15065

Gabbroic Basalt

1475.5 grams

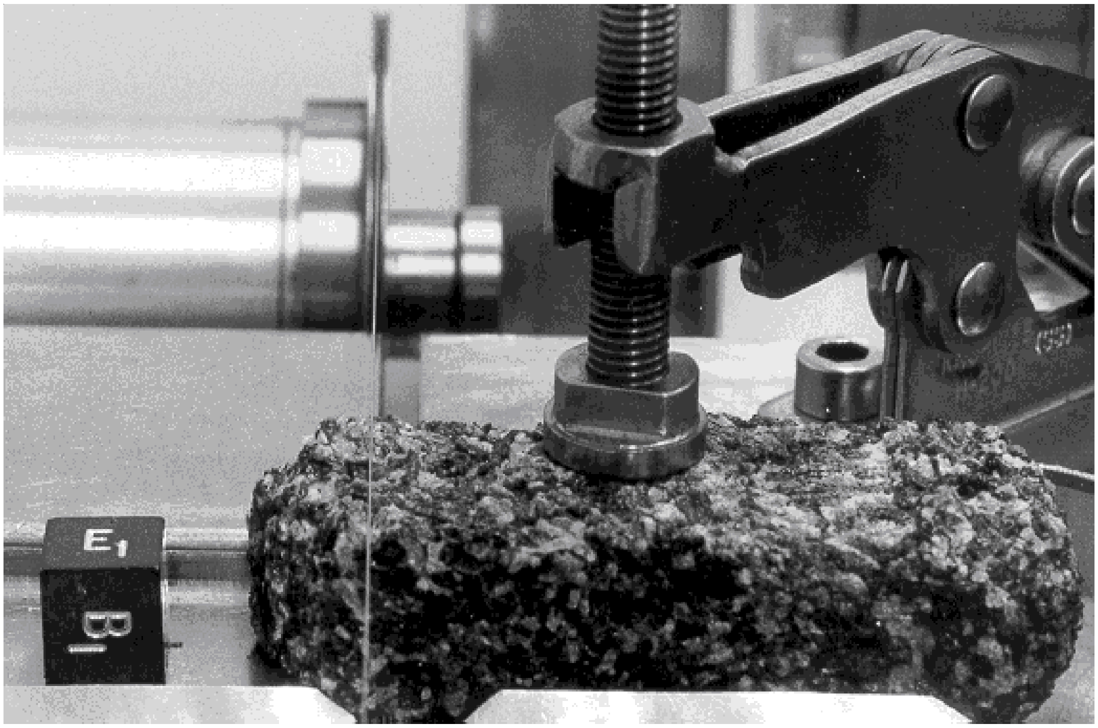


Figure 1: Photo of 15065,13 set up in wire saw apparatus. Cube is 1 cm. NASA S71-60957.

Introduction

15065 is a coarse-grained mare basalt that is about 3.35 b.y. old. It was collected as part of a suite of samples at different distances from the rim of Elbow Crater (a radial sample collection). Indeed it was the coarsest basalt (of the sequence 15065, 15075 and 15485) and closest to the crater, perhaps from the deepest layer of the basalt flow (Swann et al. 1971).

15065 may not be related to either the olivine-normative, nor quartz-normative suires of Apollo 15 basalts (Ryder 1985). In any case the vuggy, mafic portion of 15065 deserves more study.

Petrography

Ryder (1985) termed 15065 a coarse-grained quartz-normative basalt. However, it has two distinct regions with different feldspar to mafic mineral content (originally noted by Morrison and Silver in the original Apollo 15 catalog (Butler 1972). 15065 has abundant prismatic/euhedral pigeonite crystals with greenish cores and red-brown rims intergrown with anhedral to subhedral plagioclase (figures 1, 2 and 3). Ragged anhedral olivine grains (Fo_{50}) are found enclosed in pigeonite cores.

