (from Nyquist et al. 1979).

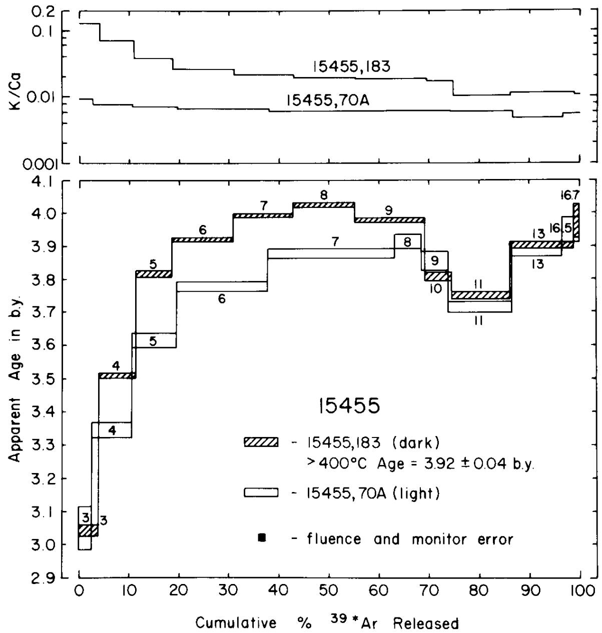


Figure 19: Ar/Ar plateau diagram for 15455 matrix and white clast (from Alexander and Kahl 1974).

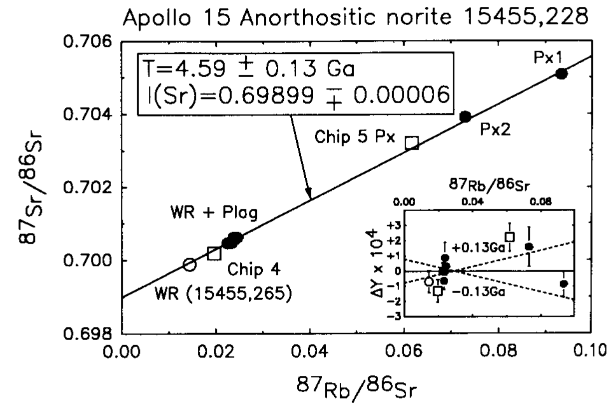


Figure 19: Rb/Sr mineral isochron for 15455,228 anorthositic norite clast (Shih et al. 1993).

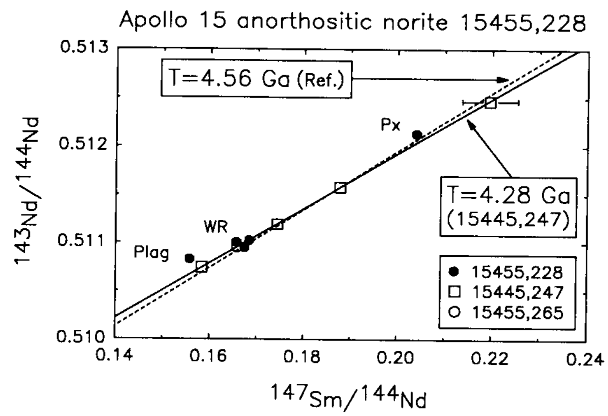


Figure 20: Nd/Sm mineral isochron for 15455,228 anorthositic norite clast (Shih et al. 1993).

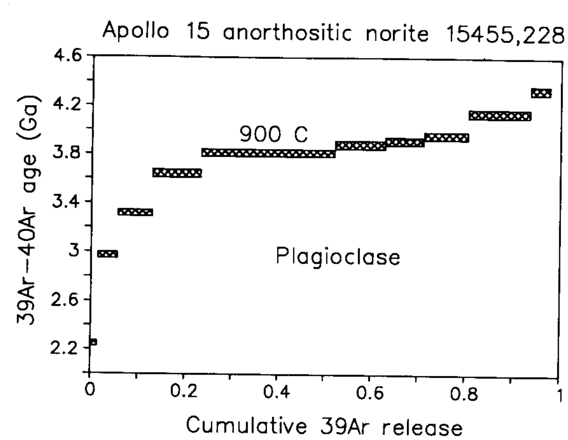


Figure 21: Ar/Ar plateau diagram for 15455,228 anorthositic norite clast (Shih et al. 1993).

Although the mineral mode and major element chemistry is different, Warren and Wasson (1979) found the CTA clast has a trace element signature similar to that of CAN (table 3, figure 14). Thus, this troctolitic anorthosite is related to the norite suite rather than the feroan anorthosites (figure 11).

Taylor et al. (1972, 1973), Philpotts (unpublished) and Lindstrom et al. (1988) analyzed the matrix (Table 1, figure 12). Ganapathy et al. (1973) showed that matrix had high Ir and Au while Ganapathy et al. (1973) and Warren and Wasson (1979 and 1980) showed that the clasts were free of meteoritic tracers Ir and Au (hence termed "pristine").

Lindstrom et al. (1988), Hertogen et al. (1977) and Nyquist et al. (1979) showed that the impact melt rock matrix of 15455 and that of 15445 were chemically similar (figure 17). It is thought the matrix represents ejecta from the Imbrium Basin.

