77075 - 172.4 grams
77076 – 14 grams
77077 - 5.5 grams
Impact Melt dike in Cataclastic Norite

Figure 1: Front and back photos of 77075. Scale and cube are 1 cm. NASA# S73-17186 and S73-17185. These pieces were found to fit together (see figures 14, 15 and 16)..

Introduction

Samples 77075, 77076 and 77077 were sampled from one of the dark dikes within the large, off-white "noritic" clast in the boulder at Station 7 (see the section on the Station 7 Boulder). The dike is about 3 cm thick (Chao et al. 1974), and has portions of the white clast attached on both sides. The white "noritic" material (77077, figure 5) is the same as sample 77215 (figure 1). Piece 19 of 77215 also appears to be identical to 77075.

The dark dike material in 77075 is a fragment-laden melt rock with a matrix texture and chemical composition generally similar to sample 77115, except it has a finer grain size (Chao et al. 1974). Schmitt (in Schmitt and Cernan, 1973) observed that the dike

Figure 2: Closeup photo of boulder at Station 7 Apollo 17 . The vein through the off-white norite clast can be clearly seen through the brown patina. Schmitt observed that this vein (77075) is continuous with the surrounding breccia (77115) and cross-cuts the norite (77215). AS17-146-22327.

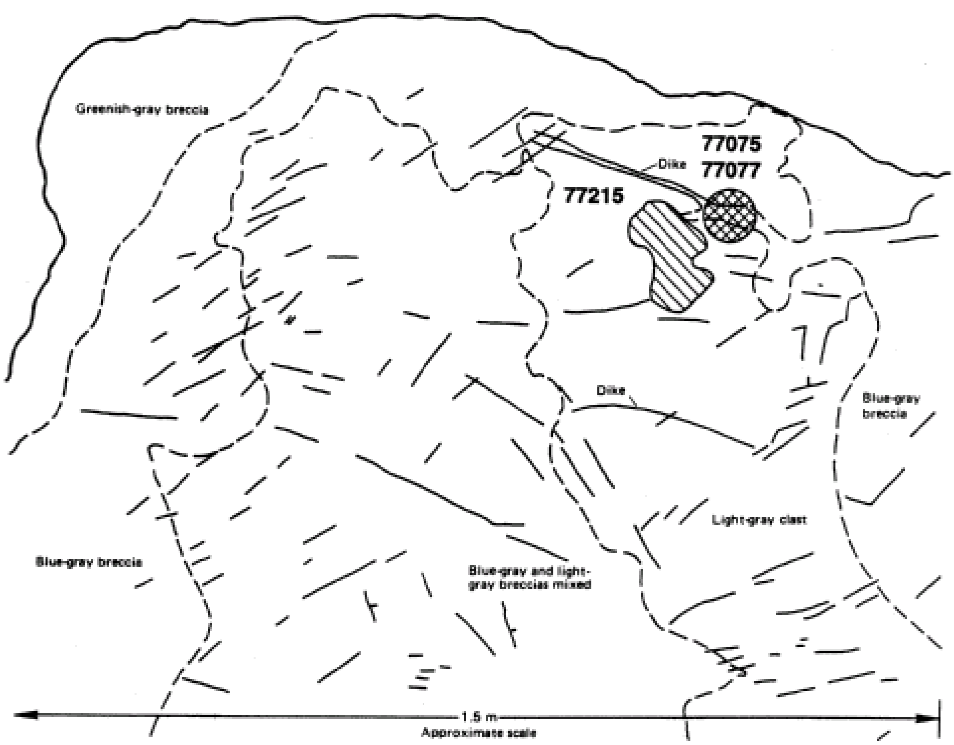

Figure 3: Sketch of north side of Station 7 Boulder, showing large norite clast (light grey clast) with penetrating veins and the location of the samples taken (from Wolfe and others, 1981).

