77115

Impact Melt Breccia

115.9 grams

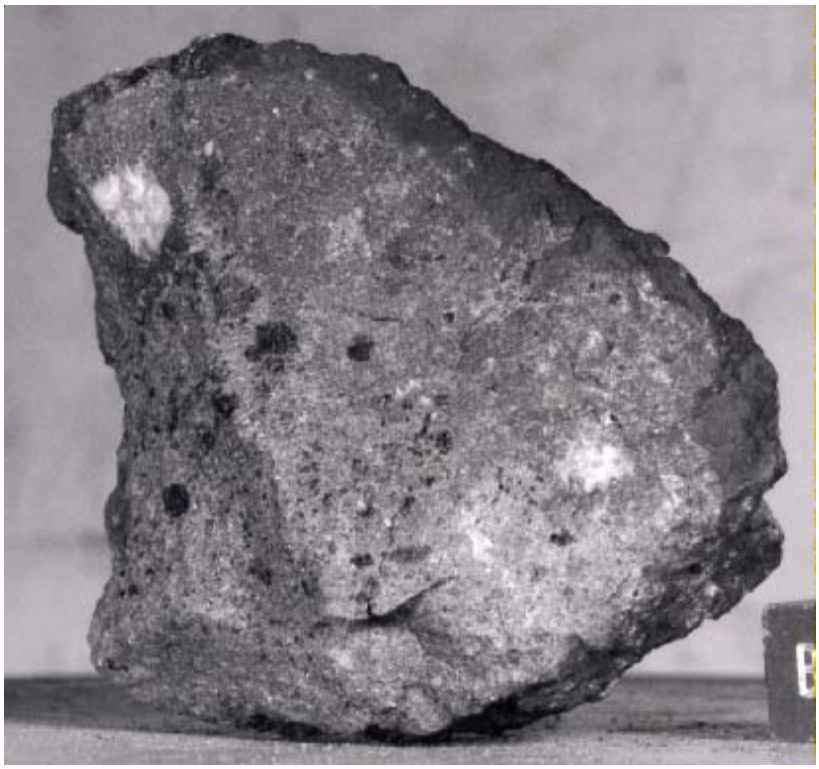

Figure 1: Photo of freshly broken surface of 77115 illustrating white clast and dark clasts (?). Cube is 1 cm. NASA# S73-24129.

Introduction

Sample 77115 was sampled as "blue-gray breccia" from the boulder at Station 7 on the North Massif, Taurus-Littrow, Apollo 17. It is a sample of the boulder matrix that incorporated the large white clast (77215). It contains obvious large lithic clasts, as seen in hand specimen (figure 1), and contains numerous small lithic and mineral clasts in the matrix. The texture and chemical composition are similar to that of the back dike (77075). Schmitt observed that the dike 77075 was continuous with 77115 and that these samples were closely related in origin.

Sample 77115 is a gray, vuggy, very fine-grained, fragment-laden, crystalline-matrix breccia containing abundant xenoliths (clasts). It consists of two parts: a gray, fine-grained matrix making up most of the rock, and a thin layer of brown granular matrix breccia (Minkin et al. 1978). Chao et al. (1975) stated that 77115 was "not a breccia in a normal sense, but is a crystalline rock, formed by crystallization of a fragment-laden melt". The probable origin of impact melt breccias has been explained by Simonds (1975) and Onorato et al. (1976).

This sample and others from the Station 7 boulder were studied by the International Consortium led by Ed Chao (see summary by Minkin et al. 1978). The results on 77115 were also summarized in the catalog by Meyer (1994).