Summary of Age Data for 15455

	Ar/Ar	Rb/Sr	Nd/Sm
Alexander and Kahl 1974	3.94 ± 0.04 b.y.		
	3.82 ± 0.04		
Bernstein 1983	3.9 ± 0.25		
Shih et al. 1993	~ 3.9		
		4.59 ± 0.13	
			4.53 ± 0.29

Table 1. Chemical composition of 15455 (matrix and whole).

			black		dark ves dark mx								
reference	Keith 73		Taylor 73		Ganapathy 73			Philpotts		Lindstrom 1988			
weight			,14		,38	,183		Ryder85		,258	,259	,260	
SiO2 %			47.3	(f)									
TiO2			1.35	(f)							1.71		(a)
Al2O3			17.1	(f)							16.3		(a)
FeO			8.79	(f)						9.53	9.79	9.66	(a)
MnO													
MgO			13.3	(f)							16.2		(a)
CaO			10.6	(f)							9.4		(a)
Na2O			0.58	(f)						0.552	0.548	0.527	(a)
K2O	0.128	(e)	0.17	(f)				0.143	(c)	0.14	<6		(a)
P2O5													
S %													
sum													
Sc ppm			13	(f)						17.3	17.9	17.8	(a)
V			39	(f)									
Cr			1800	(f)						1660	1700	1700	(a)
Co			22	(f)						32	38	39	(a)
Ni			184	(f)						260	330	350	(a)
Cu			3.3	(f)									
Zn					3.5	2.2	(d)						
Ga			3.3	(f)									
Ge ppb					385	456	(d)						
As													
Se					92	89	(d)						
Rb			2.7	(f)	2.2	2.7	(d)	2.91	(c)				
Sr								161	(c)	160	180	170	(a)
Y			93	(f)									
Zr			480	(f)				297	(c)	270	230	260	(a)
Nb			33	(f)									
Mo													
Ru													
Rh													
Pd ppb													
Ag ppb													
Cd ppb					2.3	2.5	(d)						
In ppb					0.34	0.35	(d)						
Sn ppb			220	(f)									
Sb ppb													
Te ppb					5.4	5.1	(d)						
Cs ppm			0.16	(f)	0.114	0.122	(d)			0.13	0.18	0.14	(a)
Ba			370	(f)				238	(c)	250	250	230	(a)
La			32	(f)						21.8	22	22.3	(a)
Ce			81	(f)				62	(c)	56.6	57	56.6	(a)
Pr			11.5	(f)									
Nd			47	(f)				38.6	(c)	33	36	36	(a)
Sm			12.8	(f)				10.6	(c)	10.3	10.3	10.3	(a)
Eu			1.82	(f)				1.91	(c)	1.87	1.85	1.81	(a)
Gd			15.5	(f)				12.6	(c)				
Tb			2.41	(f)						2.12	2.07	2.15	(a)
Dy			16	(f)				13.4	(c)				
Ho			3.76	(f)									
Er			10.7	(f)				7.74	(c)				
Tm			1.6	(f)									
Yb			9.8	(f)				6.85	(c)	6.9	6.45	6.45	(a)
Lu			1.5	(f)				1.08	(c)	0.95	0.93	0.95	(a)
Hf			9.8	(f)						8.12	7.84	7.76	(a)
Ta										1.01	1.04	1.03	(a)
W ppb													
Re ppb					0.63	0.41	(d)						
Os ppb													
Ir ppb					7	4.8	(d)			2	3.6	2.8	(a)
Pt ppb										2.2	3.2	2.4	(a)
Au ppb					5.8	4.6	(d)						
Th ppm	2	(e)	5.31	(f)						2.82	3.32	3.45	(a)
U ppm	0.53	(e)	1.37	(f)	0.875	0.715	(d)			0.75	0.62	0.65	(a)

technique: (a) INAA, (b) , (c) IDMS, (d) RNAA, (e) radiation counting, (f) ssms

Table 2. Chemical composition of 15455 Norite Clast (CAN).

	white		gabbro						**C3**					
reference	Taylor73		Ganapathy73		Philpotts		Shih 93		Warren 80		Shih et al. 1993			
weight	,20		,70		(Ryder85)		,228		,228		,228			
SiO2 %	44.4	(f)							47.7	(b)				
TiO2	<0.07	(f)							0.1	(b)				
Al2O3	26.2	(f)							27	(b)				
FeO	4.2	(f)							2.91	(b)				
MnO									0.05	(b)				
MgO	10.9	(f)							6.96	(b)				
CaO	14.3	(f)							14.8	(b)				
Na2O	0.36	(f)							0.44	(b)				
K2O	<0.06	(f)			0.058	(c)	0.059	(c)	0.08	(b)				
P2O5														
S %														
sum														
Sc ppm		(f)							5.33	(a)				
V	16	(f)												
Cr	440	(f)							1180	(a)				
Co	10	(f)							27.2	(a)				
Ni	12	(f)							21	(a)				
Cu	1.3	(f)												
Zn			1.85	(d)					1	(a)				
Ga	2.6	(f)												
Ge ppb			9.4	(d)					56	(a)				
As														
Se			8.3	(d)										
Rb		(f)	1.1	(d)	1.09	(c)	1.13	(c)			1.133	1.065	1.104	(c)
Sr					124	(c)	138	(c)			137.9	126.5	134.8	(c)
Y	4.9	(f)												
Zr	11	(f)							70	(a)				
Nb	0.95	(f)												
Mo														
Ru														
Rh														
Pd ppb														
Ag ppb														
Cd ppb			1	(d)										
In ppb			0.05	(d)										
Sn ppb		(f)												
Sb ppb														
Te ppb			2.6	(d)										
Cs ppm		(f)	0.126	(d)										
Ba	42	(f)			58.7	(c)	59.7	(c)	125	(a)				
La	3	(f)					5.11	(c)	4.8	(a)				
Ce	6.7	(f)			10.5	(c)	12.6	(c)	11.8	(a)				
Pr	0.95	(f)												
Nd	3.73	(f)			6.66	(c)	7.79	(c)	7.4	(a)	5.368	6.584	6.248	(c)
Sm	0.88	(f)			1.86	(c)	2.13	(c)	1.74	(a)	1.495	1.804	1.729	(c)
Eu	1.67	(f)			1.03	(c)	1.07	(c)	1.38	(a)				
Gd	0.95	(f)			2.21	(c)	2.4	(c)						
Tb	0.14	(f)							0.35	(a)				
Dy	0.84	(f)			2.59	(c)	2.69	(c)						
Ho	0.17	(f)												
Er	0.46	(f)			1.64	(c)	1.61	(c)						
Tm	0.06	(f)												
Yb	0.36	(f)			1.65	(c)	1.48	(c)	1.22	(a)				
Lu	0.06	(f)			0.262	(c)	0.213	(c)	0.17	(a)				
Hf	0.17	(f)							0.67	(a)				
Ta									0.14	(a)				
W ppb														
Re ppb			0.0023	(d)					0.006	(a)				
Os ppb														
Ir ppb			0.002	(d)					0.02	(a)				
Pt ppb														
Au ppb			0.009	(d)					0.023	(a)				
Th ppm	0.05	(f)							0.59	(a)				
U ppm	0.23	(f)	0.195	(d)					0.18	(a)				