CDR That's one of the blue-gray rocks. And it's got a light-colored fragment that runs the full height of it, about a meter and a half thick. And then it's got the gray or blue-gray rock on the other side. As a matter of fact – let me look at it closely. It's a fragment in it all right. I wouldn't be absolutely positive, but it sure looks like I see a dikelet in here that's in the inclusion. And I'm going to get a clsoeup stereo of it. I'd call it a dikelet, if you pinned me down. I wish I could break a sample off. Here's another one. It is a dikelet. There's three or four of them. The material in the dike looks – yes, it's not covering it. It's between the lighter colored rock, and it's the blue-gray rock. Well, maybe it isn't a dikelet. Maybe it's just a screen covering, a flow covering.

LMP No, there're dikes. They're little veinlets of –

CDR Let me get this whole thing in a bag. I got a rock, bob. It's fractured, primarily around a dike. It's in several pieces, but we're going to put in all in one bag (543 = 77215).

LMP We need to put one of those dikes in another bag. It looks like some fraction of the blue-gray material has obviously intruded. Now, can you get that dike there? Piece of it?

CDR I can get it right here. Yes. It's this soft, white inclusion again. It breaks pretty easy. Oh, It's got to be a dike. Oh, Yes, it is because I broke into it.

LMP It is. ((544 = 77075, 77076) Although the blue-gray up on the hill looked like a fragment of breccias, if this is still related, then it's – been some partial melting at some time.

CDR There's a preserved contact between the dike and the – white material.

LMP That's what I wanted.

CDR Why don't we get this big piece of dike now?

LMP See if you can get – whoa! Don't hit it again. There, you've still got some contact there.

CDR Now, there's some good contact. That'll do it.

LMP Dike and intruded rock in 544. Now, these dikes are a dark bluish-gray. And it looks like they are finely crystalline – maybe with some –very fine phenocrysts.

CDR I'm taking some closeups.

LMP We ought to get a piece of the normal gray that the dikes are coming from. Hey, over here on this side, it looks like the vesicular anorthositic gabbro. (bag 561 = 77115) That's a sample of the gray, looks like recrystallized breccias that the dikes are continuous with.

Figure 4: Photo of 77076. Cube is 1 cm. S73-17104

Figure 5: Phot of 77077. Cube is 1 cm. S73-17182

material was continuous with the "blue-gray, matrix-rich breccia" (represented by 77115) that surrounds the off-white "noritic" clast that the dike cuts (figures 2 and 3).

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 77075 were also summarized in the catalog by Meyer (1994).

Petrography

Dike rock 77075 is the finest grained, most fragment-rich lithology of the station 7 boulder (Chao et al. 1974, Minkin et al. 1978). The holocrystalline matrix is a fine-grained intergrowth of subophitic plagioclase and pyroxene, with minor olivine and ilmenite. Average grain size is 5-10 microns with poikilitic pyroxenes 10-20 microns. A few percent mineral and lithic clasts are also present (figure 6). The dense, dark dike has a sharp boundary with the porous, "noritic" microbreccia (figure 7).

McGee et al. (1980) conclude that the 77075 dike crystallized and cooled through the solidus more rapidly than did the enclosing lithologies 77115 and 77135. Presumably, the relatively rapid cooling of the dike also inhibited precipitation of augite. It is thought that the incorporation of cool clasts into the melt, and injection of the melt into a cooler noritic host, contributed to rapid initial cooling and the fine grain

