12034

DRAFT

Regolith Breccia
155 grams

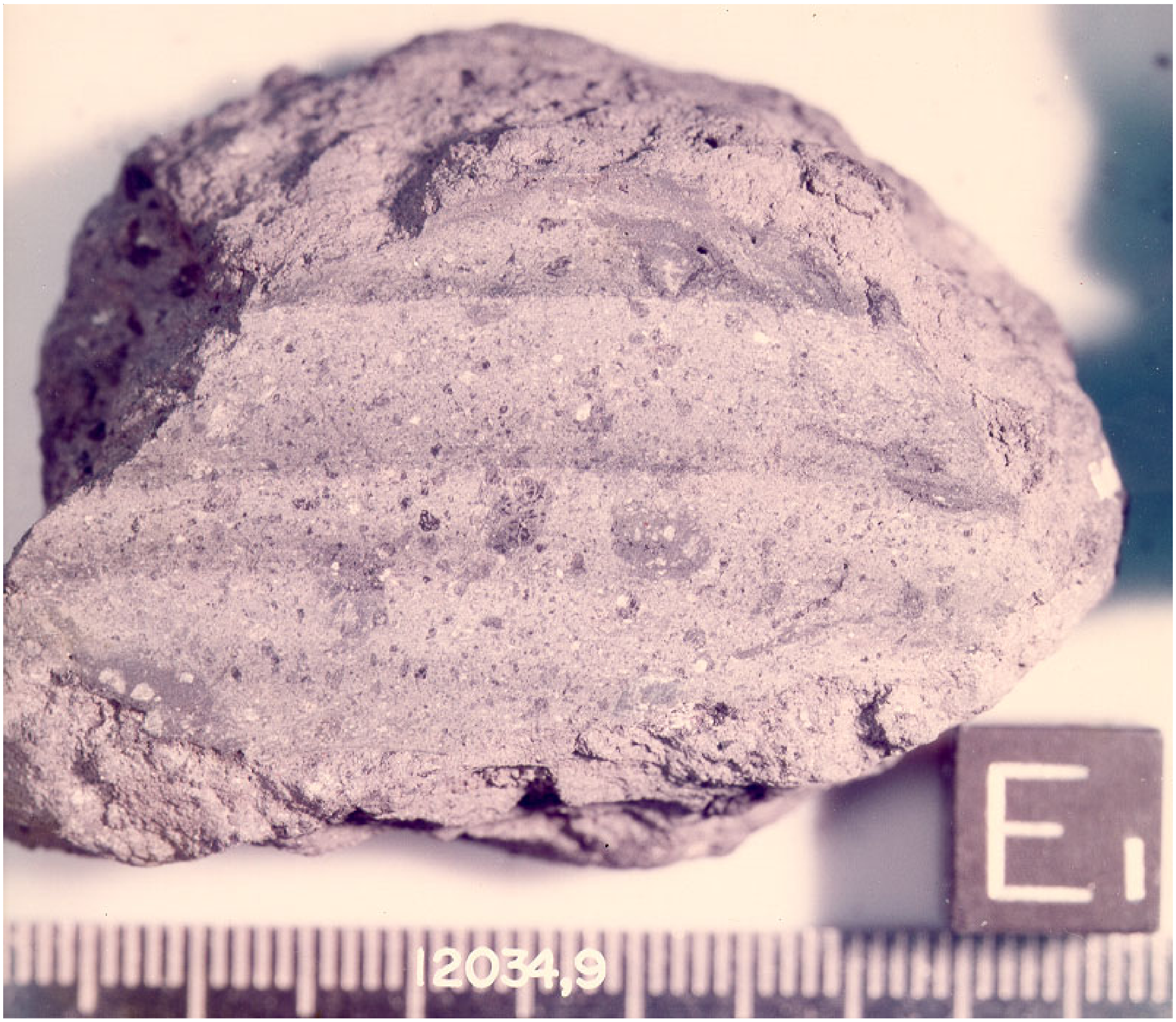

Figure 1: Lunar sample 12034 after first saw cut in 1970. NASA S75-34235. Cube is 1 cm.

Introduction

12034 was collected from the bottom of the same trench as soil sample 12033. These samples were located about 15 meters inside the rim of Head Crater (Schoemaker et al. 1970). *"Let's sample that rock that I dug up from down deep (~15 cm). Let me get a photo of it (AS12-49-7195 - 6)".*

12034 is a regolith breccia, but it is largely made up of components foreign to the Apollo 12 regolith and is from some distant, non-mare, regolith (figure 1). It contains abundant KREEP; both as glasses and annealed lithic fragments.

12034 has not been dated, but there is evidence in the U/Pb data that there has been a young event.

Petrography

Simon et al. (1985) described regolith breccias from Apollo 12 and give new analyses. They note that although 12034 is a soil breccia, it is unlike the soils at

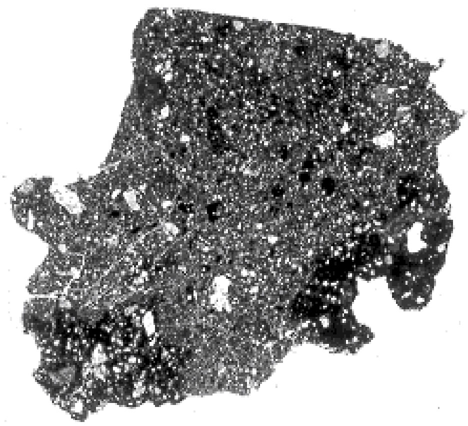

Figure 2: Photo of thin section 12034,106 showing clastic texture. Scale is about 1.2 cm.