Mineralogical Mode for 15065

	Sample Catalog Butler 1971	**Brown et al. 1972**	**Longhi et al. 1972**	**Juan et al. 1972**
Olivine		2	1.3	
Pyroxene	60		63	70
Plagioclase	35		31.6	27
Opaque	1		2.2	2
Silica	1		1.9	

Figure 2: PET photo of 15065 showing mafic mineral segregation on right side near the 1 inch cube. NASA S71-42924.

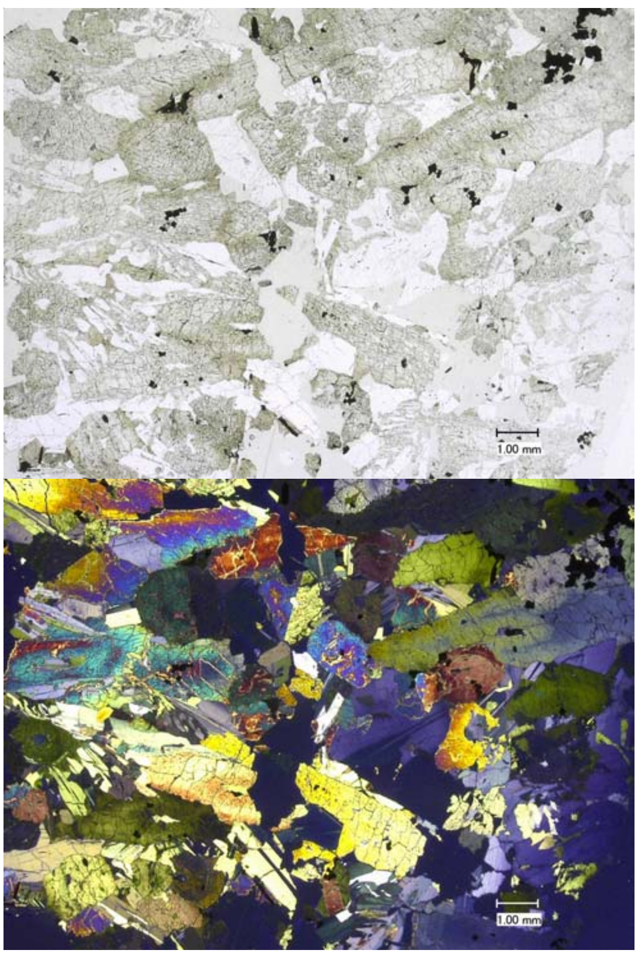


Figure 3: Photomicrograph of thin section 15065,89 by C Meyer @ 20x.

Brown et al. (1972), Gay et al. (1972) and others recognized that 15065 was one of the more slowly cooled basalts. Lofgren et al. (1975), Grove and Walker (1977), Taylor et al. (1976) and Onorato et al. (1979) performed mineral analyses and laboratory experiments to determined the cooling rate.

Mineralogy

Olivine: Mg-rich olivine is found as cores in pigeonite, while fayalite is found in the interstitial residuum.

Pyroxene: The chemical composition of pyroxene in 15065 was reported by Grove and Bence (1977)(figure 4). Yajima and Hafner (1974) determined the equilibrium temperature from the cation distribution in pigeonite.

Plagioclase: Longhi et al. (1972, 1976) studied the Mg and Fe content of plagioclase (An_{80-91}).

Ilmenite: The Zr content of ilmenite has been reported (Taylor and McCallister 1972, Blank et al. 1982).

Chromite: Taylor et al. (1975) and El Goresy et al. (1976) studied chromite and ulvospinel.