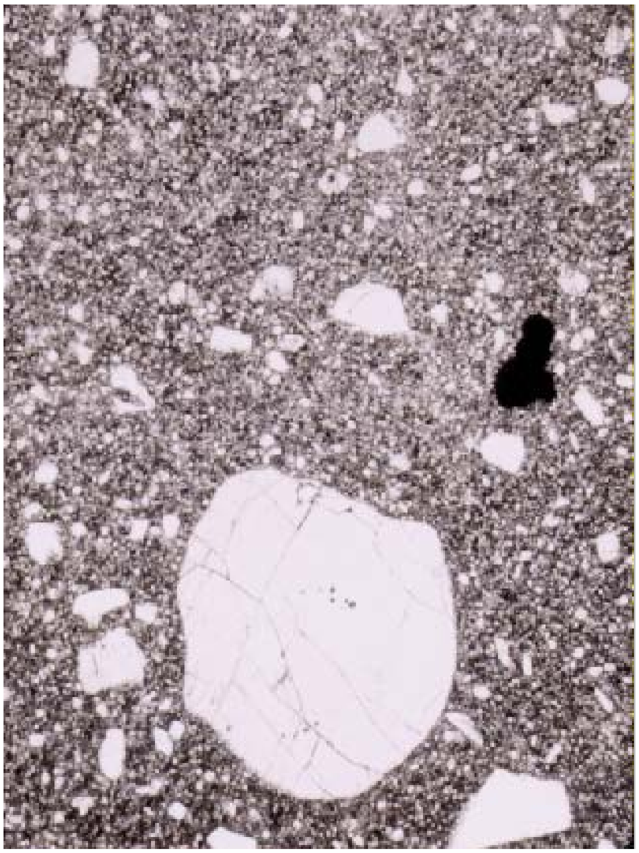

Figure 6: Photomicrograph of thin section of dark dike in 77075 showing olivine clast and other small xenoliths in a finely crystalline matrix.

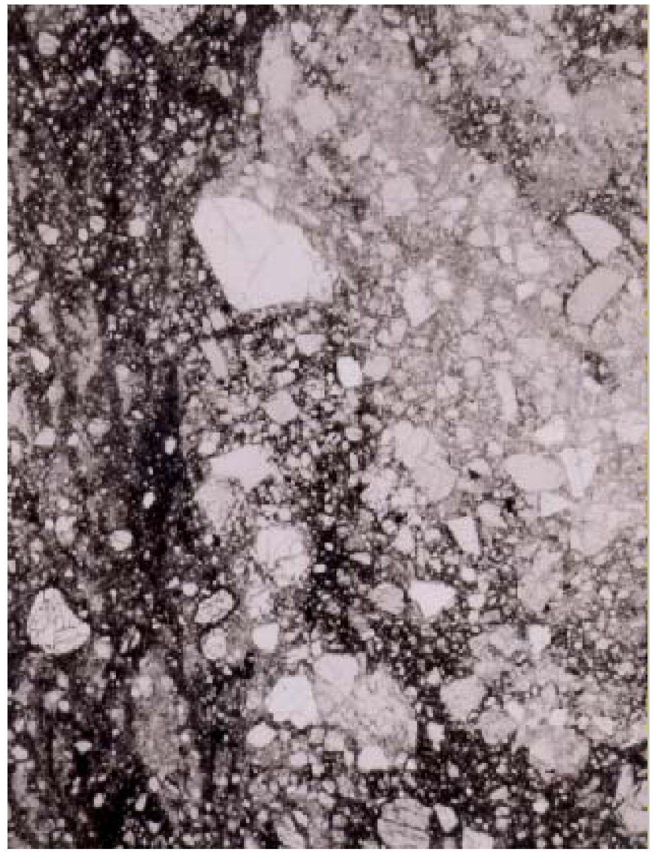

Figure 7: Photomicrograph of thin section of cataclastic norite (white material) in 77075.

size of the dark dike material (McGee et al. 1980, Sanford and Heubner 1980).

Mineralogy

Pyroxene: The composition of pyroxene in the melt rock portion was determined by TEM (McGee et al. 1980), because it was too fine grained for accurate electron microprobe analysis (Figure 8). Augite was not seen in 77075 by microscope, but was found as 10 micron exsolution lamellae using TEM techniques. Bersch (1991) precisely determined the composition of the orthopyroxene in the white "noritic" portion of 77075.

Mineralogical Mode of 77075 (dark dike material)

	Chao et al. 1974	Minkin et al. 1978
Pyroxene	16.7	24 vol. %
Plagioclase	62.1	64
Olivine	16	8
Ilmenite	2.7	4
Ni-Fe	2.1	

Plagioclase: The plagioclase in the matrix of 77075 is An_{89-92}, while some xenoliths of plagioclase range to An_{97} (Chao et al. 1974).

Olivine: Small xenocrysts of olivine (Fo_{66-93}) are found in the matrix of 77075 (Chao et al. 1974, Minkin et al. 1978).

Other minerals: Ilmenite is very fine and platy (Chao et al. 1974). Blebs of Fe-Ni are present.

Chemistry

Winzer et al. (1974) and Norman et al. (2002) have analyzed the aphanitic dark dike and Warren and Wasson (1978) analyzed the white material attached (table 1 and figure 10). The composition of the dark dike matches that of 77115 and the white material is the same crushed norite as 77215.