technique: (a) INAA, (b) fused bead, (c) IDMS, (d) RNAA, (e) radiation counting, (f) SSMS

Table 3. Chemical composition of 15455 troctolite clast (CTA).

	CTA		CTA		CTA	
reference	Ganapathy 73		Warren 79		Shih 93	
weight	,179		,106		,265	
SiO2 %			44.3	(b)		
TiO2			0.08	(b)		
Al2O3			21.9	(b)		
FeO			5.79	(b)		
MnO			0.07	(b)		
MgO			16.1	(b)		
CaO			11.6	(b)		
Na2O			0.23	(b)		
K2O			0.04	(b)		
P2O5						
S %						
sum						
Sc ppm			4.1	(a)		
V						
Cr			970	(a)		
Co			25	(a)		
Ni			26	(a)		
Cu						
Zn	1.7	(d)	1.33	(a)		
Ga			3.1	(a)		
Ge ppb	11	(d)	14	(a)		
As						
Se	9.6	(d)				
Rb	0.54	(d)			0.6087	(c)
Sr					122.1	(c)
Y						
Zr						
Nb						
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb	0.91	(d)	2.9	(a)		
In ppb	0.06	(d)	0.5	(a)		
Sn ppb						
Sb ppb						
Te ppb	7.5	(d)				
Cs ppm	0.054	(d)				
Ba			77	(a)		
La			3.2	(a)		
Ce			8.1	(a)		
Pr						
Nd			4.4	(a)	3.706	(c)
Sm			1.23	(a)	1.016	(c)
Eu			0.82	(a)		
Gd						
Tb			0.25	(a)		
Dy						
Ho						
Er						
Tm						
Yb			1.2	(a)		
Lu			0.17	(a)		
Hf			0.86	(a)		
Ta			0.14	(a)		
W ppb						
Re ppb	0.0058	(d)	0.01	(a)		
Os ppb						
Ir ppb	0.024	(d)	0.024	(a)		
Pt ppb						
Au ppb	0.042	(d)	1.9	(a)		
Th ppm			0.58	(a)		
U ppm	0.17	(d)	0.18	(a)		