Metal: Taylor et al. (1975) found high Co content of metal grains in the whole suite of samples from Elbow

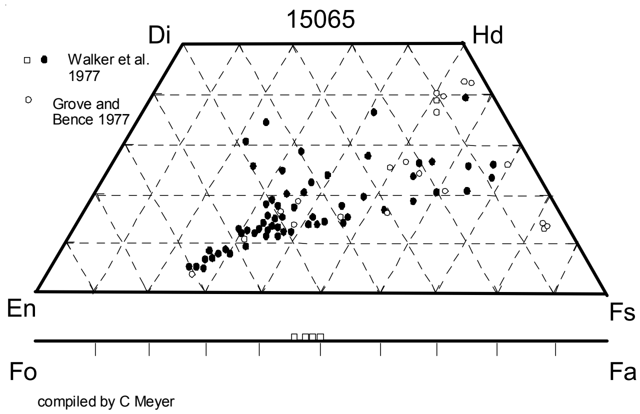


Figure 4: Pyroxene and olivine composition of 15065.

Crater (figure 5). Jedwab (1972) described facetted, isometric iron grains from vugs.

Phosphate: Prominent accessory apatite is found intergrown with ferro-augite, sulfides and silica (both tridymite and cristobalite reported).

Zirconolite: Wark et al. (1973) reported the composition of zirconolite (determined by ElGoresy).

Chemistry

Nava (1975) found that the two different regions in 15065 were indeed different in composition (tables 1 and 2). The more mafic region ha s high Fe and Ti (figure 7). Wanke and others reported the trace element content (figure 6). The composition of 15065 can't be related to either the quartz-normative , nor olivine-normative suites of Apollo 15 basalts by simple olivine removal.

Gibson et al. (1975) determined the sulfur content (600 ppm).

Barker (1974) and Gibson and Andrawes (1978) attempted to determine the composition of gases released by heating 15065 (figure 10).

Radiogenic age dating

Papanastassiou and Wasserburg (1973) and Nakamura et al.(1977) determined the age of 15065 (figures 8 and 9). Unruh et al. (1984) reported the isotopic composition of Lu-Hf and Sm-Nd.

Cosmogenic isotopes and exposure ages

Eldridge et al. (1972) determined the cosmic-ray exposure of ^{22}Na = 23 dpm/kg, ^{26}Al = 68 dpm/kg and

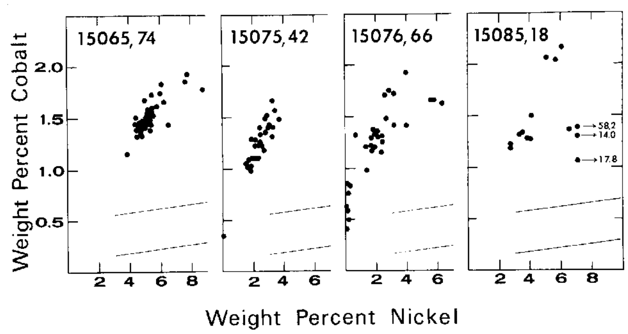


Figure 5: Composition of metal grains in basalt samples from Elbow Crater (from Taylor et al. 1975).

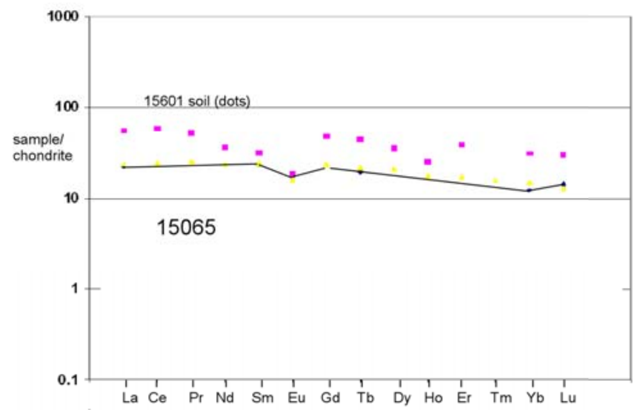


Figure 6: Trace element analysis of 15565 compared with that of 15601.

