14066

Crystalline-matrix Breccia

509.8 grams

Figure 1: Photo of surface of 14066 showing zap pits. Cube is 1 inch. NASA S71-29233.

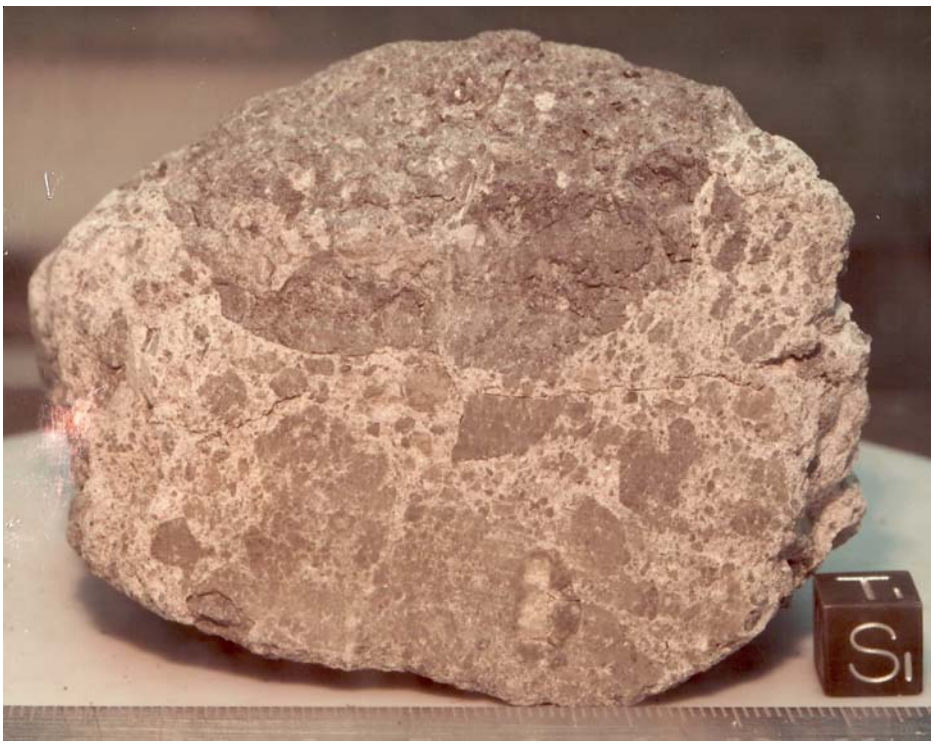


Figure 2: Sawn surface of 14066 showing breccia-in-breccia texture. Cube is 1 cm. S77-23485.

Introduction

Apollo 14 breccia sample 14066 was the largest rock brought back under vacuum in ALSRC 1006, bag 17N. It was collected at station F near Weird Rock (figure 3). It is a blocky, subrounded rock whose rounded faces are heavily covered by glass-lined zap pits (figure 1). The rock is very hackly at one end and has a few other irregular features. It is moderately friable with 15 to

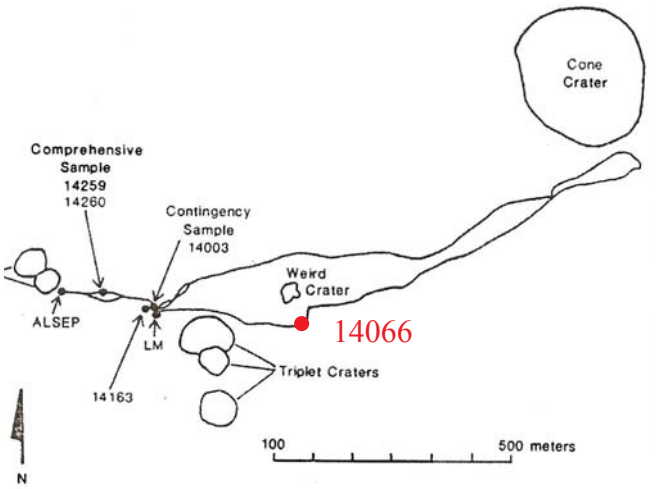


Figure 3: Location of 14066 on Apollo 14 traverse map.