Mode for 12034

	Chao et al. 1971	McGee et al. 1979
Basaltic rock	5.2 %	5.96
Anorthositic rock	1.6	
Mineral fragments	14.7	12
Glass-welded aggregate	25.7	
Devitrified glass	2.2	
Heterogeneous glass	6.6	23
Homogeneous glass	0.3	tr.
Basaltic microbreccia	0.3	5
Anorthositic microbx.	1.8	
Less than 25 microns	27.3	53
Pore space	14.2	

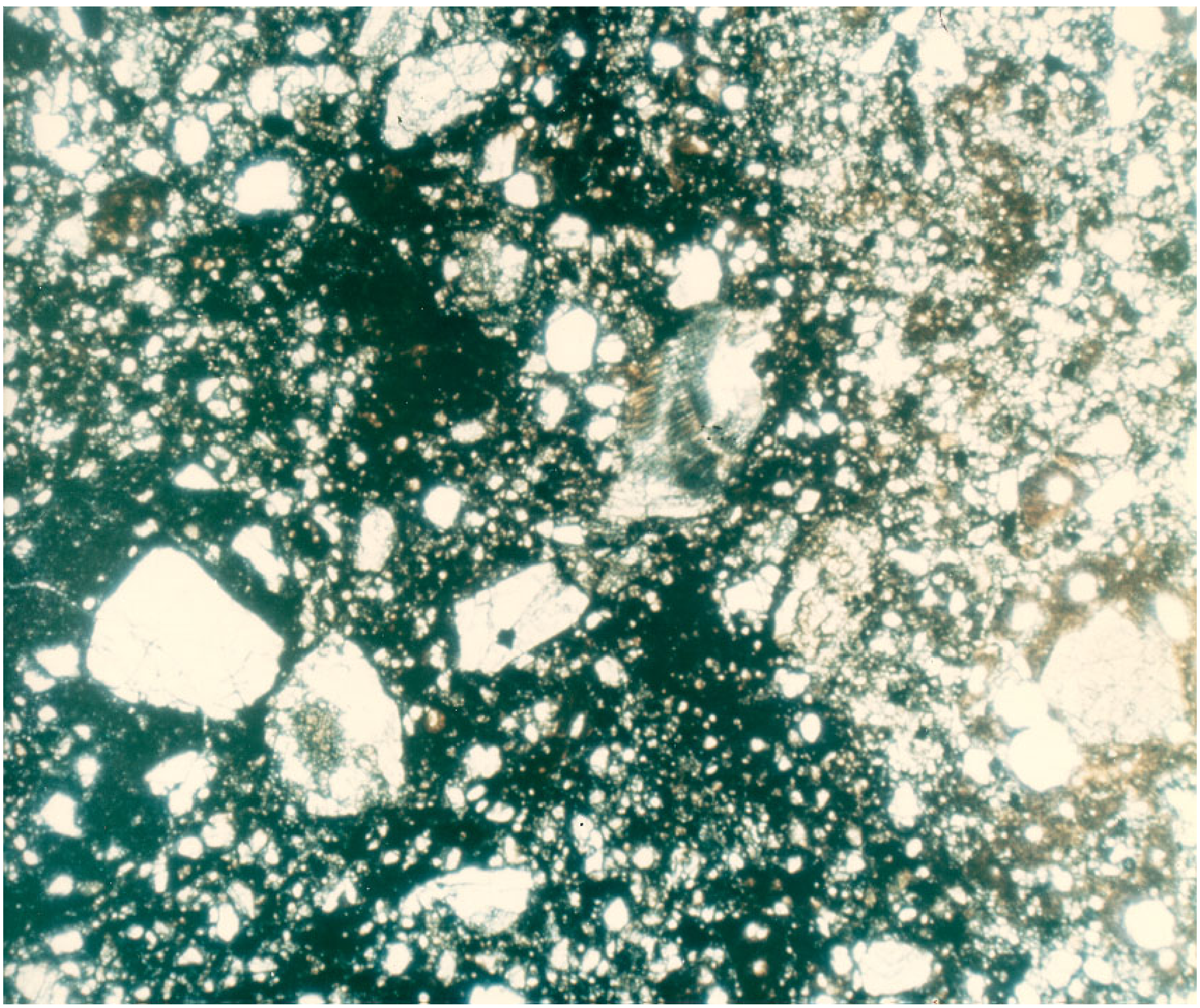

Figure 3: Thin section photomicrograph of 12034. NASA S70-49463. Scale unknown.