The trace element data of Norman et al. (2002) and that of Morgan et al. (1974) generally agree and they both report high Ir in the dike material.

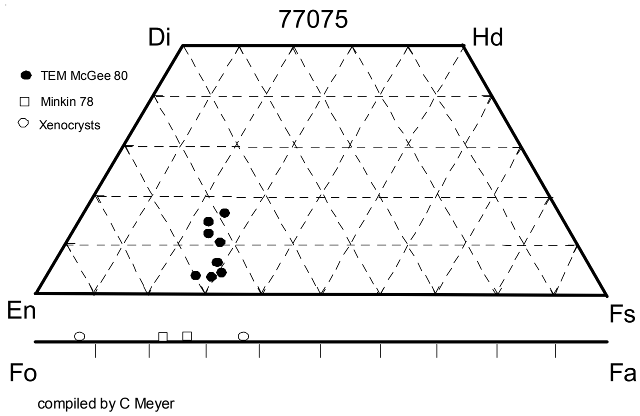

Figure 8: Pyroxene and olivine composition of 77075 dike. Pyroxene had to be determined by TEM, because of fine grain size (~5 micron).

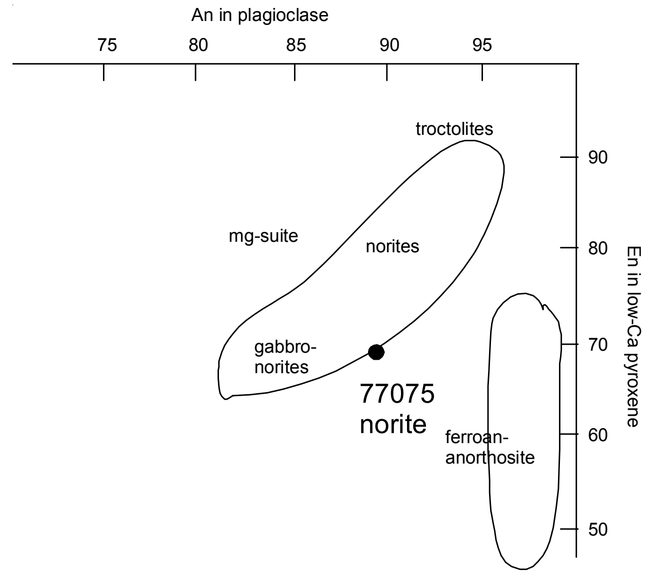

Figure 9: Plagioclase and pyroxene composition of white clast material on 77075. Data from Minkin et al. 1978.

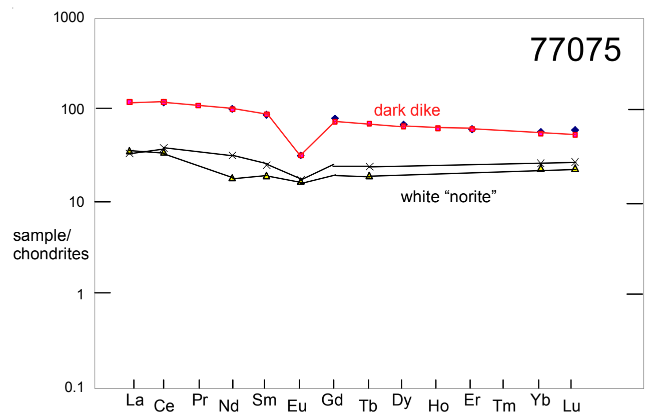

Figure 10: Normalized rare-earth-element composition diagram for 77075. Data for dark dike from Winzer et al. (1974) and Norman et al. (2002). Data for white norite is from Warren and Wasson (1978).