Petrography

The fine-grained matrix of 77115 consists largely of an interlocking network of anhedral and lath plagioclase surrounded by pyroxene in a micropoikilitic texture (figure 2). The pyroxene oikocrysts are approximately 25-30 microns and the matrix plagioclase is ~15 microns. Equant grains of olivine are scattered throughout the matrix. Clusters of

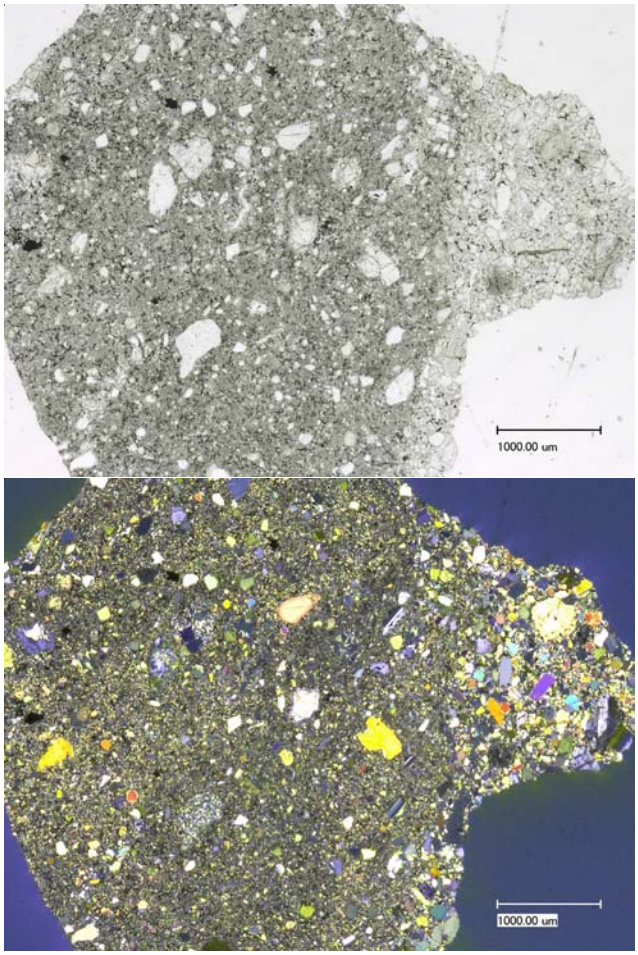

Figure 2: Photomicrographs of thin section 77115,7 by C Meyer @50x.

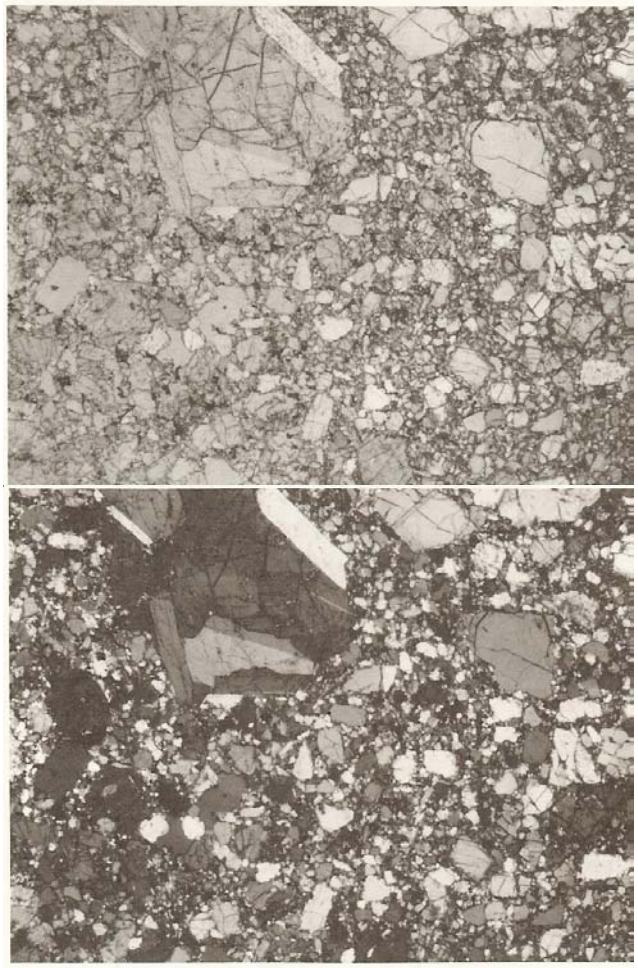

Figure 3: Photomicrographs of a "white" clast in 77115,11. Field of view is 5 mm.

ilmenite platelets and other minerals are found in the mesostasis between pyroxene oikocrysts.