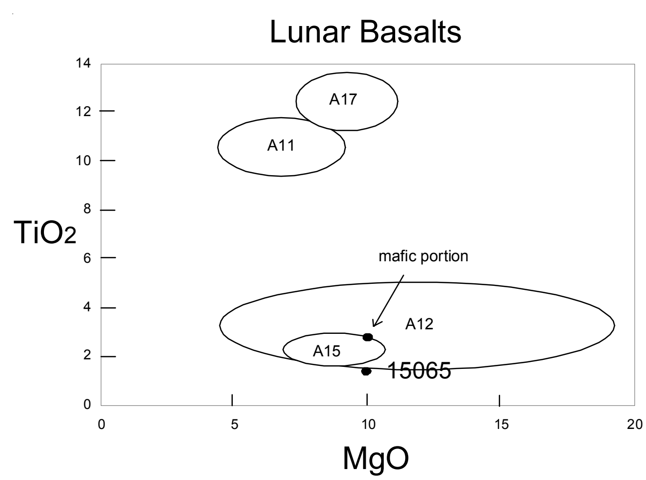


Figure 7: Composition of 15065 compared with that of other lunar basalts.

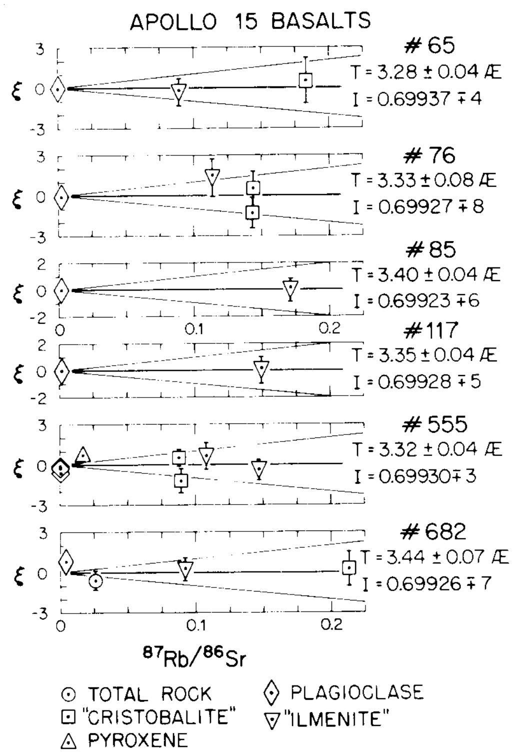


Figure 8: Rb/Sr isochrons for various Apollo 15 basalts including 15065 (top). This is reproduced from Papanastassiou and Wasserburg (1973).

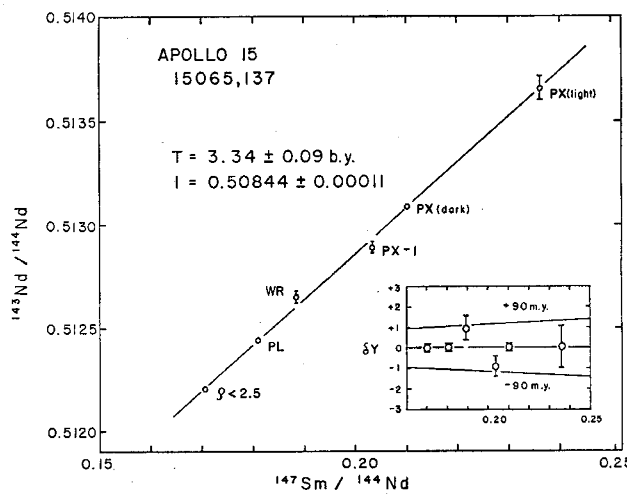


Figure 9: Sm/Nd isochron for 15565 (Nakamura et al. 1977).

Summary of Age Data for 15065

	Rb/Sr	Sm/Nd
Papanastassiou and Wasserburg 1973	3.28 ± 0.04 b.y.	
Nakamura et al. 1977		3.34 ± 0.09

Caution: These are calculated with original decay constants !