Modal Petrology for 12034

	Simon et al. 1985
Mare Basalt	1.7
ANT	3
CMB	0.7
Poik. Bas.	1.2
Regolith bx.	2.8
Agglutinate	8
Pyroxene	1.5
Olivine	0.3
Plag.	2
Opaques	
Glass	5.2
Matrix	45.5

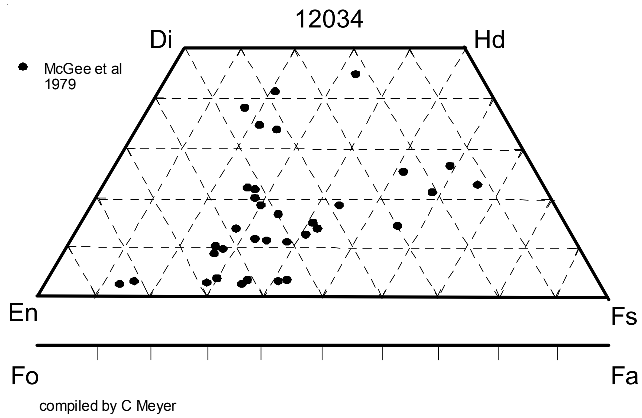

Figure 4: Composition of pyroxene found in matrix of 12034.

Apollo 12. Simon et al. (1985) and Anderson and Smith (1971) note that it contains Mg-rich orthopyroxene and olivine.

Sample 12034 is a fragmental matrix breccia similar in appearance to the Apollo 11 fragmental matrix breccias, but with a much lower porosity (figure 2). According to McGee et al. (1979) it consists of a variety of glass, mineral and lithic clasts contained in a matrix of brown glass fragments and comminuted debris (figure 3). The texture of the matrix is seriate with fragments ranging in size from the limit of resolution up to 2 mm. Brown glass fragments dominate the less than 0.05 mm size fraction (Phinney et al. 1976). Waters et al. (1971) noted a vague stratified nature of the sample. Chao et al. (1971) and Anderson and Smith (1971) reported 14% and 10% pore space, respectively.

The glass clast population in 12034 is extremely diverse, ranging from colorless, pale green, yellow or orange homogeneous glass to completely devitrified glass with included mineral grains (Chao et al. 1971; von Engelhardt et al. 1971). Subrounded to rounded fragments of maskelynite and devitrified maskelynite occur commonly as inclusions in the large devitrified glass clasts. Devitrification features in glass clasts take the form of vaiolitic clusters of plagioclase needles and more commonly axiolitic intergrowths of tightly packed plagioclase and pyroxene crystals (McGee et al. 1979).

The lithic clasts in 12034 include basalts, dark-matrix breccia, cataclastic anorthosite and anorthositic gabbro (see modes in tables). Rare basalts have textures ranging from ophitic to vitrophryic. Anderson and Smith (1971) reported "grey mottled" basalts in 12034. These are made up of about half plagioclase and half low-Ca pyroxene (orthopyroxene?) and have the bulk composition of KREEP. Based on what we know now, they are probably fragments of impact melt.

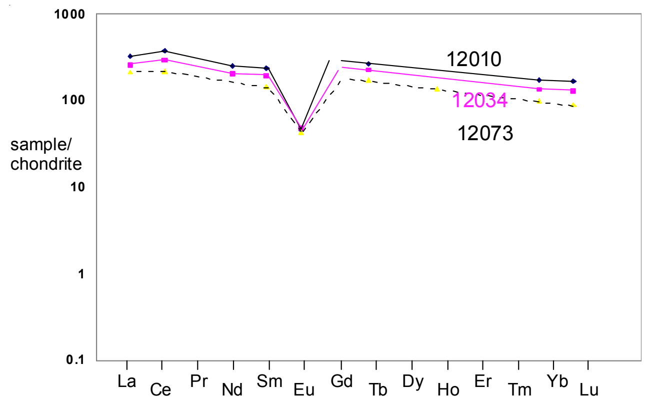

Figure 5: Comparison of REE for three regolith breccias from Apollo 12 (data from Goles et al. 1971 and Wanke et al. 1971).

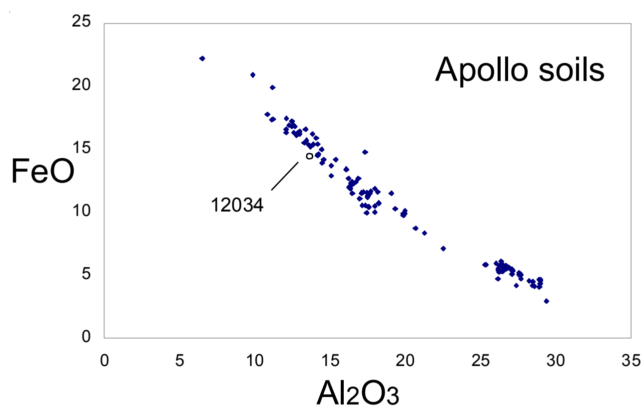

Figure 6: Composition of regolith breccia compared with all lunar soils (see table).

Chemistry

One can use the whole rock U and Th measurements from radiation counting (O'Kelley et al. 1971, Rancitelli et al. 1971) to judge which analyses are representative of the sample (table 1). The split obtained by Simon et al. (1985) is high in U and Th, while the splits analyzed by Goles et al. (1971) and Wakita et al. (1971) appear low.

Using chemical mixing models, but with different assumed compositions for end members, Meyer et al. (1971) calculated that 12034 is ~30 % mare basalt, ~5 % anorthosite and ~ 66 % KREEP, while Simon et al. (1985) calculated that 12034 is ~ 1 % basalt, 8 % anorthosite and 89 % low-KREEP. Finally, McKay et al. (1971) calculated ~ 56 % KREEP for 12034, using K, Rb and Ba only.