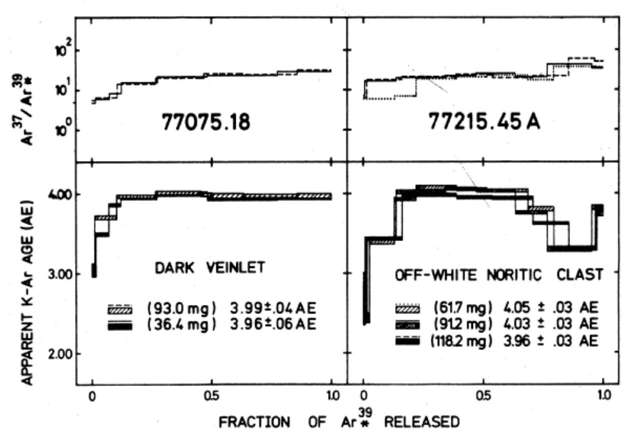

Figure 11: 40Ar/39Ar release pattern for 77075 dike material and 77215 norite (from Stettler et al. 1974).

Radiogenic age dating

Stettler et al. (1974, 1978) determined an age of 3.97 ± 0.04 b.y. for the dark dike (average of three measurements). Nakamura and Tatsumoto (1977) determined a Rb/Sr isochron for the dark dike (4.18 b.y.), as well as an imprecise Sm/Nd isochron (figure 13), but their sample may have included xenoliths of older material. Nunes et al. (1974) also reported U, Th, Pb data for 77075.

Cosmogenic isotopes and exposure ages

Stettler et al. (1974) obtained an exposure age of 25.5 m.y. for 77075 by the Ar method. A review of the exposure ages determined for this boulder is given in Arvidson et al. (1975).

Processing

The initial processing and distribution of 77075 is outlined in Butler and Dealing (1974). It was studied by the International Consortium led by Ed Chao (final report by Minkin et al. 1978). A detailed description of the splits was documented in USGS Open File Report 78-511.

Numerous close-up photos were taken of boulder 7 during sampling (see transcript). 77075, 77076 and 77077 were returned from the Moon in the same sample bag (Butler 1973). Three pieces fit nicely together (figures 14, 15 and 16) and were called 77075. 77076 appears to be identical. 77077 appears to be the adjacent white clast – also sampled as 77215.

There are 7 thin sections of 77075 and 6 for 77077.

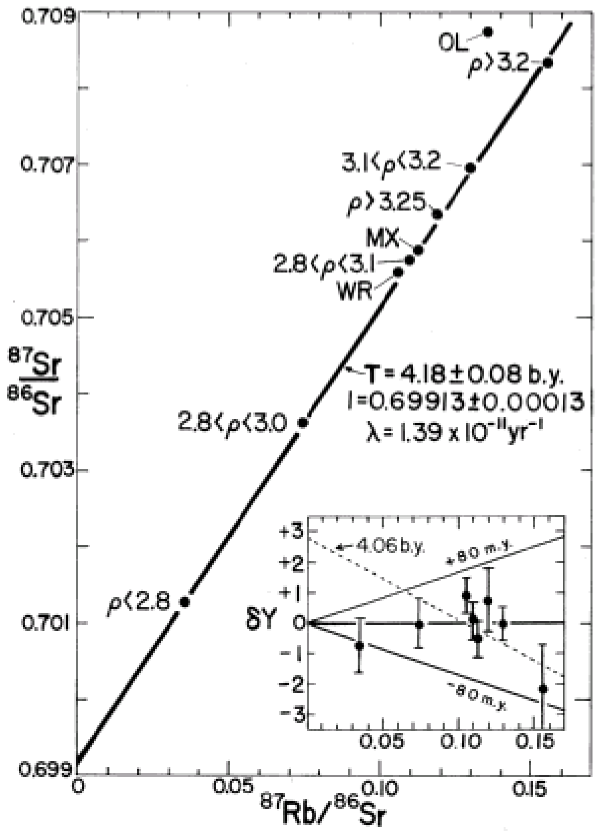

Figure 12: Internal Rb/Sr mineral isochron for 77075 dark vein material (from Nakamura and Tatsumoto 1977).