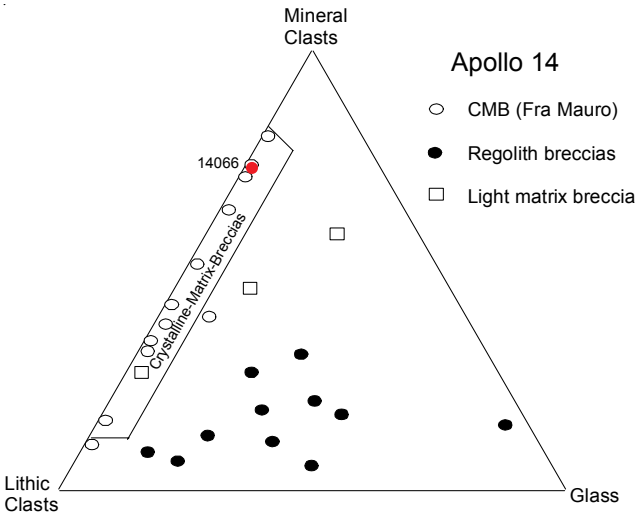


Figure 4: Clast-matrix relationship of Apollo 14 breccias (Simonds et al. 1977).

20 % of subangular dark clasts and a few light clasts in a fine-grained light matrix (figure 2).

14066 has an exposure age of 27 m.y. (Srinivasan et al. 1974) so that, although it was picked up some distance away from Cone Crater, it is probably derived from there.

Petrography

Simonds et al. (1977) classify 14066 as a typical Fra Mauro breccias (figure 4). Phinney et al. (1978) described the matrix of 14066 using the SEM. The matrix has interlocking grains of 5-20 micron plagioclase and pyroxene with 5 micron ilmenite. The matrix makes up 60-70 percent of the rock. The sample has many fractures, some penetrating. Juan et al. (1972), Stoffler and Knoll (1977), von Engelhardt et al. (1972) and Stoffler et al. (1979) also give descriptions of 14066. Twedell et al. (1978) made maps of the surfaces showing location of clasts.

Note the large pink spinel in thin section 14066,48 (figure 7). Spinel grains were also reported by Haggerty (1972) and Christophe-Michel-Levy (1972).

Significant Clasts

Alkali Anorthosite ,49 ,51

Shervais et al. (1983) reported an anorthosite clast with 86% plagioclase (An_{81}), about 15% orthopyroxene (En_{64}) and with trace K-spar and ilmenite. The pyroxene was variable in composition. Plagioclase grains are large. Warren (1993) find that this clast is probably pristine (although no Ir data).

Gabbronorite TS,47

Meyer et al. (1989) reported a large poikilitic zircon (200 microns) in a clast of gabbronorite (45% plag An_{84}; 45% pyroxene En_{69})(figure 12). This has been dated by Nemchin et al. (2008) at 4.2 b.y.

Chemistry

The composition of 14066 was reported by Rose et al. (1972), Wanke et al. (1972) and LSPET (1971. Baedecker et al. (1972) determined the Ni and Ir to be high. The sample has very high Ba, Th, and REE (figure 9).

The carbon content is moderate (figure 10).

Radiogenic age dating

Mark et al. (1973) determined the age of a clast by Rb/Sr (figure 11). Nemchin et al. (2008) obtained a U/Pb age for a unique zircon (figure 12).

Cosmogenic isotopes and exposure ages

14066 was found to have ^{26}Al activity of 103 dpm/kg, $^{22}Na = 43$ dpm/kg, $^{54}Mn = 5$ dpm/kg, $^{56}Co = 31$ dpm/kg and $^{46}Sc = 6$ dpm/kg (Keith et al. 1972).

Srinivasan (1974) determined the exposure age of 27 m.y. by the ^{81}Kr method while Kaiser (1972) determined 24 m.y. (as reported by Drozd et al. 1977).

Figure 5: Photomicrograph of thin section 14066,47. About 1 cm. NASA S71-40449.

Figure 6: Exterior of 14066. Cube is 1 cm.

Mineralogical Mode for 14066

	Simonds et al 1977
Matrix	83.5 %
Clasts	
Plagioclase	8.5
Mafic	3.5
Breccia	0.5
Granulite	1.5
Mare basalt	0.5
Felds basalt	0.5
Pore space	1

Other Studies

Hart et al. (1972) determined the density of solar-flare tracks in 14066.