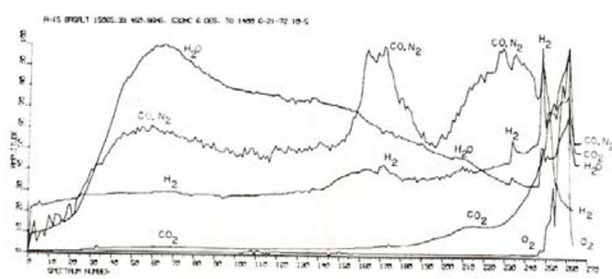


Figure 10: Gas release curves for thermal heating of 15065 (Gibson and Moore 1972).

^{54}Mn = 27 dpm/kg, but the cosmic ray exposure age hasn't been reported.

Other Studies

Hargraves and Dorety (1972) studied the magnetic properties, Adams and McCord (1972) and Charrette and Adams (1975) used 15065 to obtain reflectance spectra, Chung and Westphal (1973) studied the physical properties and Bhattacharya et al. (1973) studied tracks.

Processing

A portion of the rather vuggy, mafic portion of 15065 was separated from the main mass of 15065 before sawing. Additional mafic material can be found on piece (,117). Figure 1 shows that ,13 was cut with the wire saw (a rather messy proposition).

There are 18 thin sections of 15065. Sections number ,87 and ,91 are from the mafic portion.

Table 1a. Chemical composition of 15065 (main portion).

reference	Cuttitta73		Juan 72		O'Kelley72		Strasheim72		Wanke 75		Nava 75		Fruchter73		Ganapathy73		Baedecker73	
weight	Christian72															,5		
SiO2 %	48.47	(a)	43.2	(b)			47.24	(d)	48.99	(f)	48.2	(g)						
TiO2	1.48	(a)	1.88	(b)			1.54	(d)	1.33	(f)	1.44	(g)						
Al2O3	9.26	(a)	10.1	(b)			9.33	(d)	12.75	(f)	10.32	(g)	11.34	(f)				
FeO	19.18	(a)	19.2	(b)			19.17	(d)	17.75	(f)	18.46	(g)	19.17	(f)				
MnO	0.26	(a)	0.3	(b)			0.26	(d)	0.24	(f)	0.234	(g)	1.22	(f)				
MgO	10.57	(a)	11.5	(b)			10.69	(d)	8.8	(f)	10.35	(g)						
CaO	9.94	(a)	12.12	(b)			9.53	(d)	11.23	(f)	9.55	(g)						
Na2O	0.34	(a)	0.715	(b)			0.23	(d)	0.37	(f)	0.33	(g)	0.28	(f)				
K2O	0.05	(a)	0.068	(b)	0.046	(c)	0.05	(d)	0.05	(f)	0.041	(g)						
P2O5	0.05	(a)					0.08	(d)	0.06	(f)	0.104	(g)						
S %									0.05	(f)								
sum																		
Sc ppm	38	(a)					88	(d)	39.1	(f)			41	(f)				
V	158	(a)					185	(d)										
Cr	3626	(a)					4379	(d)	3160	(f)			4600	(f)				
Co	52	(a)	70				47	(d)	37.7	(f)			46	(f)	45	(f)		
Ni	151	(a)	147				78	(d)		(f)							63	(f)
Cu	64	(a)	*56*				48	(d)	5.42	(f)								
Zn			*38*						<1	(f)					1.6	(f)	0.92	(f)
Ga	4.1	(a)	*24*						3.76	(f)							3.1	(f)
Ge ppb									<100	(f)					5.3	(f)	21	(f)
As									0.9	(f)								
Se									0.08	(f)					167	(f)		
Rb	<1	(a)					5	(d)	0.7	(f)					0.76	(f)		
Sr	110	(a)	*214*				98	(d)	134	(f)								
Y	23	(a)					29	(d)	24	(f)								
Zr	63	(a)					79	(d)	94	(f)								
Nb	12	(a)					13	(d)	6	(f)								
Mo																		
Ru																		
Rh																		
Pd ppb																		
Ag ppb			0.545												0.91	(f)		
Cd ppb															1.5	(f)	1.2	(f)
In ppb															0.51	(f)	0.32	(f)
Sn ppb																		
Sb ppb															0.016	(f)		
Te ppb															3.4	(f)		
Cs ppm									0.05	(f)					0.062	(f)		
Ba	50	(a)					85	(e)	96	(f)								
La	<10	(a)					7.1	(e)	7.73	(f)			5.1	(f)				
Ce							30	(e)	20.6	(f)								
Pr							3.7	(e)	3.15	(f)								
Nd							20	(e)	14.6	(f)								
Sm							5	(e)	4.72	(f)			3.4	(f)				
Eu							1.05	(e)	1.14	(f)			0.94	(f)				
Gd							5.6	(e)	5.3	(f)								
Tb							0.86	(e)	0.96	(f)			0.7	(f)				
Dy							6.8	(e)	6.66	(f)			2	(f)				
Ho							1.25	(e)	1.2	(f)								
Er							3.9	(e)	3.7	(f)								
Tm							0.47	(e)										
Yb	3.8						2.9	(e)	2.98	(f)			2	(f)				
Lu							0.3	(e)	0.43	(f)			0.34	(f)				
Hf									3.36	(f)			2.1	(f)				
Ta									0.45	(f)			0.4	(f)				
W ppb									102	(f)								
Re ppb									<0.1	(f)					0.0015	(f)		
Os ppb																		
Ir ppb															0.0054	(f)	0.048	(f)
Pt ppb																		
Au ppb			4						0.031	(f)					0.021	(f)	0.19	(f)
Th ppm					0.51	(c)			0.7	(f)								
U ppm					0.15	(c)			0.19	(f)					0.235	(f)		

