77035

Micropoikilitic Impact Melt Breccia
5727 g, 15 x 15.5 x 22 cm

INTRODUCTION

Sample 77035 is primarily a non-descript impact melt rock that has partially dissolved the original clasts or welded them into its recrystallized matrix such that they cannot be easily extracted. It does contain one large, pristine clast of norite (Fig. 1).

PETROGRAPHY

The main mass of 77035 is a micropoikilitic impact melt breccia, apparently very similar to the matrix of the large boulders at Stations 6 and 7 (Simonds et al., 1974). It is dense, nonvesicular, and except for one large white clast, relatively free of obvious clasts (Fig. 2) The micropoikilitic matrix (Fig. 3) is uniform throughout the rock, and the sawn surfaces are aphanitic and nondescript. The relict clastic texture of the matrix is obscured.

WHOLE-ROCK CHEMISTRY

Boynton et al. (1975) and Wanke et al. (1975) have analyzed the matrix of 77035 (Table 1 and Fig. 4). Wanke et al. (1977) report V analyses and Garg and Ehmann (1977) have determined the Zr and Hf contents. The Zr/Hf ratio is high for 77035. Hughes and Schmitt (1985) have utilized the composition of 77035 to discuss the Zr-Hf-Ta fractionation during lunar evolution. Jovanovic and Reed (1974) have determined Cl, F, Br, and I. Petrowski et al. (1974) have determined C and S.

SIGNIFICANT CLASTS

Sample 77035 has one large white clast (-100 g) that has been studied by Warren and Wasson (1979) and Warren and Kallemyen (1984) (Table 1). Warren (1993) lists this large clast as probably pristine (Fig. 1). It is a cataclastic norite, apparently monomict, with approximately 60% plagioclase (An 93) and 40% orthopyroxene ($WO_2En_{89}Fs_9$). The pyroxene

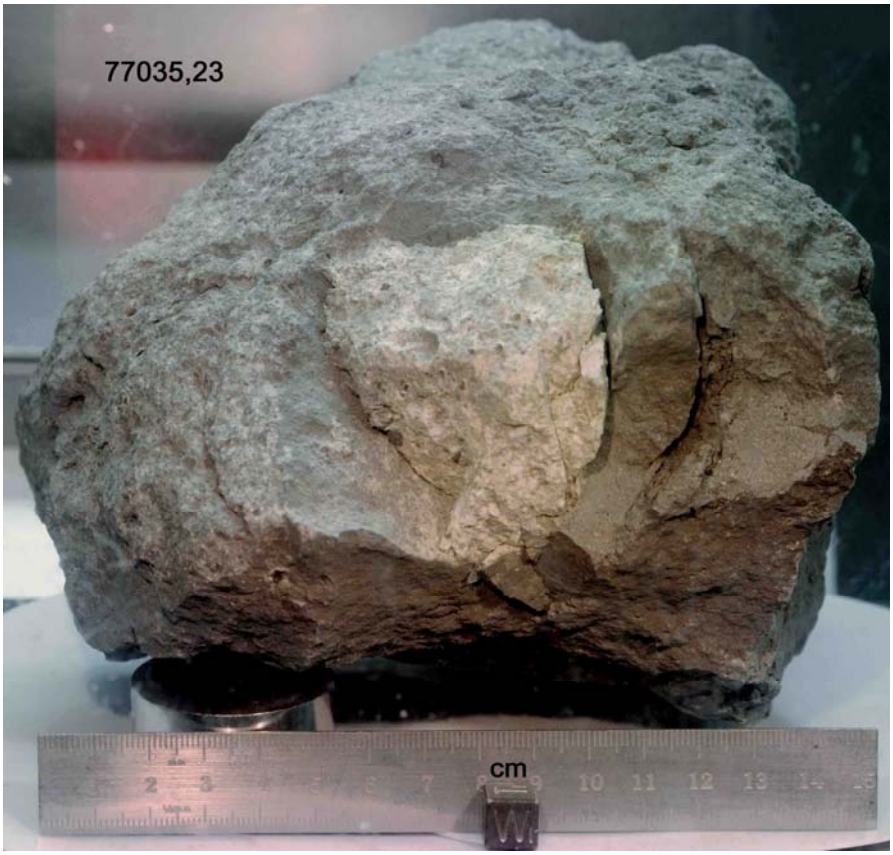

Figure 1: Photograph of 77035 showing the large white clast of pristine norite. S78-27393.