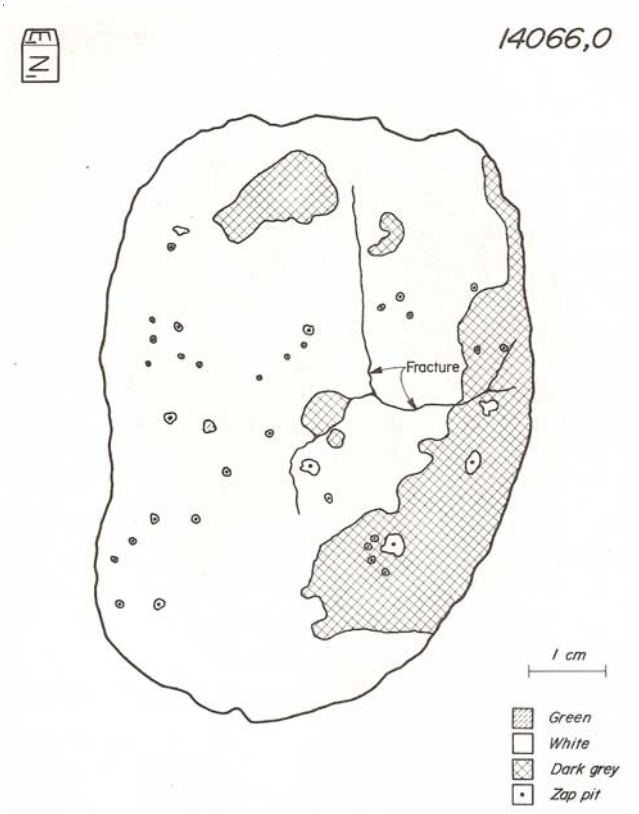
Collinson et al. (1972) and Cisowski et al. (1983) determined the magnetic properties.

Srinivasan (1974), Drozd et al. (1977) and Hohenberg et al (1978) determined the abundance and isotopic ratio of rare gases.

Processing

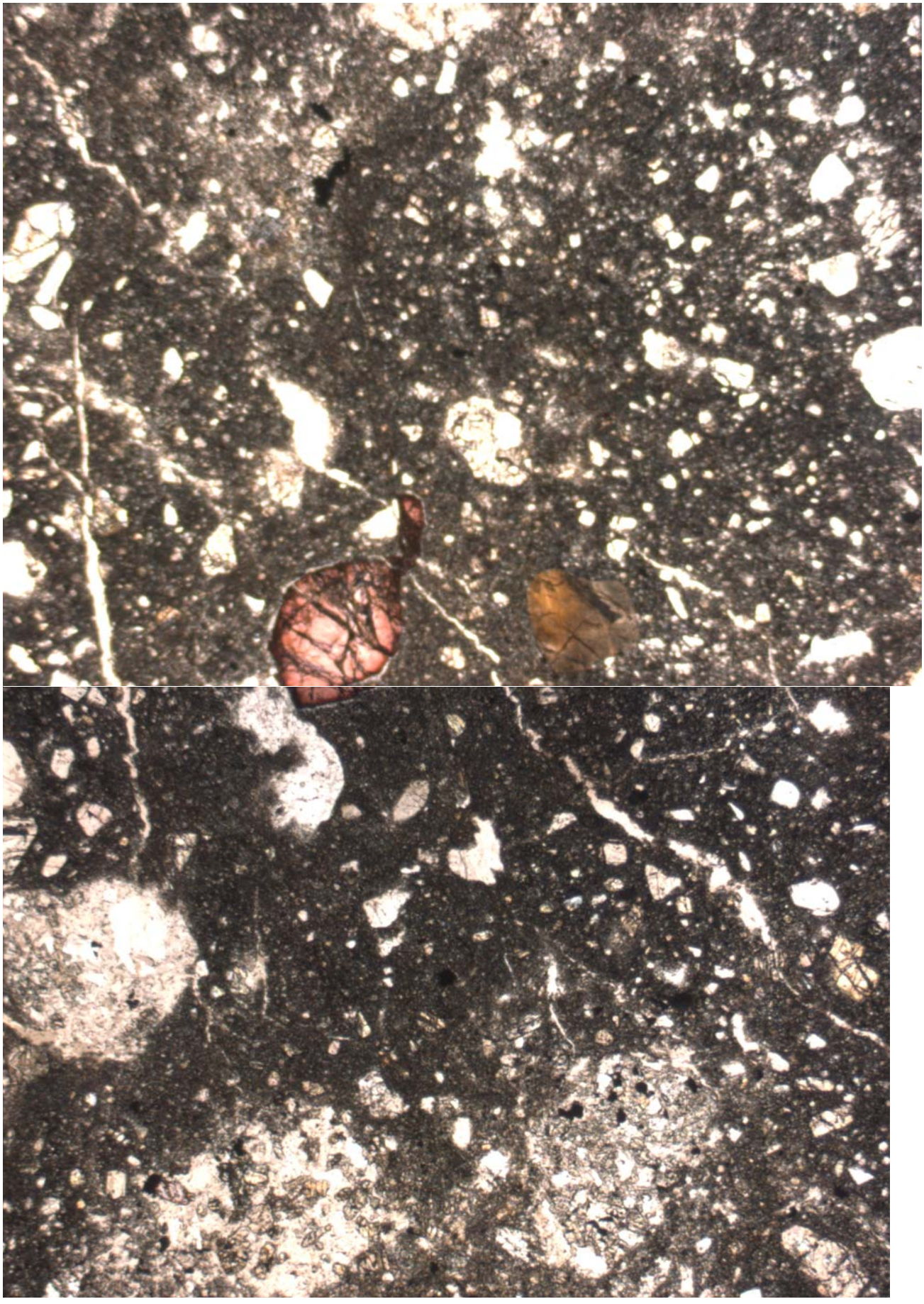
Returned in bag 17N in ALSRC 1006. This large Fra Mauro breccia is one of the few that never saw terrestrial atmosphere. ALSRC 1006 was returned sealed and was opened only in the nitrogen.