Radiogenic age dating

Tatsumoto et al. (1971) determined the U, Th and Pb isotopes in 12034, providing evidence for a young event (figure 7). The Nd – Sm data give a model age for KREEP in 12034 of 4.3 – 4.4 b.y. (Lugmair and Carlson 1978).

Cosmogenic isotopes and exposure ages

O'Kelly et al. (1971) determined the cosmic ray induced activity of 12034 as ^{22}Na = 29 dpm/kg, ^{26}Al = 45 dpm/kg, ^{46}Sc = <10 dpm/kg, ^{48}V = <60 dpm/kg, ^{54}Mn = 16 dpm/kg, ^{56}Co = <16 dpm/kg and ^{60}Co = < 4 dpm/kg. Rancitelli et al. (1971) determined ^{22}Na = 34 dpm/kg, ^{26}Al = 60 dpm/kg, ^{54}Mn = <40 dpm/kg, ^{56}Co = <56 dpm/kg and ^{60}Co = 1.5 dpm/kg. Breccia 12034 was shielded from solar cosmic rays, having been buried in a trench.

Basford et al. (1973) determined the isotopic composition of Kr and Xe, but do not give an expsoure age.

Other Studies

Epstein and Taylor (1971)	oxygen isotopes
Reed and Jovanovic (1971)	halogens

Processing

One end was cut off 12034 in 1970, and in 1975, a small slab was cut (see figures). There are 16 thin sections. 12034 was never studied in "consortium mode".

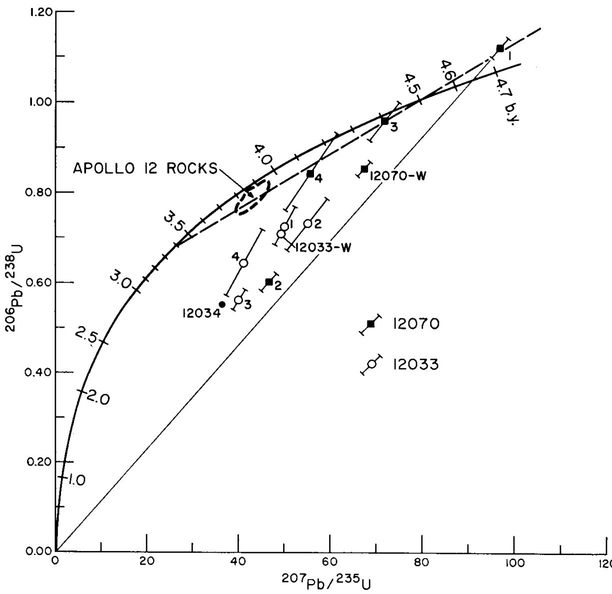

Figure 7: U/Pb concordia diagram showing that 12034 data is discordant (Tatsumoto et al. 1971).

Table 1. Chemical composition of 12034.

reference	Simon85		Wakita 71			O'Kelly71		Hubbard73		Wiesmann75		Goles71		Rancitelli71		Tatsumoto71	
weight			0.199	.267 g		155 g											
SiO2 %			45.8		(a)			47.76	(d)			45.78	(e)				
TiO2	1.8	(e)	2.7	2.8	(a)			2.33	(d)	2.28	(c)	2.3	(e)				
Al2O3	14.7	(e)	15.7	15.7	(a)			15.49	(d)			14.6	(e)				
FeO	12	(e)	13.3		(a)			12.42	(d)			13.29	(e)				
MnO	0.156	(e)	0.167	0.173	(a)			0.19	(d)			0.17	(e)				
MgO	8.3	(e)	9.6		(a)			8.31	(d)								
CaO	11.5	(e)	11.2	11.6	(a)			10.85	(d)			11.3	(e)				
Na2O	0.78	(e)	0.788	0.755	(a)			0.67	(d)	0.86	(c)	0.78	(e)				
K2O	0.67	(e)		0.529	(a)	0.55	(b)	0.48	(d)	0.5	(c)			0.56	(b)		
P2O5								0.53	(d)								
S %								0.09	(d)								
sum																	
Sc ppm	29	(e)	31		(a)							30	(e)				
V	65	(e)	90	110	(a)												
Cr	1724	(e)	35		(a)					1790	(c)	1840	(e)				
Co	17.5	(e)										30.4	(e)				
Ni	90	(e)															
Cu																	
Zn																	
Ga																	
Ge ppb																	
As																	
Se																	
Rb				11	(a)					12.75	(c)						
Sr	170	(e)								195	(c)						
Y				186	(a)												
Zr	870	(e)	640		(a)					756	(c)	630	(e)				
Nb																	
Mo																	
Ru																	
Rh																	
Pd ppb																	
Ag ppb																	
Cd ppb																	
In ppb				35	(a)												
Sn ppb																	
Sb ppb																	
Te ppb																	
Cs ppm				0.48	(a)												
Ba	850	(e)	470		(a)					748	(c)	720	(e)				
La	68.3	(e)	75	60	(a)					68.3	(c)	60.4	(e)				
Ce	170	(e)		172	(a)					172	(c)	176.7	(e)				
Pr				20.4	(a)												
Nd	110	(e)		100	(a)					105	(c)	92	(e)				
Sm	29.5	(e)	32	29.4	(a)					29.5	(c)	28.3	(e)				
Eu	2.8	(e)	2.95	2.65	(a)					2.81	(c)	2.69	(e)				
Gd				33.3	(a)					35.6	(c)						
Tb	6.6	(e)		5.51	(a)							8.12	(e)				
Dy	42	(e)		34	(a)					38	(c)						
Ho				8.8	(a)												
Er	3.7	(e)		21.7	(a)					23.4	(c)						
Tm				3.6	(a)												
Yb	25	(e)	25	22.4	(a)					21.5	(c)	21.7	(e)				
Lu	3.6	(e)	3.3	2.74	(a)							3.14	(e)				
Hf	22	(e)	27		(a)					20.4	(c)	20.4	(e)				
Ta	3.3	(e)										3.09	(e)				
W ppb																	
Re ppb																	
Os ppb																	
Ir ppb																	
Pt ppb																	
Au ppb																	
Th ppm	17.2	(e)	13.2		(a)	13.1	(b)			11.7	(c)	11.53	(e)	13.9	(b)	13	(c)
U ppm	4.5	(e)				3.4	(b)			3.4	(c)			3.53	(b)	3.5	(c)