Figure 2: Photograph of 77035. Cube is 1 cm. S73-15907.

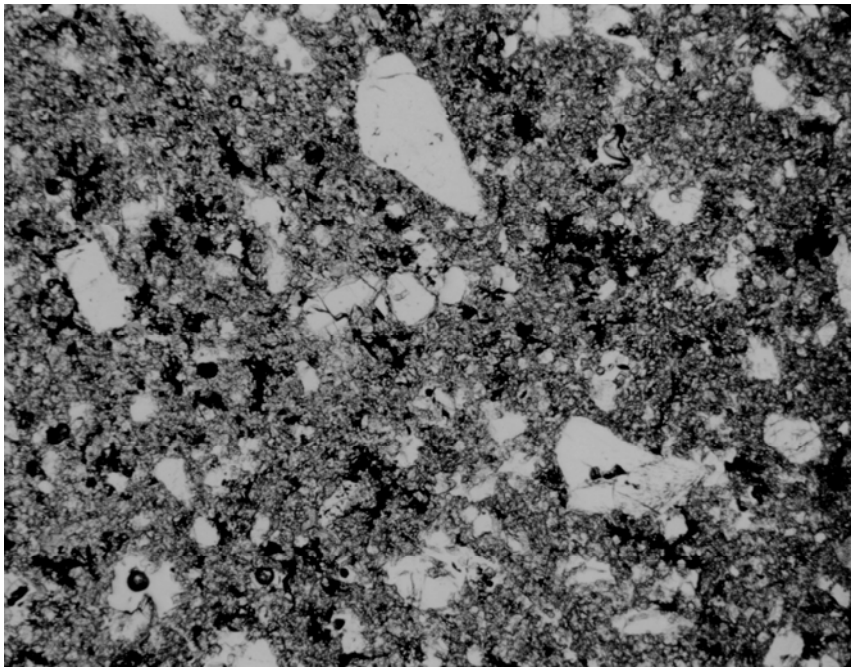

Figure 3: Photomicrograph of, matrix in thin section 77035,92. Field of view is 3 x 4 mm.

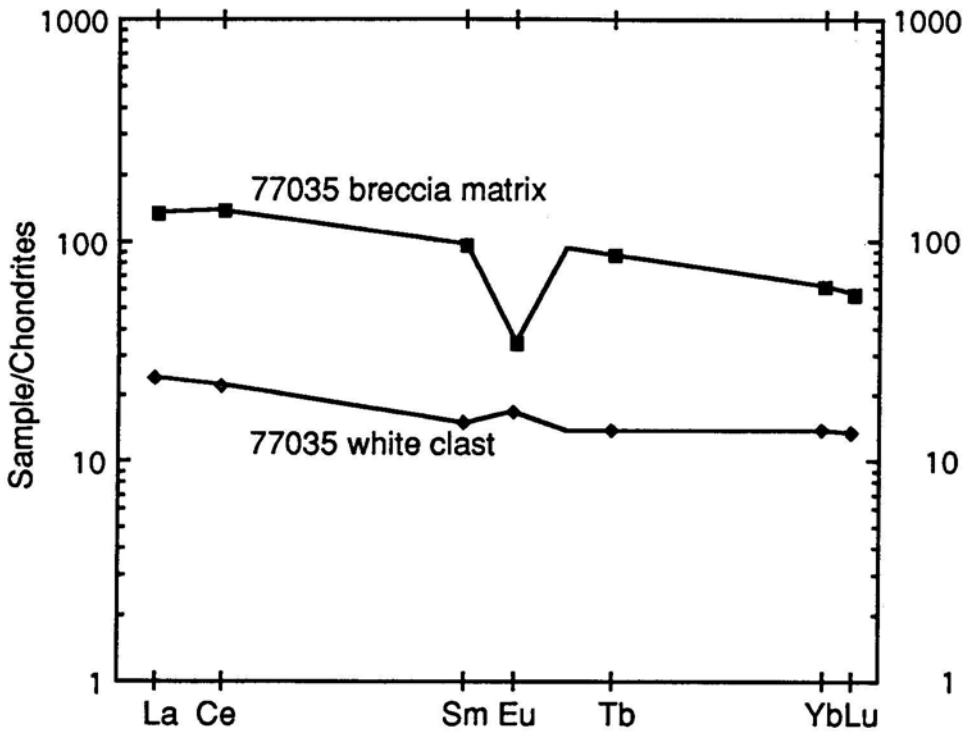

Figure 4: Normalized rare earth element diagram for 77035 showing matrix and large white norite class. Data from Boynton et al. (1975) and Warren and Wasson (1978).