technique: (a) INAA, (b) fused bead, (c) IDMS, (d) RNAA

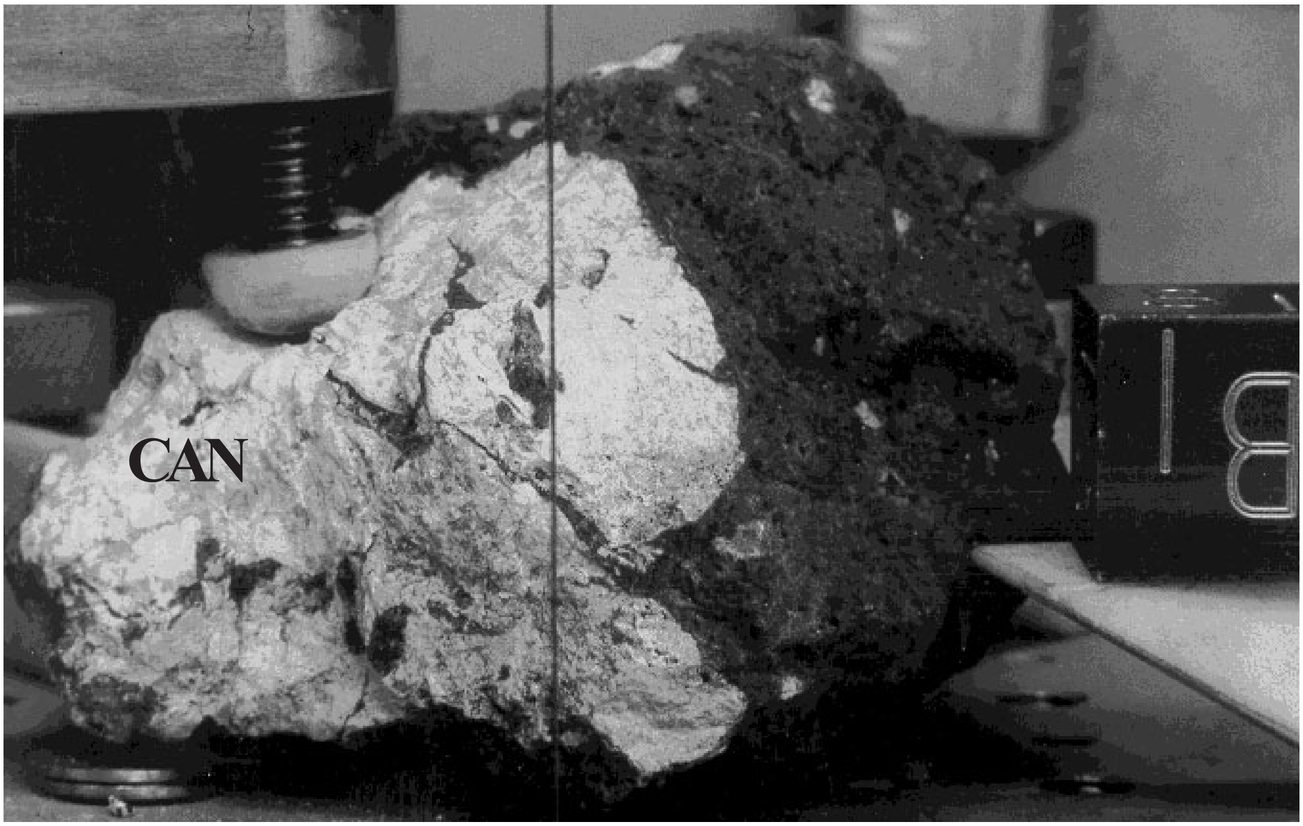
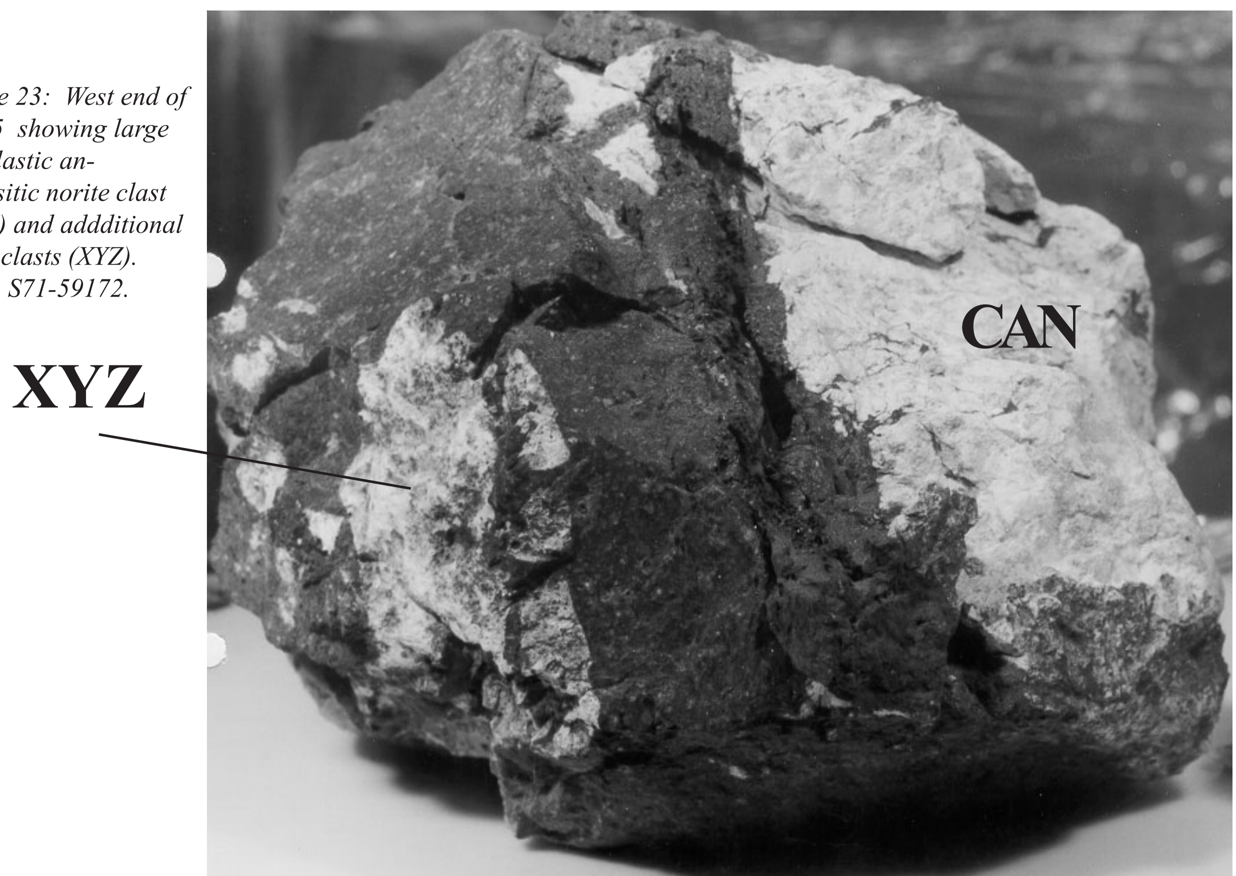


Figure 22: Sample 15455 as it was positioned for first saw cut to produce slab - see following figures. Cube is 1 inch. NASA S71-59598.

Figure 23: West end of 15455 showing large cataclastic anorthositic norite clast (CAN) and addditional white clasts (XYZ). NASA S71-59172.