There is only one saw cut – no slab. There are 18 thin sections for 14066



Next page Figure 7: Photomicrograph of thin section 14066,48 by C Meyer.

Scale = 2.8 mm across



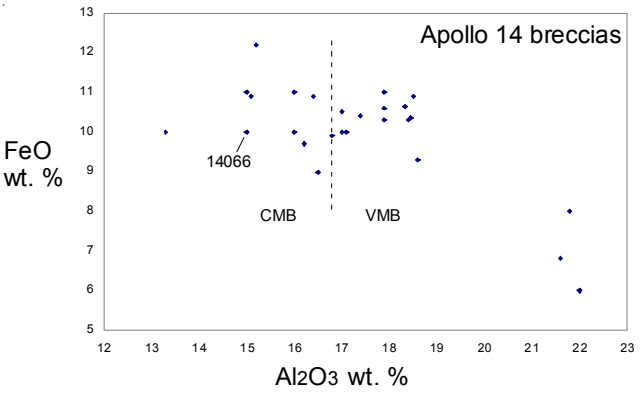


Figure 8: Composition of 14066 compared with all Apollo 14 breccias.

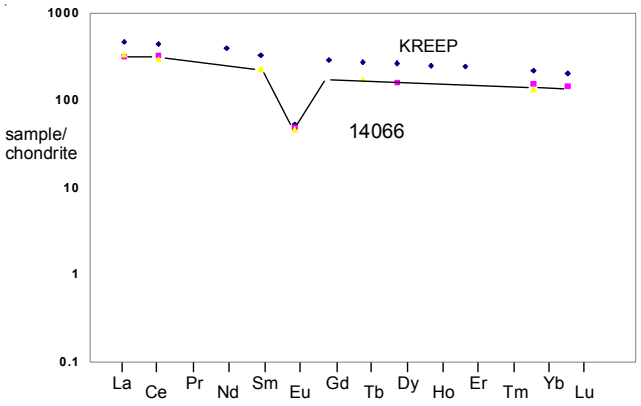


Figure 9: Normalized rare-earth-element diagram for 14066 compared with that of KREEP.