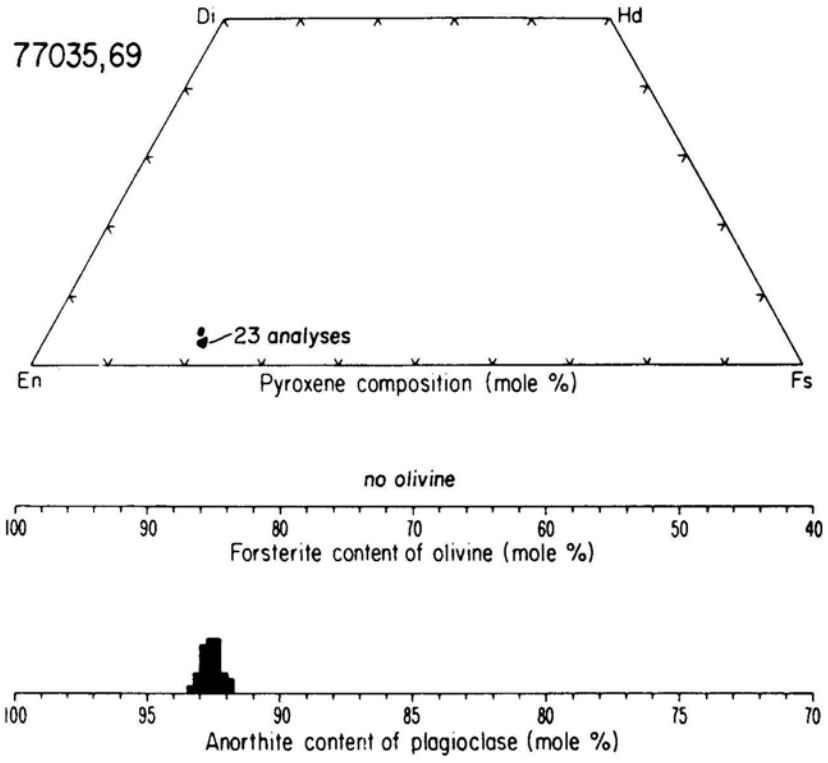

Figure 5: Pyroxene composition of large norite clast in 77035. From Warren and Wasson (1979).

diagram (Fig. 5) is from Warren and Wasson (1979). Fig. 6 gives the position on the plutonic rock diagram, showing that it is within the Mg-norite suite of lunar highland rocks. Bersch et al. (1991) have precisely determined the composition of pyroxene in 77035,69. Papike et al. (1994) have determined the REE in the orthopyroxene of this brecciated norite clast using the ion microprobe method. Much of this clast has been shocked into diaplectic glass and thoroughly comminuted.

Eckert et al. (1991), Neal et al. (1992), and Neal et al. (1994) have studied additional lithic clasts in 77035 (Table 2). They report one "dunite," two "norite," and two "anorthosite" clasts. It was very difficult to extract these clasts from the crystalline matrix of this rock, and the trace element data for these clasts (Fig. 7) may be compromised because these sample splits may have been contaminated by breccia matrix. All the small clasts studied by Neal et al. contained high Au; some have very high Ir (Table 2). Warren (1993) lists these clasts as only "marginally pristine."

Clast, 206 has 37 ppm Ir. The REE profile is flat (Fig. 7). It has about 66% plagioclase (An_{93-96}), 12% orthopyroxene ($WO_4En_{73}Fs_{23}$), ~14% high-Ca pyroxene, and ~7% olivine (Fo_{71-74}).

Clast, 229 is a gabbronorite with ~75% plagioclase (An_{85-87}), ~11% orthopyroxene (En_{71-72}), ~11% high-Ca pyroxene ($Wo_{43}En_{44}Fs_{13}$), and ~3% olivine (FO_{69-73}). It has a positive Eu anomaly (Fig. 7) and is reported as pristine by Neal et al. (1994).

Clast ,226 is essentially all olivine (dunite?) FO_{80-89} and has a deep negative Eu anomaly (Fig. 7).