technique (a) RNAA, (b) radiation counting, (c) IDMS, (d) XRF, (e) INAA

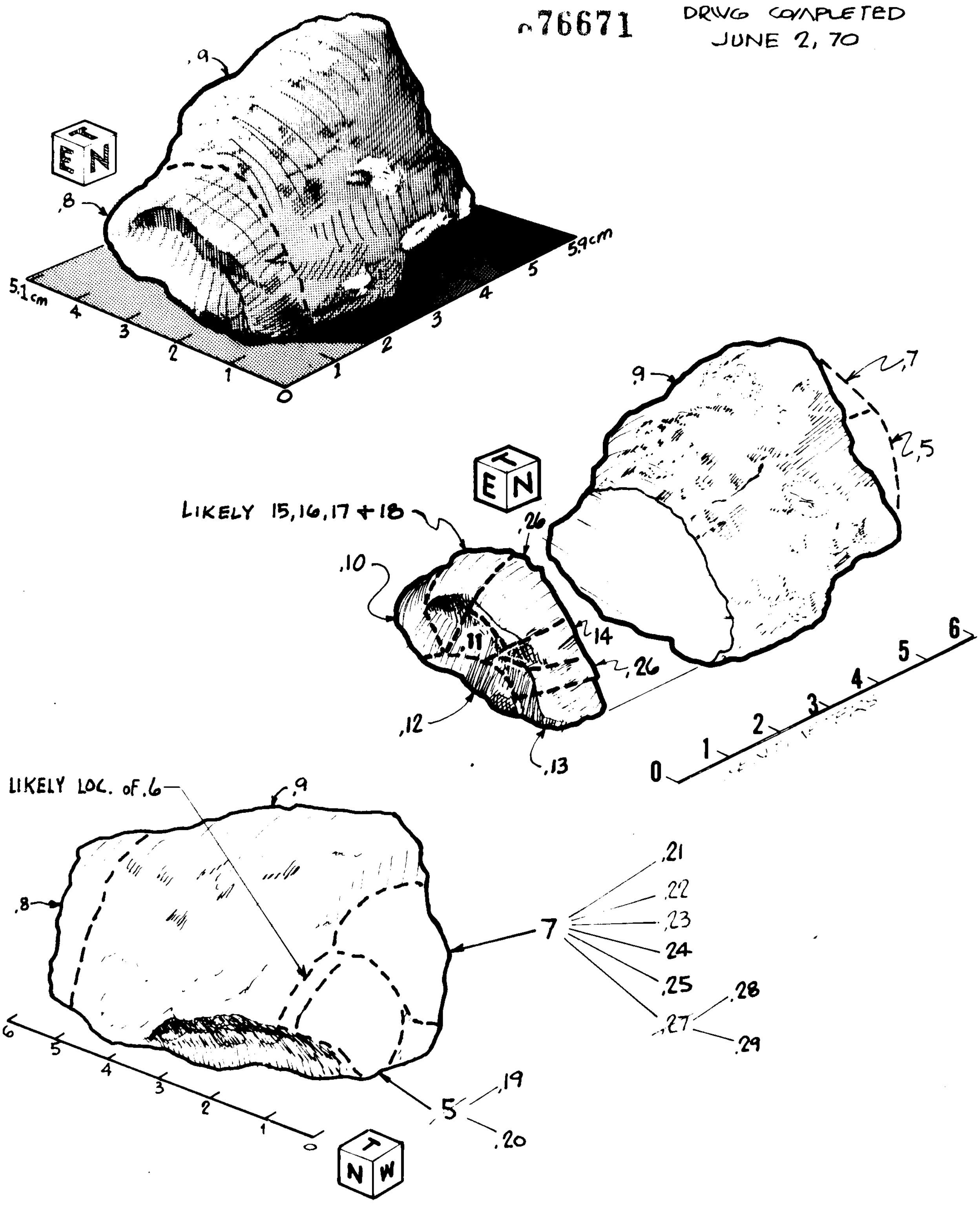

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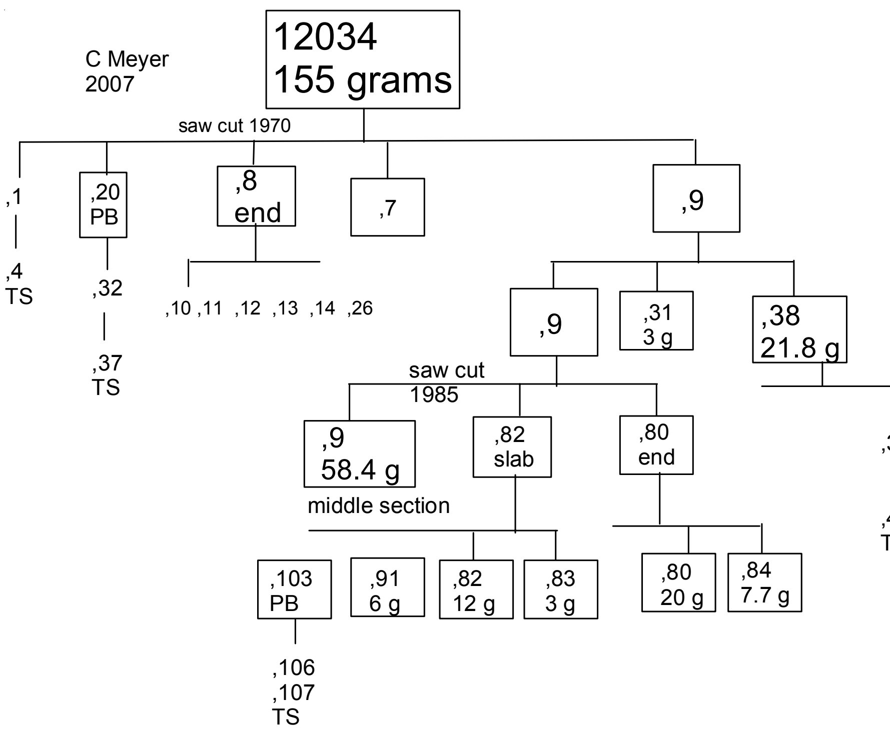
Figure 8: Group photo of 12034 after cutting slab (,82) and end (,80-,84) pieces in 1975. NASA S75-34414. Cube is 1 cm.