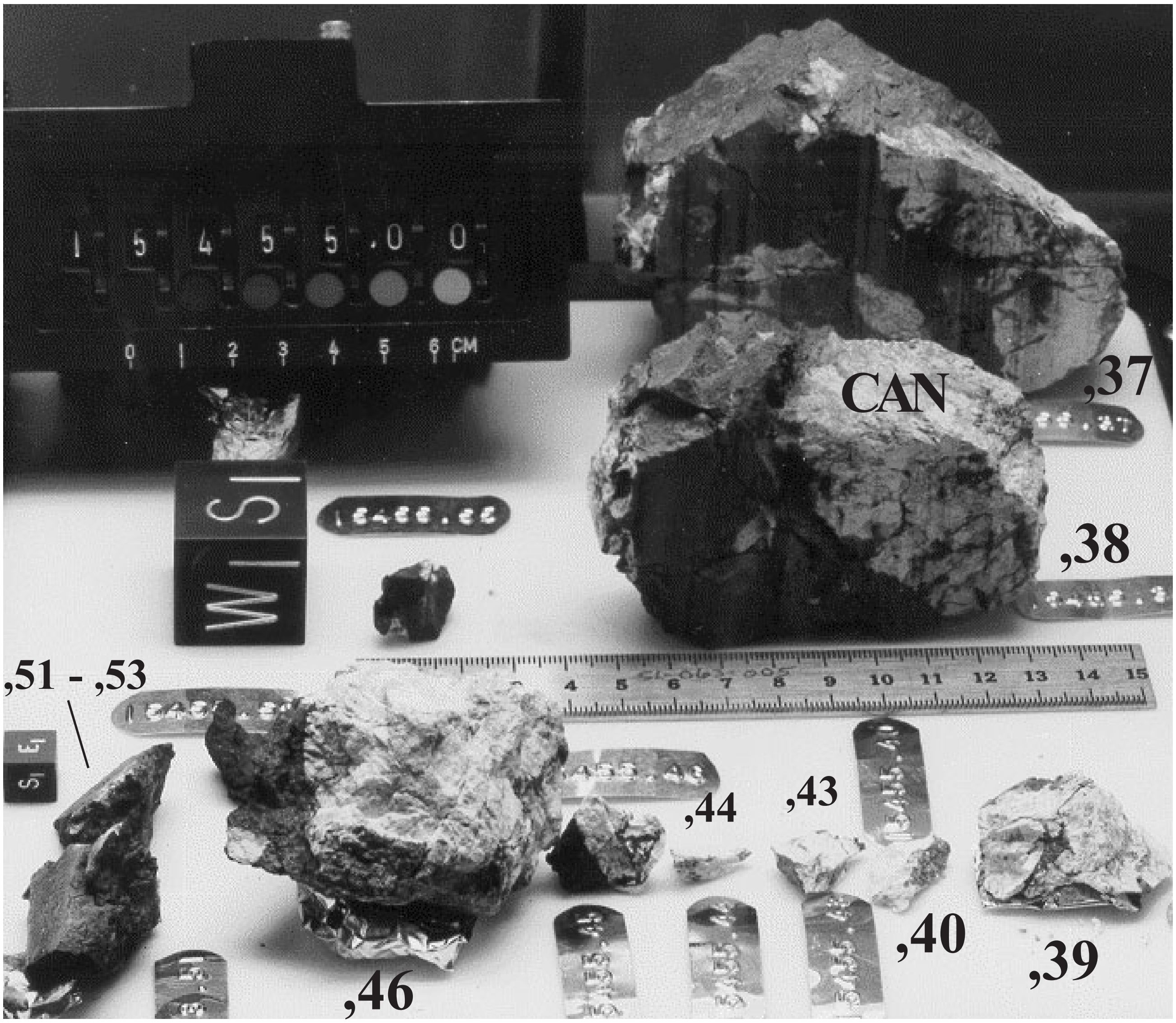


Figure 24: Group photo after sawing slab. Large cube is 1 inch, scale is in cm. NASA S71-60227.

Radiogenic age dating

Shih et al. (1993) found that the norite clast was very old (4.59 ± 0.13, figure 19). Shih et al. (1993) and Alexander and Kahl (1974) determined Ar/Ar plateau ages for the dark matrix (3.94 b.y.) and the light clast (3.82 b.y.) – inconsistent with textural relationships (figure 1). It is clear that the Ar/Ar age of the norite clast was partially reset.

Silver (1973) determined U, Th and Pb isotopes in both the matrix and the white clast (Table 5).

Cosmogenic isotopes and exposure ages

Keith et al. (1973) determined the cosmic-ray-induced activity of ^{22}Na = 42 dpm/kg., ^{26}Al = 70 dpm/kg., ^{54}Mn = 10 dpm/kg., ^{56}Co = 6 dpm/kg. and ^{46}Sc = 5 dpm/kg.

Alexander and Kahl (1974) determined ^{38}Ar exposure age to be 205 ± 21 m.y., while Bernstein (1983) determined 190 m.y.