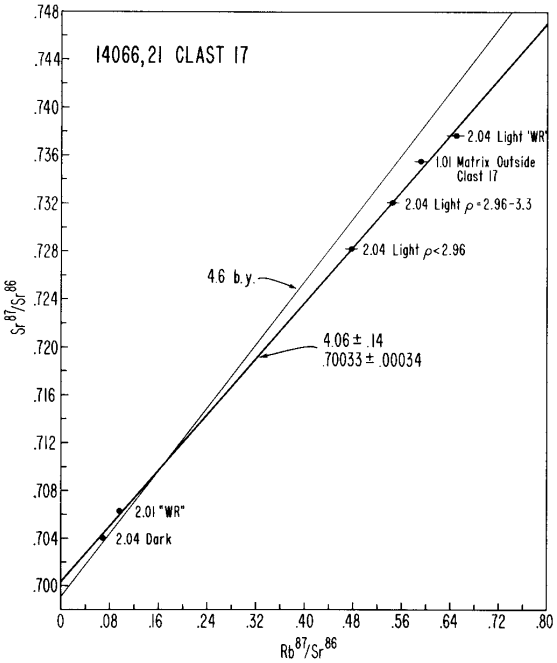


Figure 11: Rb/Sr isochron diagram for 14066 clast 17 (from Mark et al. 1973)

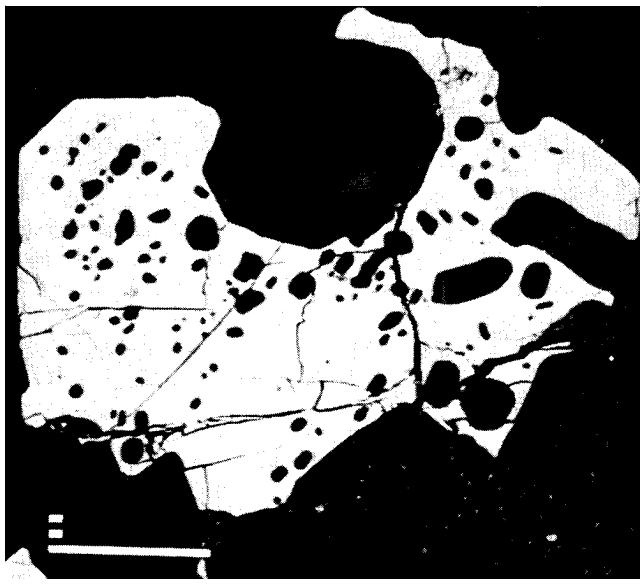


Figure 12: Large poikilitic zircon in gabbronorite clast in 14066,47 (Meyer et al. 1989). Sacle is 100 microns.

Summary of Age Data for 14066

	Rb/Sr	U/Pb
Mark et al. 1973	4.06 ± 0.14 b.y.	
Nemchin et al. 2008		4.2 b.y. (zircon clast)