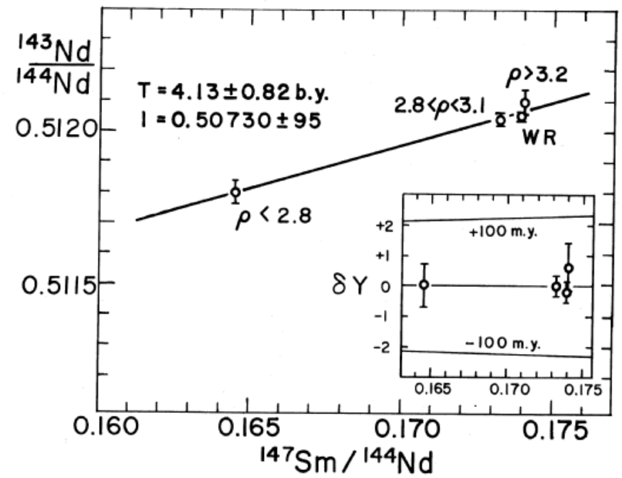

Figure 13: Imprecise Sm/Nd isochron for dark dike in 77075 (from Nakamura and Tatsumoto 1977).

Summary of Age Data for 77075

	Ar/Ar	Rb/Sr	Sm/Nd	U/Pb
Stettler et al. 1974	3.99 ± 0.03 b. y.			
	3.96 ± 0.08			
Stettler et al. 1978	3.98 ± 0.03			
Nakamura et al. 1977		4.18 ± 0.08	4.13 ± 0.82	
Nunes et al. 1974				

Caution: Not corrected for new decay constants.

Table 1. Chemical composition of 77075

	dark		dark		white	white		dark		77077	77215
reference	Norman 02		Winzer 74		Warren 78			Morgan 74		Warren 78	Winzer 77
weight	3 g		66 mg							*comparison*	*comparison*
SiO2 %	46	(d)	46.4	(e)	51.1	50.9	(g)			50.9	51.1
TiO2	1.52	(d)	1.38	(i)	0.34	0.35	(g)			0.3	0.3
Al2O3	17.9	(d)	18.17	(e)	14.97	14	(g)			16.16	13.98
FeO	8.99	(d)	9.31	(e)	10.67	10.16	(g)			8.74	10.38
MnO	0.12	(d)	0.11	(e)	0.17	0.18	(g)			0.15	0.17
MgO	13	(d)	12.57	(e)	12.9	13.78	(g)			10.6	14.31
CaO	10.8	(d)	10.55	(e)	8.82	8.82	(g)			9.94	8.65
Na2O	0.66	(c)	0.65	(e)	0.38	0.36	(g)			0.44	0.39
K2O	0.24	(c)	0.23	(e)	0.18	0.16	(g)			0.22	0.18
P2O5			0.26	(i)							0.14
S %											
sum											
Sc ppm	16.9	(a)			16.6	16.5	(g)			13.8	
V	44	(a)									
Cr	1354	(a)	1163	(e)							2463
Co	25.4	(a)			33	25.9	(g)			25.2	
Ni	211	(a)			6.1	<1.1	(g)	286	(h)	< 1.7	
Cu	13.5	(a)									
Zn	14.4	(a)			3.25	3.31	(g)	2.8		2.84	
Ga	5.1	(a)			4.03	4.1	(g)			5	
Ge ppb					10.9	16.8	(g)	532		18.7	
As											
Se								112			
Rb	8.9	(a)	6.1	(f)				6.4			3.21
Sr	183	(a)	165	(f)							102
Y	117	(a)									
Zr	507	(a)			210	170	(g)			150	
Nb	34.6	(a)									
Mo											
Ru	27.2	(b)									
Rh											
Pd ppb	25.9	(b)									
Ag ppb								1.2			
Cd ppb											
In ppb											
Sn ppb											
Sb ppb								1.92			
Te ppb											
Cs ppm	0.29	(a)						0.27			
Ba	327	(a)	333	(f)	160	158	(g)			220	154
La	29.1	(a)			7.2	8.3	(g)			9.9	
Ce	75.7	(a)	74.3	(f)	22	24	(g)			25	24.6
Pr	10.2	(a)									
Nd	47.3	(a)	47.5	(f)	8.5	15	(g)			16	15.5
Sm	13.5	(a)	13.4	(f)	3	3.9	(g)			4.28	4.4
Eu	1.85	(a)	1.84	(f)	0.98	1.01	(g)			1.12	1.03
Gd	14.9	(a)	16.4	(f)							5.21
Tb	2.64	(a)			0.74	0.92	(g)			1	
Dy	16.6	(a)	17.2	(f)							6.64
Ho	3.59	(a)									
Er	10.2	(a)	10	(f)							4.57
Tm											
Yb	9.2	(a)	9.53	(f)	3.9	4.4	(g)			4.5	4.88
Lu	1.33	(a)	1.5	(f)	0.59	0.68	(g)			0.67	0.592
Hf	10.2	(a)	10.8	(f)	3.5	3.5	(g)			3.4	
Ta	1.48	(a)			0.34	0.4	(g)			0.38	
W ppb	0.71	(a)									
Re ppb	1.48	(b)						0.781	(h)		
Os ppb											
Ir ppb	15.8	(b)			0.25	0.0084	(g)	8.89	(h)	0.0029	
Pt ppb	33.8	(b)									
Au ppb					0.026	0.088	(g)	5.09	(h)	0.056	
Th ppm	5.36	(a)			1.57	1.8	(g)			2	
U ppm	1.39	(a)			0.5	0.58	(g)	1.45	(h)	0.59	