Other Studies

Cisowski et al. (1982)	magnetics
Housley et al. (1976)	magnetics
Epstein and Taylor (1972)	oxygen isotopes
Reed and Jovanovic (1972)	Cl, Br, Li
Jovanovic and Reed (1977)	
Modzeleski et al. (1972)	CO, CO_2, CH_4
Moore et al. (1973)	C
Heuer et al. (1972)	
Christie et al. (1973)	HEVM

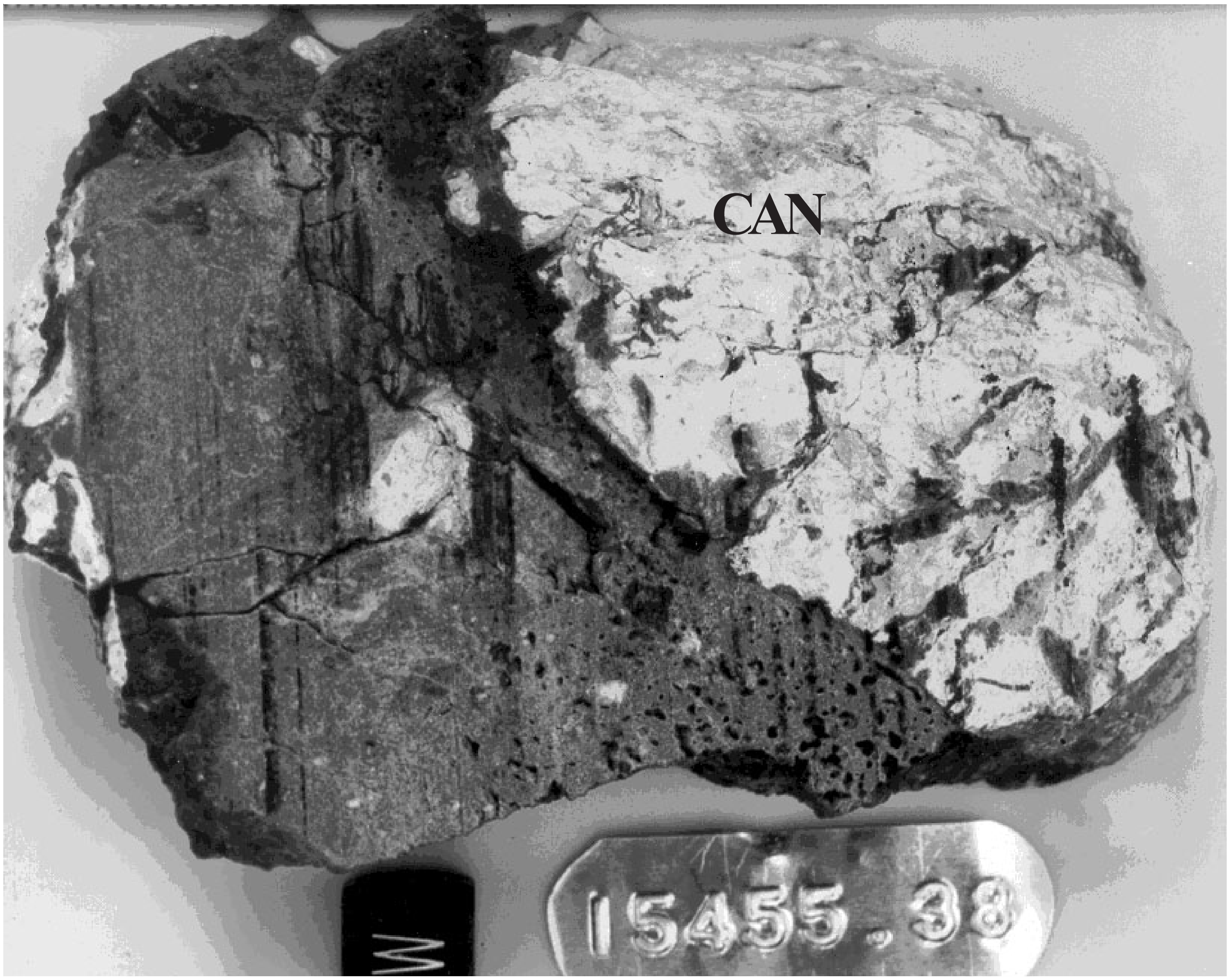
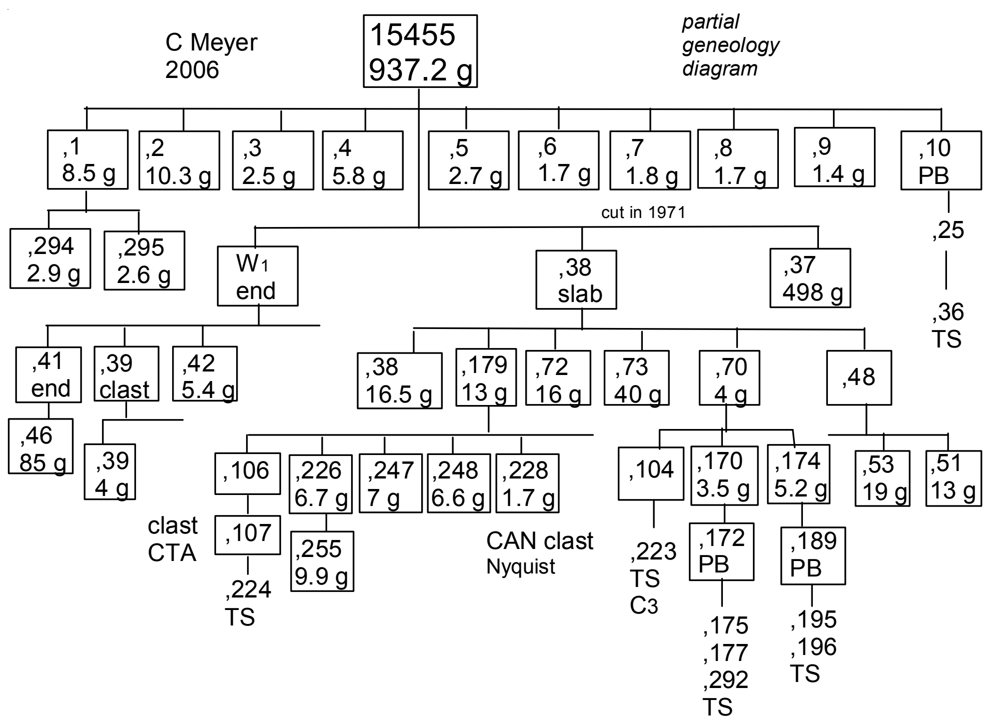


Figure 25: Sawn surface of slab (15455,38). NASA S71-60943. Cube is 1 cm.