Caution: Old Rb decay constant

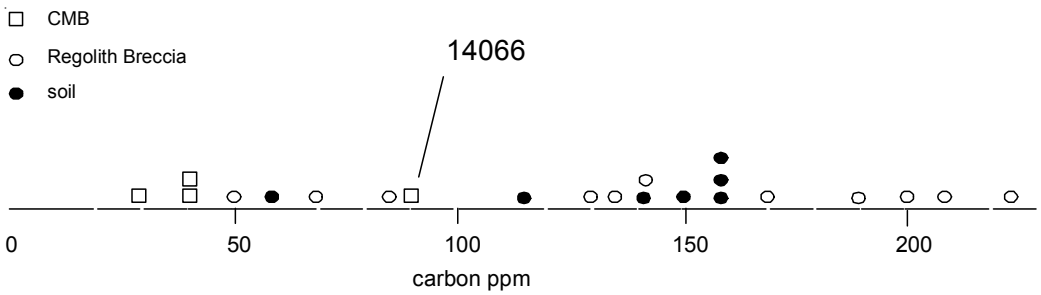
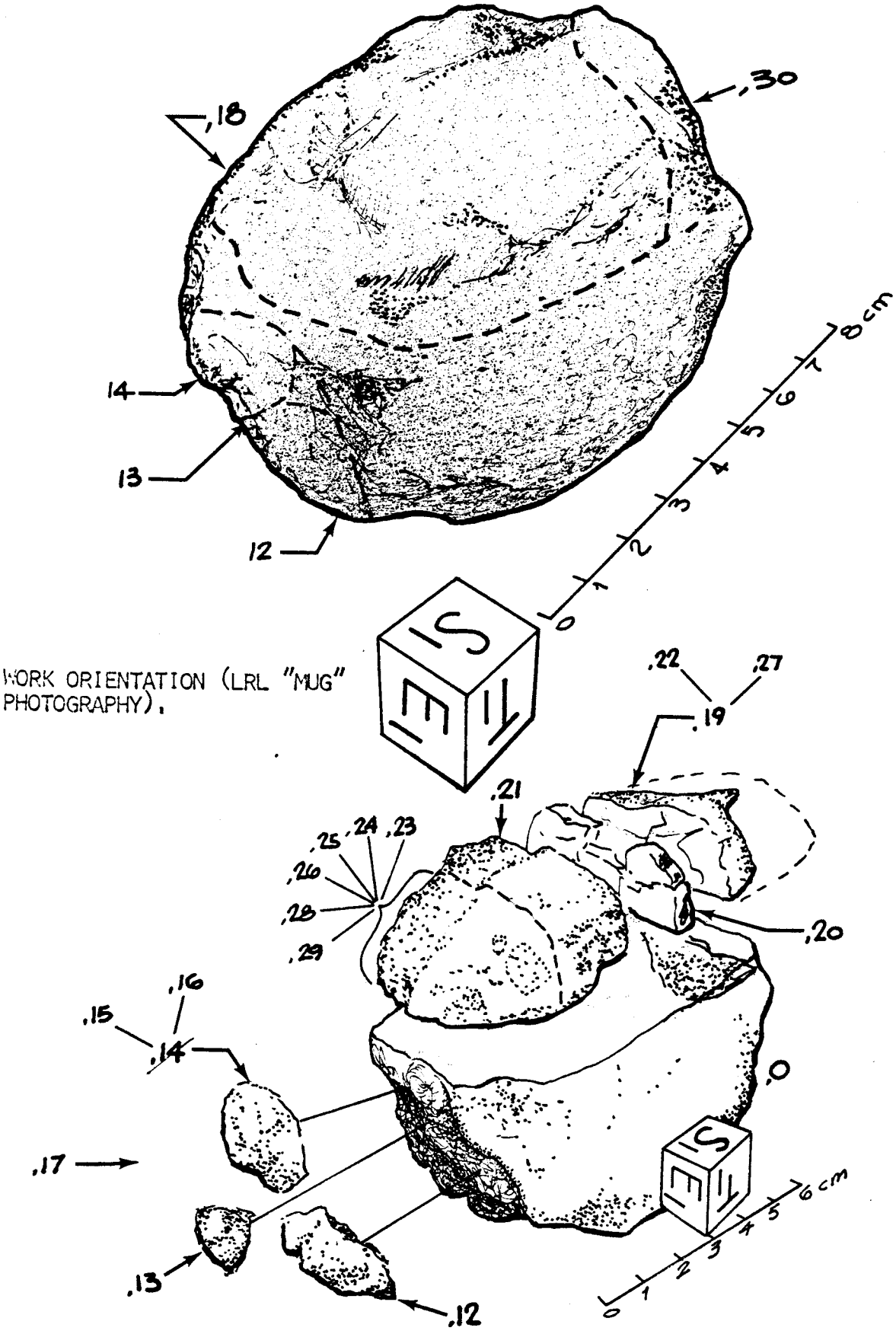


Figure 10: Carbon content of Apollo 14 soils and breccias (Moore et al. 1971) showing 14066.

Table 1. Chemical composition of 14066.