Bickel and Warner (1978) report a small clast (plutonic fragment?) in thin section 77035,71.

RADIOGENIC ISOTOPES

Murthy and Coscio (1977) have reported Sr isotope measurements for a plagioclase clast in 77035.

PHYSICAL PROPERTIES

Sugiura et al. (1978) studied the thermal remanent magnetization in 77035 (Fig. 8). Simmons et al. (1975) studied differential strain and crack closure in 77035. (These results proved applicable to the microcracks in the Vietnam Memorial!) Horai and Winkler (1976) studied the thermal diffusivity of 77035 (Fig. 9).

PROCESSING

The main portion of 77035 was very hard, and it was extremely difficult to separate the small clasts that were welded into it.

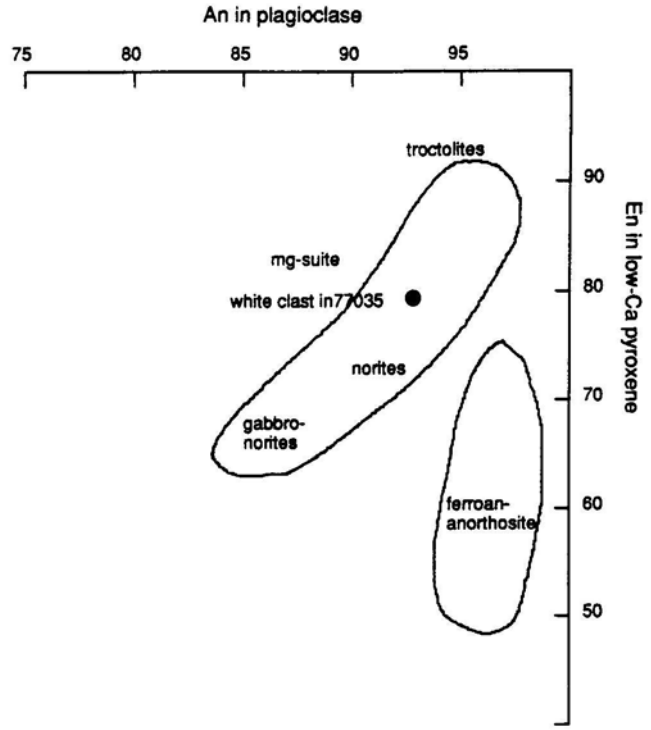

Figure 6: Position of norite clast on the plagioclase-pyroxene diagram for pristine lunar samples. Fields from James and Flohr (1983).

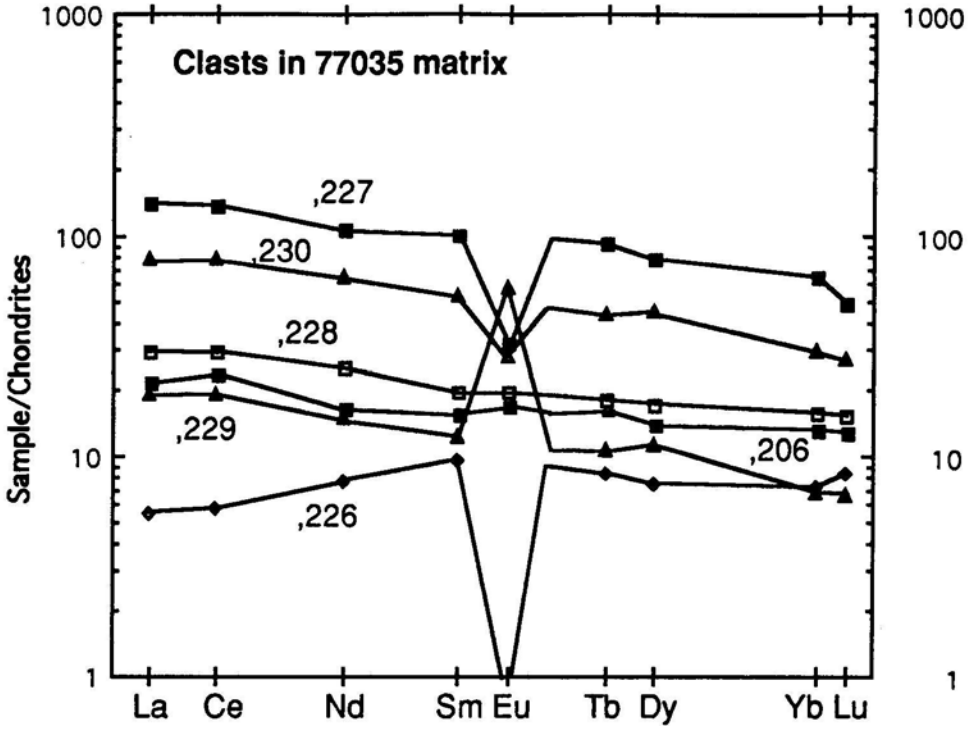

Figure 7: Normalized rare earth element diagram for small clasts in 77035. Data from Neal et al. (1994).