Chao et al. (1975) find that the clast population of 77115 is different from that of 77135 (which generally surrounds 77115). Chao et al. and Huebner et al. (1976) report diffusively-rimmed xenocrysts in 77115. Thornber and Huebner (1980) and Sanford and Huebner (1980) discuss cation diffusion and cooling rates for 77115. They use chemical gradients in olivine to calculate a cooling rate of 10-25 deg C/hr.

The texture of 77115, 77135 and 77075 dike material is similar to that of the samples of the large boulder at Station 6. These samples are interpreted as recrystallized melt breccia from a large basin impact (Serenitatis ?).

Significant Clasts

The "troctolite" clast in 77115,19 was analyzed by Winzer et al. (1974) and Warren and Kallemeyn (1993). It is unusual in that it has high REE (figure 8), yet plagioclase is An_{95}, olivine is Fo_{89} and pyroxene is $Wo_2En_{88}Fs_{10}$ (figure 7). Warren and Kallymeyn also note that the Cr-spinel in this clast is "uncommonly Mg-rich."

Chao et al. (1975) discuss a brownish-gray lighology found as a thin veneer on the surface of 77115. This "clast" is apparently a recrystallized breccia with a bimodal grain-size, containing millimeter-size clasts of granulated clinopyroxene set in a matrix of smaller, slightly fractured yello-green olivine (Fo_{68}) and colorless to light gray plagioclase. No composition is presented.

The obvious small dark clasts in 77115 (as seen in figure 1) apparently remain unstudied.

Figure 4: Photo of sawn surface of 77115,15. Field of view is 5 cm. NASA# S73-34471.

Mineralogy

Olivine: The composition of olivine is Fo_{66-72} (Chao et al. 1975). A precise analysis for olivine in 77115 can be found in Bersch et al. (1991).

Pyroxene: The composition of pyroxene in 77115 is given in figure 5. The fine scale exsolution in pyroxene in 77115 was studied by McGee et al. (1980).

Plagioclase: Chao et al. (1975) determined the composition of plagioclase in 77115. Matrix plagioclase is An_{85-88}. Hansen et al. (1979) report the trace element composition of plagioclase.

Ilmenite: Engelhardt (1979) studied the ilmenite.

Chemistry

Table 1 and figure 8 summarize the chemical composition of 77115. The composition of the matrix (without the mineral clasts) was also determined by broad beam electron probe analysis (Chao et al. 1975).

The "troctolite" clast (,19) has very high REE, while its mineral chemistry shows it to be a mafic sample (figure 7).

Table 2 summarizes the additional chemical data obtained during age dating experiments.

Radiogenic age dating

Stettler et al. (1978) have restudied the ages of 77115 and confirmed their results obtained in 1975 (figure 9). 77115 has a pronounced intermediate temperature plateau at 3.90 ± 0.03 b.y., which is problematical, because this rock was observed to be continuous with the dike rock (77075), which has been dated as 3.98 ± 0.03 by the same laboratory.

Nakamura et al. (1976) determined an imprecise "age" of 3.75 ± 0.2 b.y by Rb-Sr (figure 10). Nunes et al. (1974) reported U-Th-Pb data.

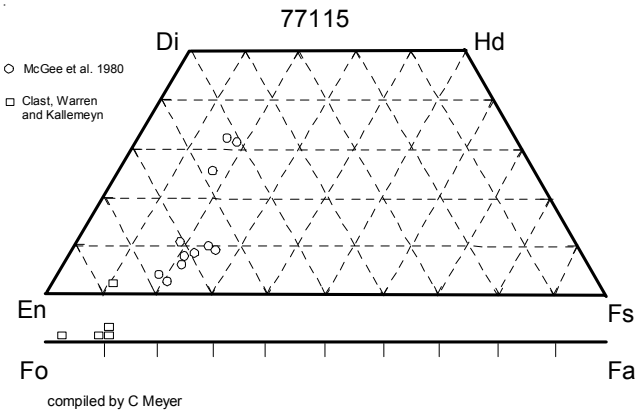

Figure 5: Pyroxene and olivine composition of 77115 (data from McGee et al. 1980 and Warren and Kallemeyn 1993).