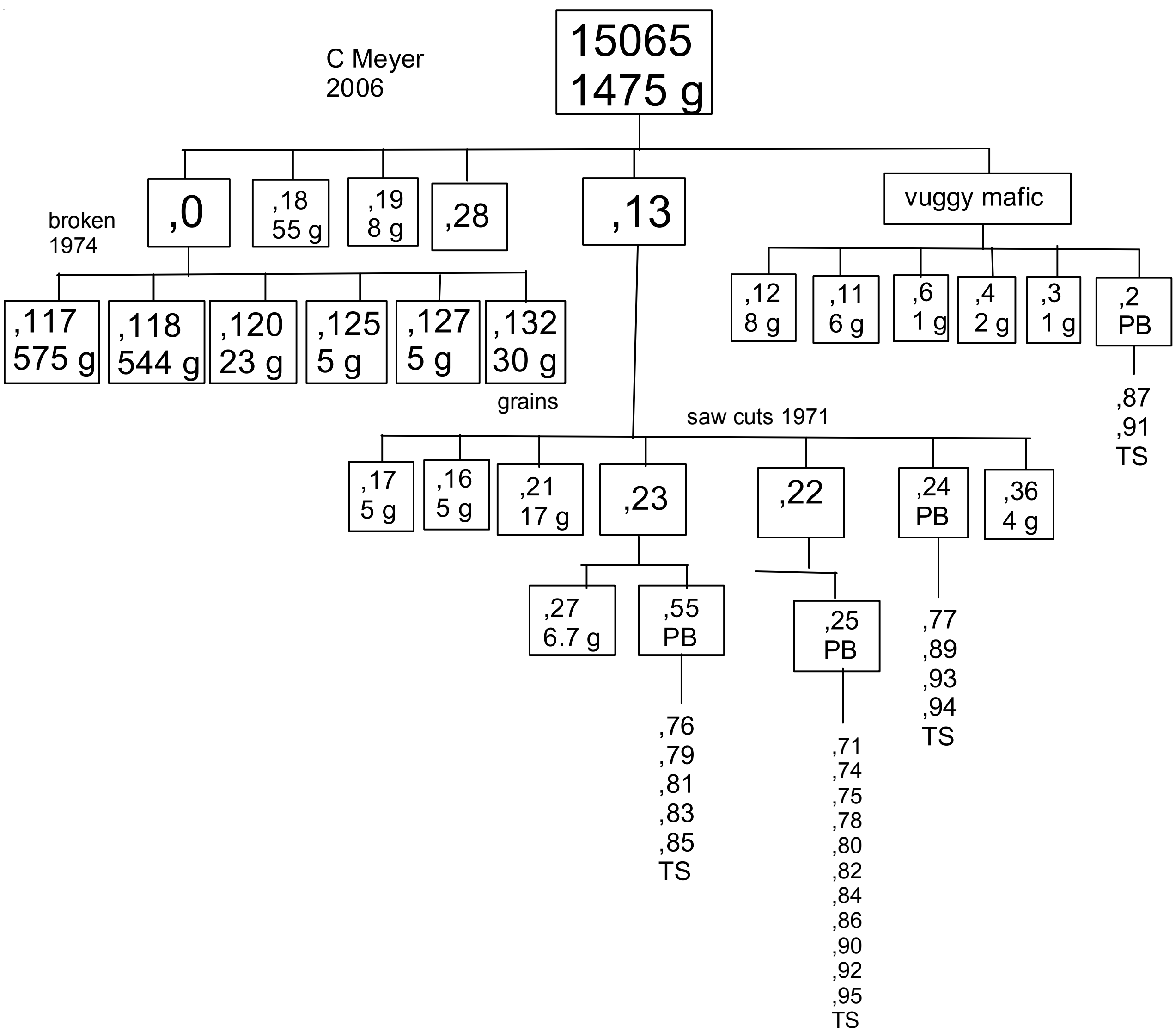
technique: (a) conventional, (b) ?, (c) radiation counting, (d) ave. of mixed, (e) MS, (f) INAA, RNAA