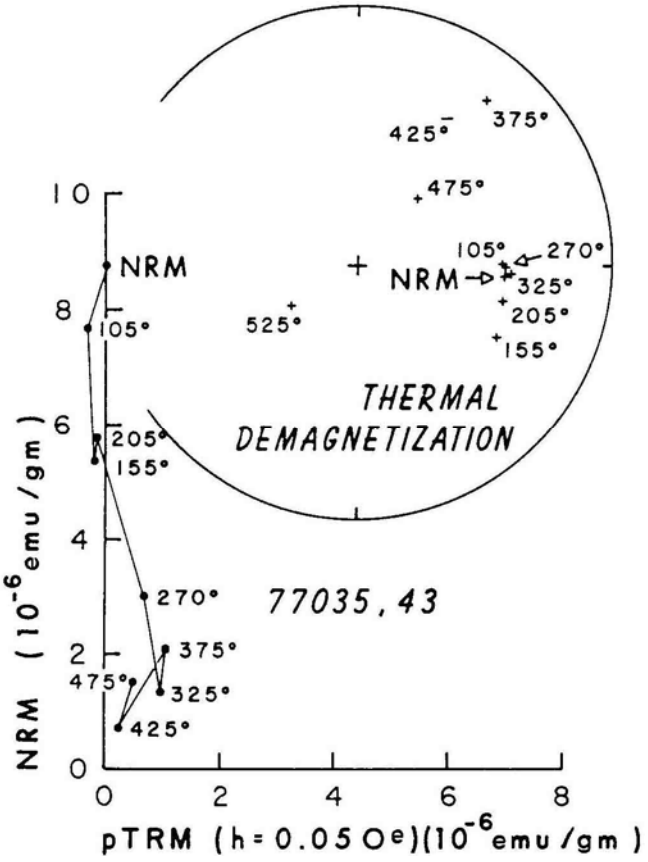

Figure 8. Remanent magnetization of 77035. From Sugiura et al. (1978).

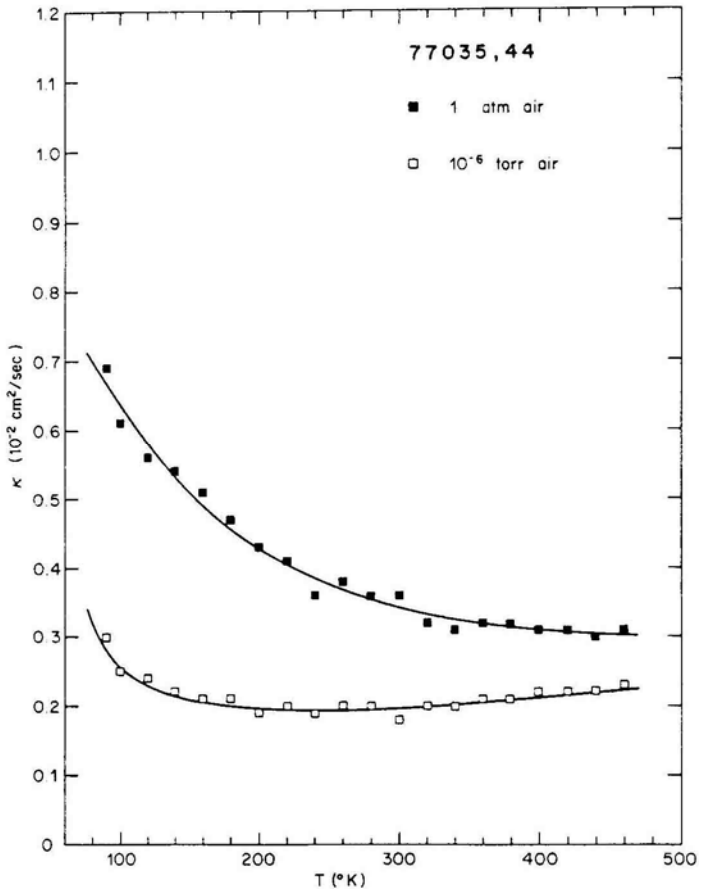

Figure 9: Thermal diffusivity of 77035. From Horai and Winkler (1976).