Figure 6: Close-up photo of white clast in 77115. NASA# S74-15602. Clast is 8 mm.

Other Studies

Cisowski et al. (1983) and Hale et al. (1978) have reported the magnetic properties of 77115.

Thornber and Huebner (1980) determined the phase relationships as function of crystallization temperature. Sanford and Huebner (1979) studied diffusion in olivine.

Processing

77115 has been sawn (figure 4). The initial processing and distribution of 77115 and other samples from Station 7 boulder is summarized in Butler and Dealing (1974) and Minkin et al. (1978). There are 28 thin sections (figure 2).

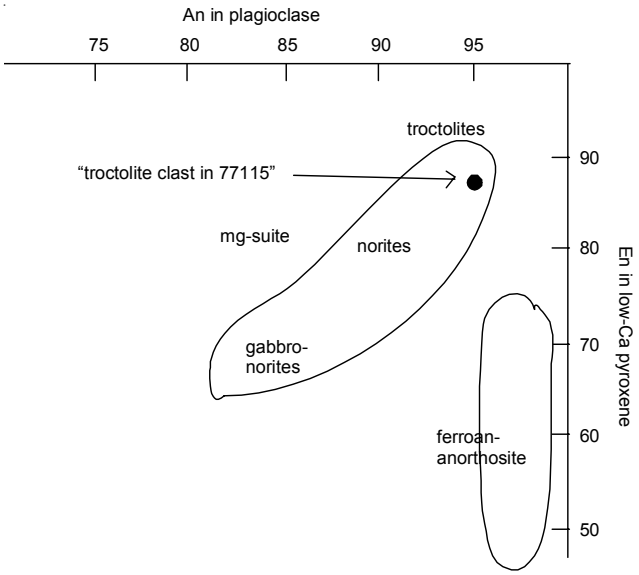

Figure 7: Mineral compsosition of "troctolite clast in 77115" (data from Warren and Kallemeyn 1993).

Mineralogical Mode of 77115

	Matrix Minkin et al. 1978	Xenocrysts Chao et al. 1975
Pyroxene	29 vol. %	11
Plagioclase	60	65
Olivine	6.3	20
Ilmenite	3.4	3

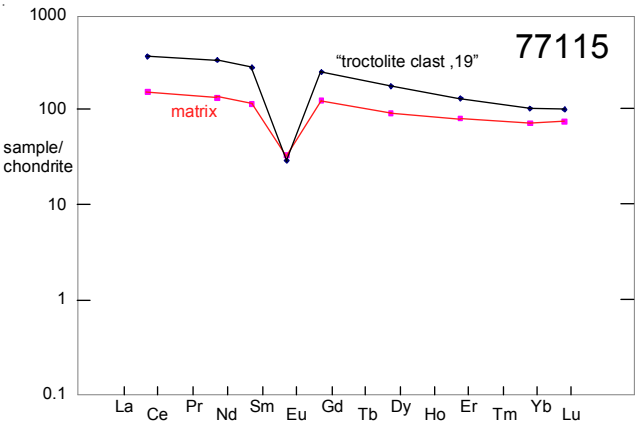

Figure 8: Normalized rare-earth-element diagram for 77115 matrix and "troctolite" clast. Data from Winzer et al. 1974.