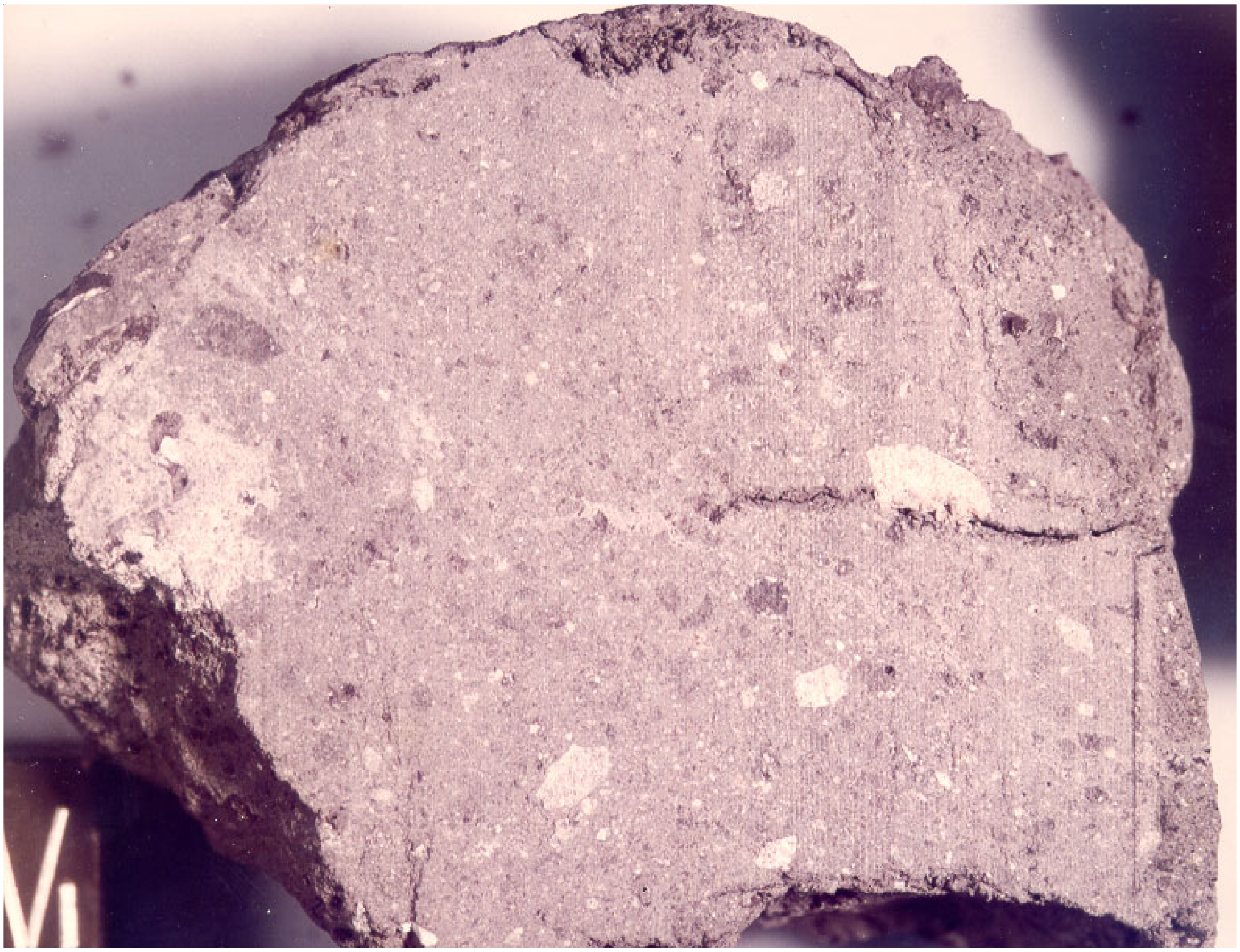


Figure 9: Sawn surface of middle piece (,9) of 12034 - side facing slab (,82). Cube is 1 cm. NASA S75-34243.

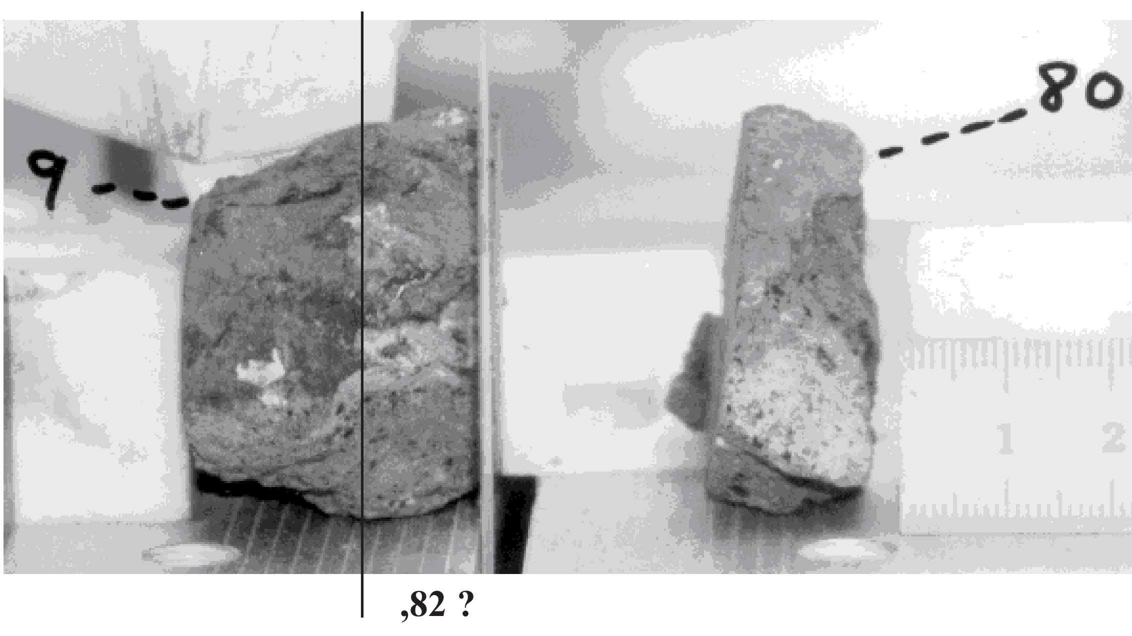


Figure 10: Processing photo of 12034 after