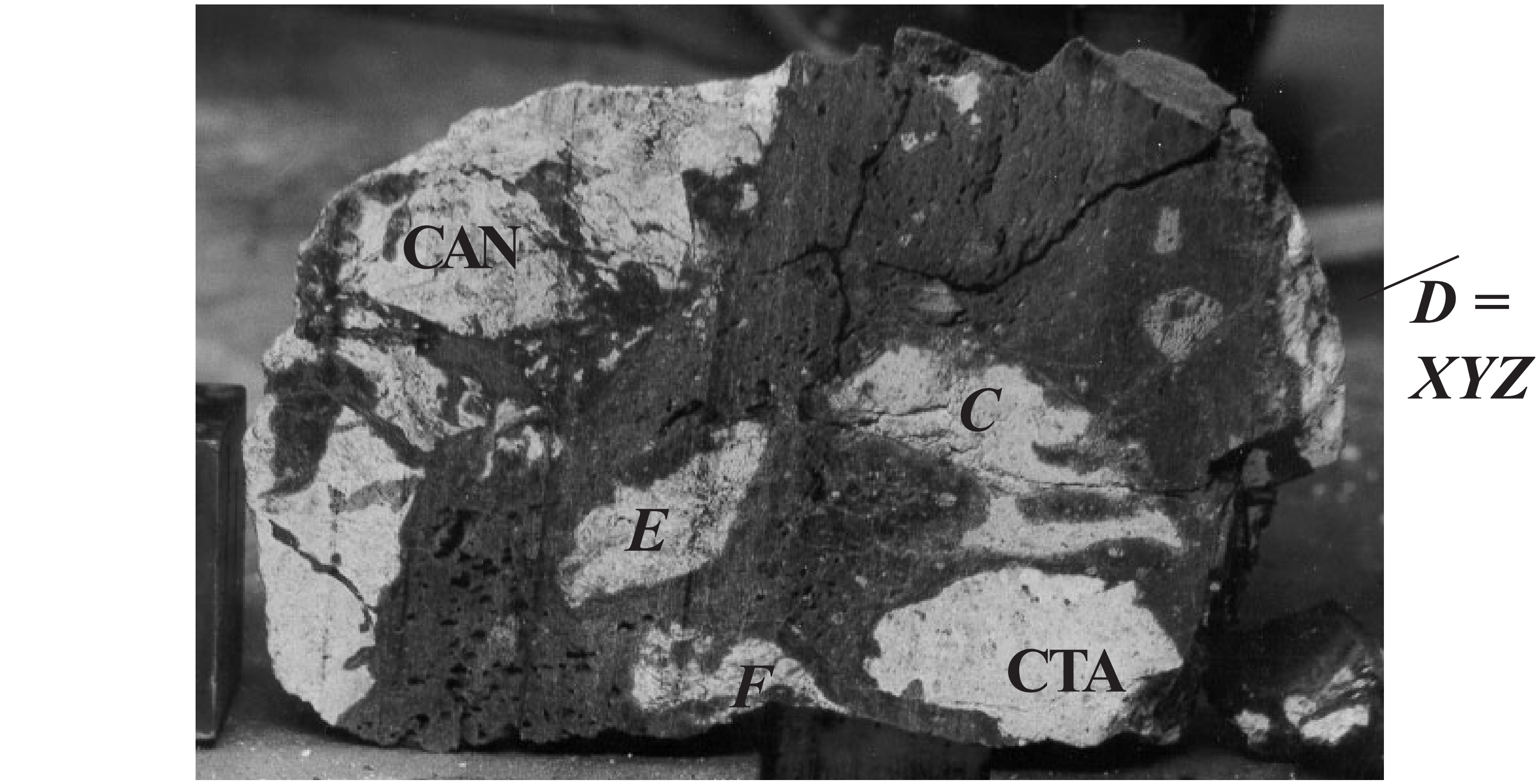


Figure 26: Opposite side of slab 15455,38 showing large anorthositic norite clast (CAN), egg-shaped troctolitic anorthosite (CTA) and clasts C, D, E, F (unstudied). NASA S71-59584. Cube is 1 inch.