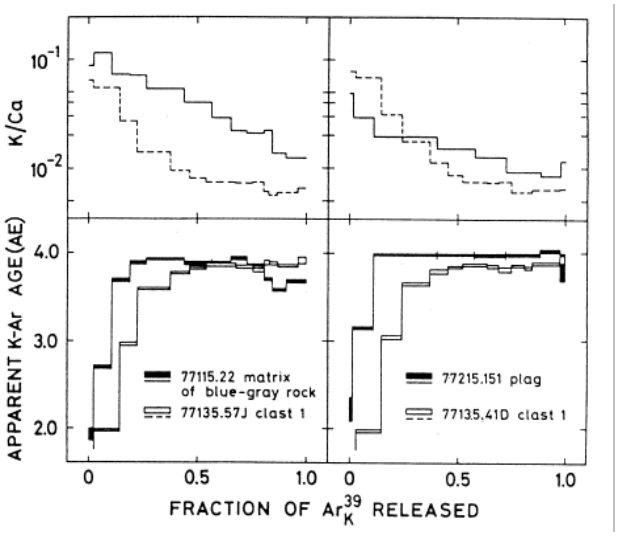

Figure 9: Argon release pattern for 77115 (from Stettler et al. 1978).

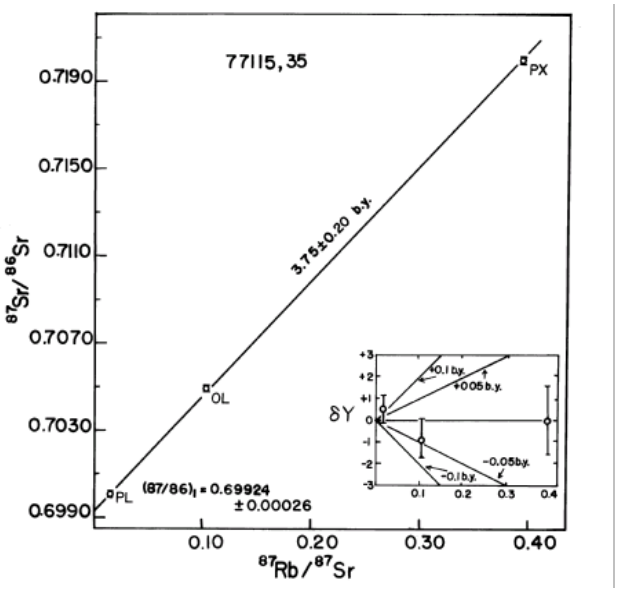

Figure 10: Rb-Sr mineral isochron for 77115 (from Nakamura et al. 1977).

Summary of Age Data for 77115

	Ar39/40	Rb/Sr
Stettler et al. 1978	3.90 ± 0.03 b.y.	
Nakamura et al. 1976		3.75 ± 0.2

Caution: Not corrected for new decay constants.