cutting end ,80. Location of slab ,82 is approximate.

Figure 11: Slab (,82) cut from 12034 facing middle piece (,9). Cube is 1 cm. NASA S75-34238.

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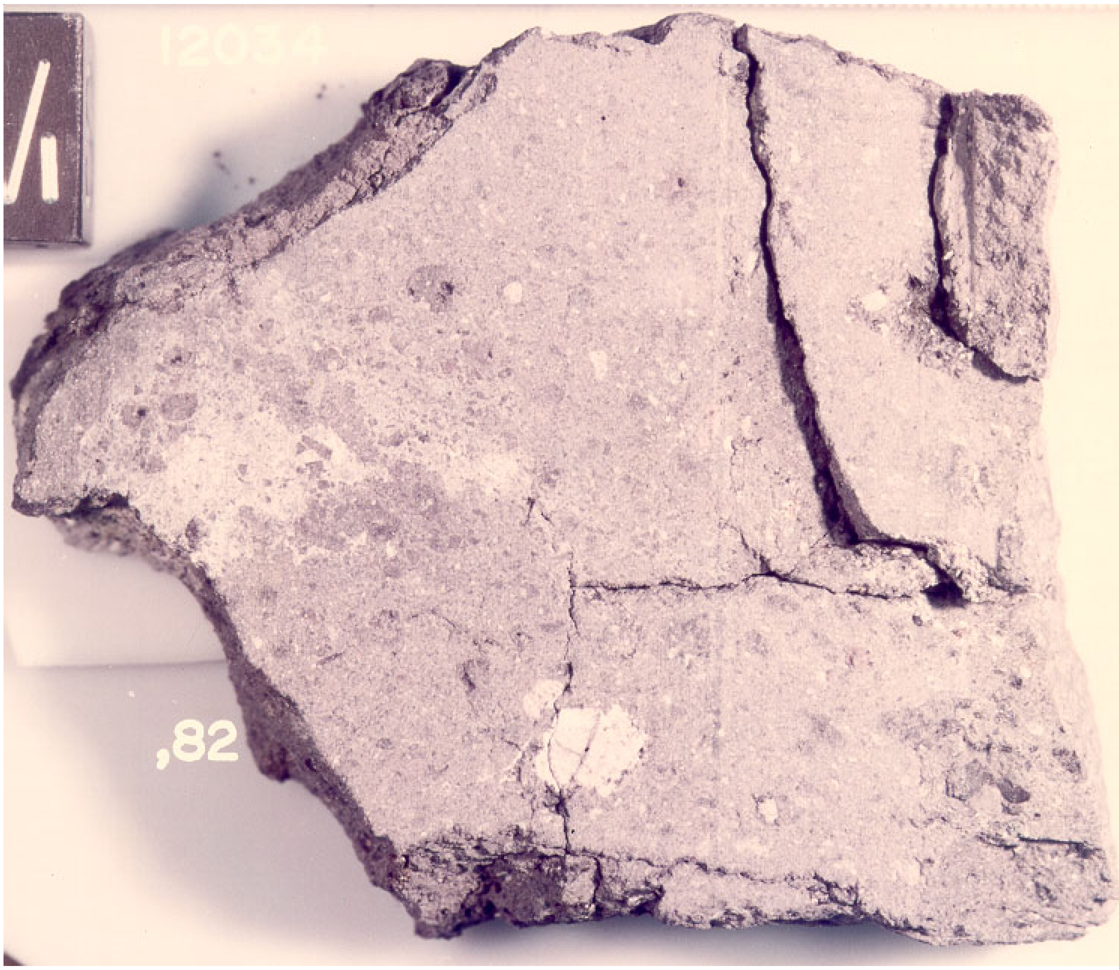