Table 1b. Chemical composition of 15065 (mafic portion).

reference	Nava 75		Cuttitta73		Ganapathy73	
weight			Christian72		,41	
SiO2 %	47.7	(g)	47.95	(a)		
TiO2	2.86	(g)	2.3	(a)		
Al2O3	6.05	(g)	5.33	(a)		
FeO	23.77	(g)	23.6	(a)		
MnO	0.307	(g)	0.31	(a)		
MgO	9.52	(g)	10.15	(a)		
CaO	9.33	(g)	9.3	(a)		
Na2O	0.27	(g)	0.25	(a)		
K2O	0.081	(g)	0.07	(a)		
P2O5	0.119	(g)	0.09	(a)		
S %						
sum						
Sc ppm			53	(a)		
V			178	(a)		
Cr			3421	(a)		
Co			66	(a)	40	(f)
Ni			54	(a)		
Cu			14	(a)		
Zn					1	(f)
Ga			5.3	(a)		
Ge ppb					6.7	(f)
As						
Se					53	(f)
Rb			1	(a)	0.39	(f)
Sr			100	(a)		
Y			39	(a)		
Zr			103	(a)		
Nb			<10	(a)		
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb					0.88	(f)
Cd ppb					1.1	(f)
In ppb					0.18	(f)
Sn ppb						
Sb ppb					0.24	(f)
Te ppb					0.96	(f)
Cs ppm					0.026	(f)
Ba			75	(a)		
La			22	(a)		
Ce						
Pr						
Nd						
Sm						
Eu						
Gd						
Tb						
Dy						
Ho						
Er						
Tm						
Yb			6.6			
Lu						
Hf						
Ta						
W ppb						
Re ppb					0.0094	(f)
Os ppb						
Ir ppb					0.144	(f)
Pt ppb						
Au ppb					0.014	(f)
Th ppm						
U ppm					0.085	(f)

technique: (a) conventional, (b) ?, (c) radiation counting, (d) ave. of mixed, (e) MS, (f) INAA, RNAA

Figure 11: Photo of 15065,117 showing area of mafic mineral segregation. NASA S74-27569. Sample is 11 cm across.



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