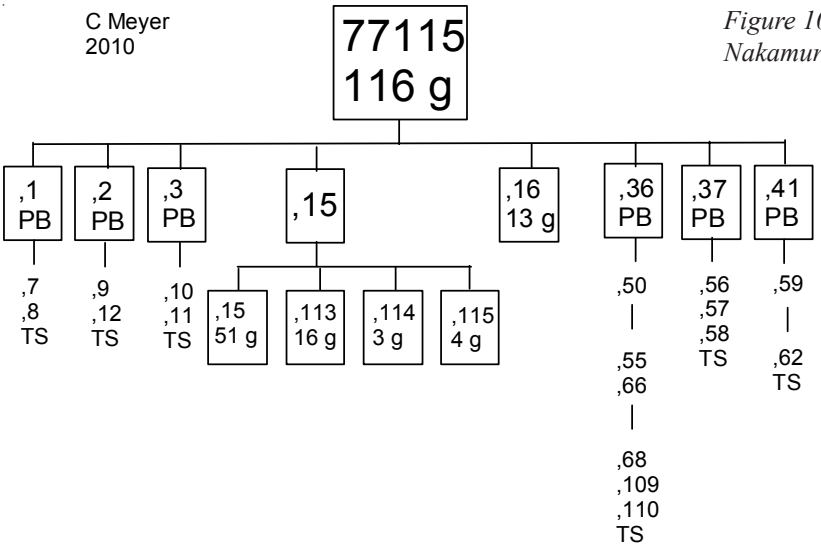

Table 1. Chemical composition of 77115

				"t" clast	matrix		matrix	matrix	matrix	matrix	
reference	Ebihara 92			Winzer 74							
weight				,19			,69	,70	,71		
SiO2 %				41.8	46.6	46.5	47	47.1	47.1	47.2	47.1	(d)
TiO2				0.17	1.15	1.3	1.26	1.31	1.23	1.34	1.21	(c)
Al2O3				16.78	18.63	17.06	17.59	17.35	18.86	17.55	16.26	(d)
FeO				6.08	8.44	8.99	8.73	8.9	8.39	9.51	9.74	(d)
MnO				0.06	0.11	0.12	0.11	0.11	0.11	0.11	0.12	(d)
MgO				23.54	11.96	13.77	12.01	12.33	10.98	12.43	13.34	(d)
CaO				10.24	11.01	10.6	10.72	10.79	11.11	10.89	10.07	(d)
Na2O				0.31	0.67	0.66	0.66	0.66	0.69	0.67	0.61	(d)
K2O				0.08	0.25	0.26		0.26	0.32	0.24		(b)
P2O5				0.53	0.37	0.29	0.31	0.33	0.31	0.31	0.24	(c)
S %												
sum												
Sc ppm												
V												
Cr												
Co												
Ni	332	287	(a)									
Cu												
Zn	2.19	2.34	(a)									
Ga												
Ge ppb	512	462	(a)									
As												
Se	101	104	(a)									
Rb	8.93	7.43	(a)	1.24	6.1	6.32		6.82	8.82	6.35		(b)
Sr				134	176	166		170	180	167		(b)
Y												
Zr				160	549	478		538	524	477		(b)
Nb												
Mo												
Ru												
Rh												
Pd ppb	18.1	10.9	(a)									
Ag ppb	11.8	1.21	(a)									
Cd ppb	4.15	16.3	(a)									
In ppb	6.61	9.95	(a)									
Sn ppb												
Sb ppb	3.01	1.99	(a)									
Te ppb	5.48	6.15	(a)									
Cs ppm	0.23	0.281	(a)									
Ba				243	386	352		416	461	393		(b)
La												
Ce				226	120	82.9		95.4	92.4	82.7		(b)
Pr												
Nd				155	76.5	52.1		62.4	59.3	55.5		(b)
Sm				42.2	21.4	14.7		17.3	16.1	15.2		(b)
Eu				1.68	1.96	1.87		1.93	2.06	1.91		(b)
Gd				50.8	26.3	18		25.2	20.8	18.9		(b)
Tb												
Dy				44.2	28.6	20.4		22.7	21.4	19.5		(b)
Ho												
Er				21.6	15.9	11.7		13.2	12.5	11.1		(b)
Tm												
Yb				17.2	14.5	10.7		12.1	11.7	11		(b)
Lu				2.51	2.2	1.65		1.86	1.8	1.59		(b)
Hf								12.9				(b)
Ta												
W ppb												
Re ppb	0.89	0.715	(a)									
Os ppb	8.19	7.99	(a)									
Ir ppb	8.62	7.15	(a)									
Pt ppb												
Au ppb	5.52	4.43	(a)								Fruchter	
Th ppm											5.31	(e)
U ppm	1.48	1.5	(a)								1.4	(e)
technique	*(a) RNAA, (b) IDMS, (C) colorimetric, (d) AA, (e) radiation counting*											

Table 2: Composition of 77115.

	U ppm	Th ppm	K2O %	Rb ppm	Sr ppm	Nd ppm	Sm ppm	technique
Nunes et al. 1994	1.453	5.436						IDMS
Ebihara et al. 1991	1.48			8.93				RNAA
	1.5			7.43				RNAA
Winzer et al. 1974			0.26	6.82	170	62.4	17.3	IDMS
Fruchter et al. 1975	1.4	5.31	0.2					counting

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