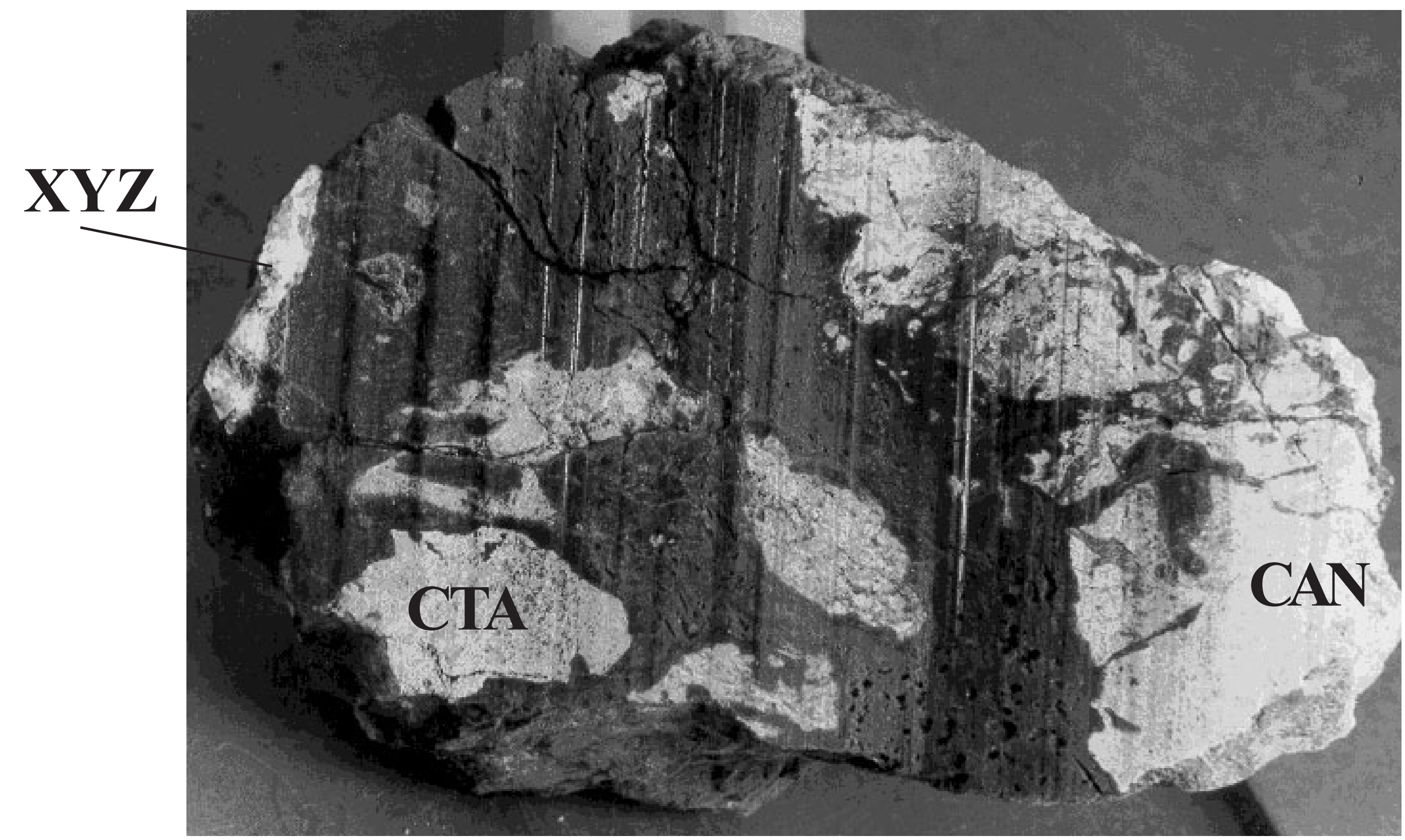


Figure 27 : Sawn surface of 15455,37 (butt end). NASA S71-59608. Note the saw marks.

Figure 28: Piece 15455,2. NASA S71-43895. Cube is 1 cm.

Figure 29: Piece 15455,4. 1 x 2.5 cm. NASA S71-44142.

Figure 30: Piece 15455,5. 2 cm. NASA S71-44094.

Figure 31: Piece 15455,6. 1.5 cm. NASA S71-44146.

Figure 32: Piece of 15455,8. Cube is 1 cm. NASA S71-43919.

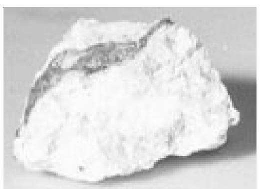


Figure 33: Piece of 15455,10. 1.5 cm. NASA S71-44084. (this piece used to make thin sections)

Figure 34: Piece 15455,12. NASA S71-44107. About 1 cm.

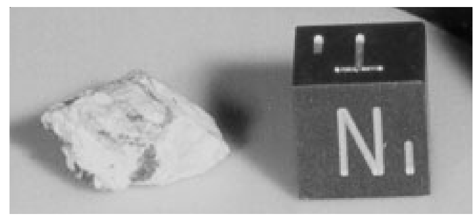


Figure 35: Piece of 15455,15. Cube is 1 cm. NASA S71-43899.

Table 4. Thin sections of 15455.

butt	Thin Sec.	butt	Thin Sec.	butt	Thin Sec.
,10	,25	,88	,169	,173	,176
	,26	,95	,162		,178
	,27		,166	,189	,195
	,28	,104	,223		,196
	,29	,106	,238	,236	,237
	,30	,107	,224		
	,31	,111	,233		
	,32		,235		
	,33	,112	,234		
	,34	,172	,175		
	,35		,177		
	,36		,292		
,86	,163				
	,167				
,87	,164				
	,168				
	,291				

Processing

Numerous small pieces broke off of 15455 during return to Earth (figures 28 – 35). Additional pieces broke off while clamping down for the saw cut (figure 22). The sample broke up further during the second saw cut (figure 24).

Sawing exposed additional white clasts (figures 21 - 23). The egg-shaped clast CTA proved interesting. Sawing also showed the details of veining of the large norite clast (figure 21).

There are 34 thin sections of 15455 (table 4).

Table 5	clast	U ppm	Th ppm	K ppm	Rb ppm	Sr ppm	Nd ppm	Sm ppm	technique
Shih et al. 1993	CAN				1.133	137.9	5.368	1.495	idms
					1.065	126.5	6.584	1.804	idms
					1.104	134.8	6.248	1.729	idms
	CTA				0.6087	122.1	3.706	1.916	idms
Silver 1973	CAN	0.258	0.665						idms
	matrix	0.77	2.855						idms
Keith et a. 1973	whole	1.37	5.31						radiation countiong