Table 1: Whole-rock chemistry of 77035.
a) Boynton et al. (1975); b) Wanke et al. (1975); c) Warren and Wasson (1979)

Split Technique	,84 (a) RNAA breccia	,84 (a) RNAA breccia	,61 (b) INAA breccia	,130 (c) INAA large white clast
SiO_2 (wt%)	–	–	46.87	–
TiO_2	1.38	1.38	1.52	0.20
Al_2O_3	17.4	18.1	18.1	19.09
Cr_2O_3	0.18	0.20	0.20	0.32
FeO	6.94	9.00	8.87	2.64
MnO	0.12	0.11	0.11	0.09
MgO			12.2	11.95
CaO	9.24	11.76	11.23	11.76
Na_2O	0.60	0.62	0.62	0.44
K_2O			0.26	0.09
P_2O_5				
Nb (ppm)				
Hf	7.4	10.6	10.8	1.9
Ta	–	1.8	1.46	0.20
U				0.31
Th	3.7	5.5	4.5	1.1
Sr			210	
Ba	–	360	370	96
Zn	2.2	2.4		1.7
Ni	281	333	360	9.5
Co	25	32	32.1	22
Sc	13.6	16.8	16.0	10.9
La	23.4	34.0	32.2	5.5
Ce	63	101	85	13
Nd			55	8.6
Sm	10.7	15.2	14.3	2.19
Eu	1.37	1.90	1.95	0.93
Tb	1.7	3.0	3.2	0.49
Dy	–	14	19.1	
Yb	7.6	11.1	10.2	2.2
Lu	1.12	1.50	1.39	0.32
Ga	5.13	5.02		
Ge (ppb)	444	433		3.9
Ir	5	6.9	9	0.050
Au	4.6	5		0.026

Table 2: Clast chemistry of 77035.
From Neal et al. (1994) (wida permission).

Split Technique	,206 INAA	,226 INAA	,227 INAA	,228 INAA	,229 INAA	,230 INAA
SiO_2 (wt%)	–	–	–	–	–	–
TiO_2	0.22	nd	1.48	0.21	0.69	0.68
Al_2O_3	23.9	0.28	17.1	19.7	27.4	32.1
FeO	5.80	11.0	8.4	5.8	3.9	2.0
MnO	0.07	0.12	0.11	0.09	0.05	0.03
MgO	7.9	49.0	11.7	11.9	5.9	4.8
CaO	14.6	nd	9.7	12.2	14.2	18.2
Na_2O	0.43	0.02	0.65	0.46	1.21	0.55
K_2O	0.08	nd	0.3	0.11	0.18	0.32
Nb (ppm)						
Cr	810	510	1170	1950	440	300
Hf	1.72	0.44	12.8	1.71	0.9	5.2
Ta	0.2	1.7	1.44	0.24	0.19	0.76
U	0.2	nd	1.5	0.29	nd	0.8
Th	0.93	0.33	5.3	1.38	0.47	2.7
Sr	180	nd	240	160	410	200
Rb	nd	nd	12	4	nd	9
Ba	110	nd	350	100	130	240
Cs	nd	nd	0.34	0.4	nd	0.32
Ni	560	110	300	26	nd	35
Co	41	62	38	21.4	5.8	4.3
Sc	9.4	5.6	15.7	10.1	3.0	5.0
La	5.1	1.28	33	7	4.5	18.1
Ce	14.1	3.5	81	17.8	11.3	47
Nd	7.5	3.4	48	11.3	6.7	29
Sm	2.27	1.38	14.8	2.89	1.81	7.7
Eu	0.96	0.026	1.78	1.10	3.19	1.58
Tb	0.59	0.3	3.3	0.65	0.38	1.6
Dy	3.4	1.8	19	4.1	2.7	11
Yb	2.12	1.18	10.3	2.5	1.09	4.8
Lu	0.31	0.2	1.19	0.37	0.16	0.66
Ge (ppb)						
Ir	37	nd	nd	nd	nd	nd
Au	11	6	9	5	6	15