reference	Rose72			Wanke72		Baedecker72		Keith72		Laul72						LSPET71	
weight	sawdust	,21						**497.5 g**		sawdust	clasts			white			
SiO2 %	46.31	47.59	(b)	49.2	(c)											*51*	(e)
TiO2	1.49	1.68	(b)	1	(c)					1.8	1	1.6	2	1	(d)	*1.9*	(e)
Al2O3	14.8	14.61	(b)	15.9	(c)					15.3	23.1	16.3	16.6	17.9	(d)	*15*	(e)
FeO	9.59	10.82	(b)	10	(c)					9.5	6.2	8.4	11.7	8.4	(d)	*9.4*	(e)
MnO	0.12	0.13	(b)	0.12	(c)					0.112	0.073	0.111	0.115	0.107	(d)	*0.16*	(e)
MgO	10.78	13.67	(b)	11.3	(c)										(d)	*9.5*	(e)
CaO	9.32	9.07	(b)	10	(c)					9.5	12.8	11	8.9	9.1	(d)	*10*	(e)
Na2O	1.1	1.01	(b)	0.84	(c)					0.764	1.07	0.864	0.935	0.759	(d)	*0.58*	(e)
K2O	0.87	0.45	(b)	0.95	(c)			0.87	(a)	0.77	0.33	1.3	0.3	1.4	(d)	*1.2*	(e)
P2O5	0.58	0.55	(b)														
S %																	
sum																	
Sc ppm	22	20	(b)	20	(c)					17.7	9.8	17.6	16.1	15.3	(d)	24	(e)
V	47	53	(b)							33	21	59	55	68	(d)	52	(e)
Cr	1505	1780	(b)	1190	(c)					1129	876	1026	1642	1044	(d)	900	(e)
Co	32	38	(b)	30	(c)					28	20	23	38	17	(d)	39	(e)
Ni	315	285	(b)			200	(c)									210	(e)
Cu	v. high	22	(b)													7	(e)
Zn																	
Ga	6.3	5.2	(b)			2.3	(c)										
Ge ppb						6.1	(c)										
As																	
Se																	
Rb	26	12	(b)													29	(e)
Sr	150	140	(b)													220	(e)
Y	280	240	(b)													250	(e)
Zr	700	830	(b)							950	640	970	550	800	(d)	970	(e)
Nb	51	44	(b)													60	(e)
Mo																	
Ru																	
Rh																	
Pd ppb																	
Ag ppb																	
Cd ppb						54	(c)										
In ppb																	
Sn ppb																	
Sb ppb																	
Te ppb																	
Cs ppm																	
Ba	1400	1000	(b)							920	770	1000	800	1350	(d)	960	(e)
La	97	87	(b)	75	(c)					79	58	78	61	57	(d)	72	(e)
Ce				200	(c)					178	130	200	180	140	(d)		
Pr																	
Nd																	
Sm										34	24	40	32	28	(d)		
Eu				2.76	(c)					2.6	4.5	2.5	3	2.3	(d)		
Gd																	
Tb				7.8	(c)					6.3	4.2	7.8	6.3	5.4	(d)		
Dy				39	(c)												
Ho																	
Er																	
Tm																	
Yb	27	22	(b)	25.1	(c)					22	14.2	28	21	17	(d)	31	(e)
Lu				3.6	(c)												
Hf				30	(c)					28	19	33	23	33	(d)		
Ta				3.6	(c)					3.2	2	3.4	3.4	3.2	(d)		
W ppb																	
Re ppb																	
Os ppb																	
Ir ppb						6.1	(c)										
Pt ppb																	
Au ppb																	
Th ppm								15.3	(a)	15	10	16	15	13	(d)		
U ppm								4.2	(a)	4	2.1	4.1	2.7	3.3	(d)		

technique: (a) radiation counting, (b) "microchemical", (c) INAA, RNAA, (d) INAA, (e) emission spec.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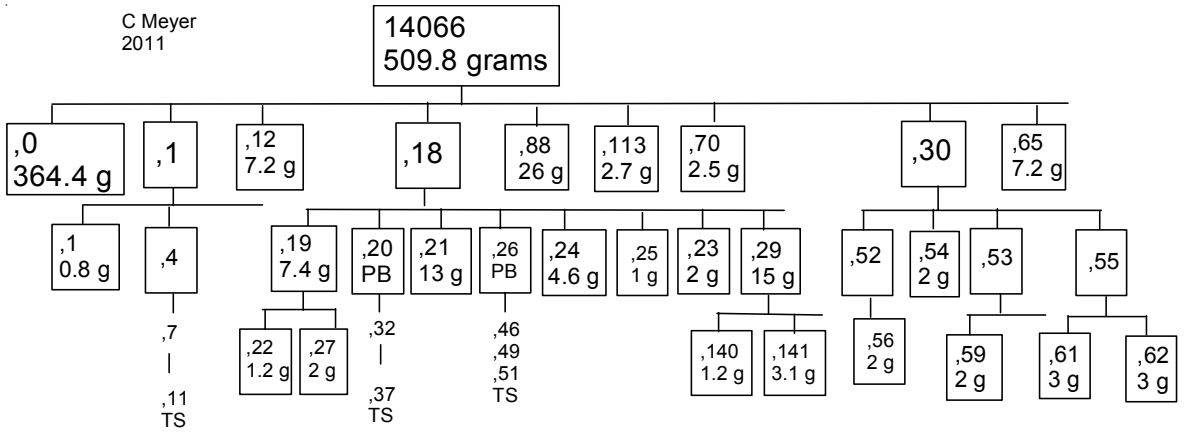

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