technique (a) ICP-MS, (b) ICP-ID-MS, (c) INAA, (d) elec. Probe, (e) AA, (f) IDMS, (g) INAA, (h) RNAA, (I) colorimetry

Table 2. Composition of 77075

		U ppm	Th ppm	K20 %	Rb ppm	Sr ppm	Nd ppm	Sm ppm	technique
Nunes et al. 1974	dark dike	1.425	5.299						IDMS
Nakamura and Tats 1977	dark dike			0.1937	5.927	161.7	49	14.1	IDMS
Winzer et al. 1974	dark dike			0.23	6.1		47.5	13.4	IDMS
Norman et al. 2002	dike	1.39	5.36	0.24	8.9	183	47.3	13.5	ICP-MS
Warren and Wasson 1978	w. norite	0.5	1.57	0.18			8.5	3	INAA
Warren and Wasson 1978	w. norite	0.58	1.8	0.16			15	3.9	INAA

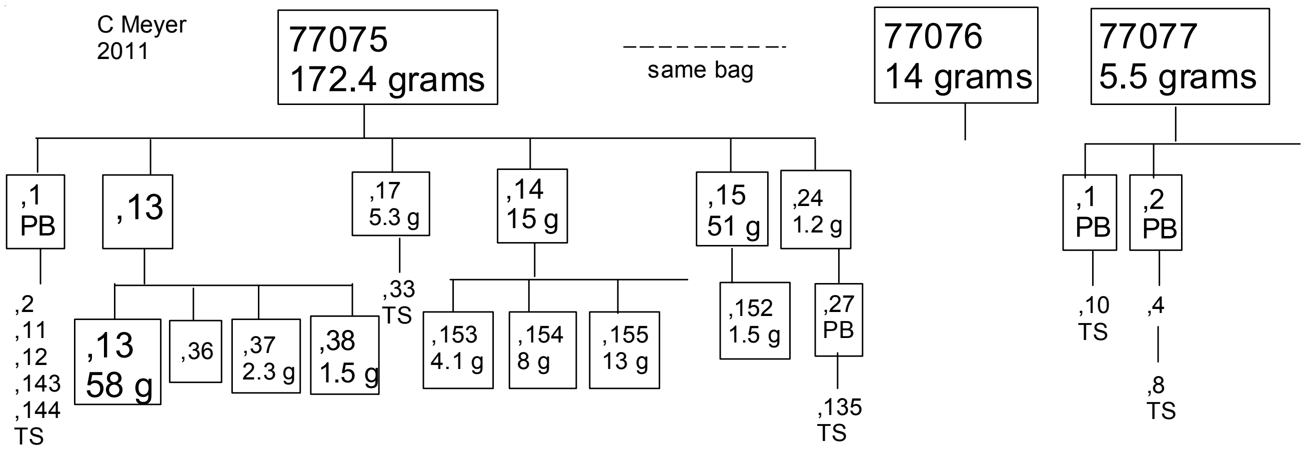

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Figure 14: Photo of 77075. Cube is 1 cm. S73-23995.

Figure 15: Photo of 77075. Cube is 1 cm. S73-24000.

Figure 16: Photo of 77075. Cube is 1 cm. S73-23996.

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