Figure 12: Slab (,82) cut from 12034 side facing (,80) end. NASA S 75-34236. Cube is 1 cm.

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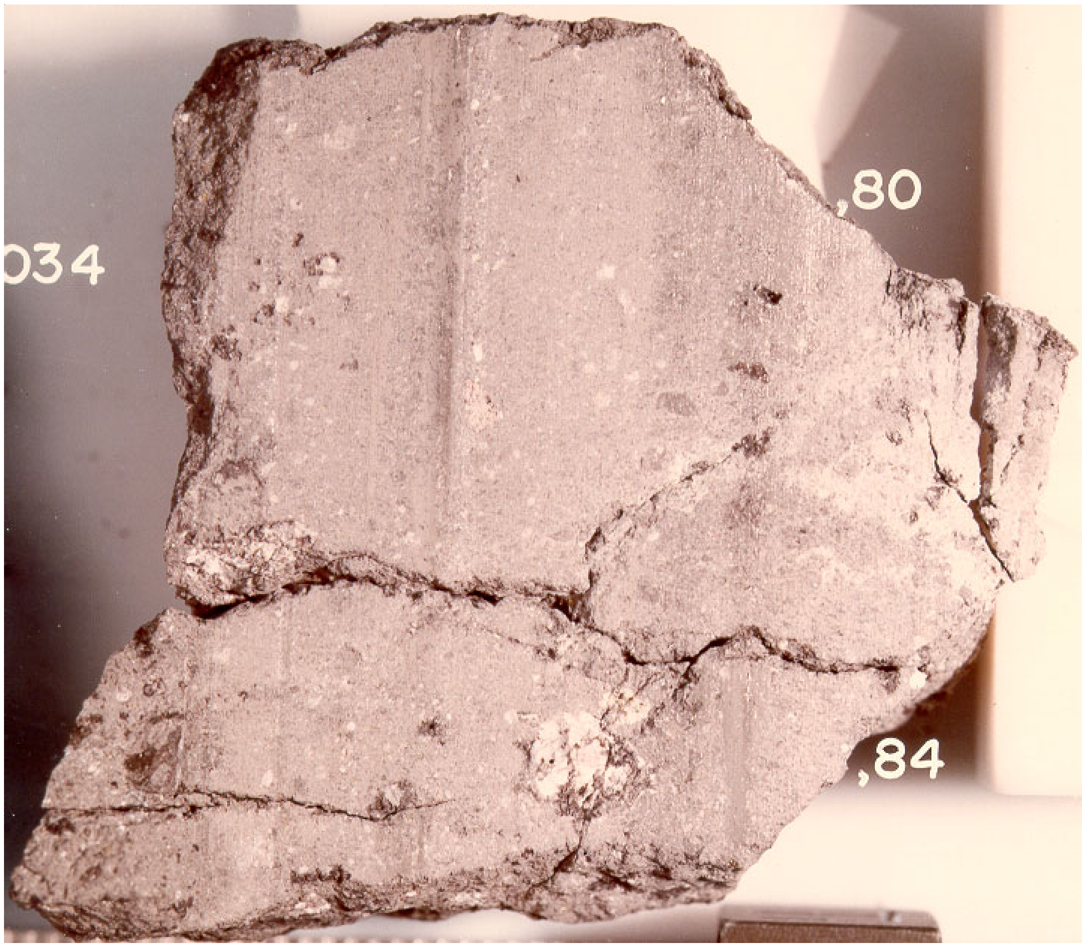

Figure 13: Sawn surface of 12034,80 (butt end). NASA S75-34244.

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