

15659, 15663 and 15672

Vesicular Olivine-normative Basalt

12.6, 10.3 and 21.4 grams



Figure 1: Photo of 15659. NASA S71-49751. Sample is 3 cm across.



Figure 2: Photo of 15663. Cube is 1 cm. S71-49717.

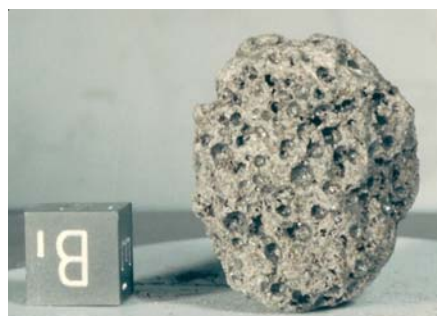


Figure 3: Photo of 15672. Scale and cube are 1 cm. S71-49820.

Mineralogical Mode

	15663	15672
Olivine	8 %	11
Pyroxene	58	58
Plagioclase	27	22
Opagues	6	6
Silica	1	0.4
Mesostasis		2.6
Dowty et al. 1973		

Introduction

Lunar samples 15659, 15663 and 15672 were collected by rake about 20 meters from Hadley Rille (see section on 15614). They are vesicular, olivine-normative basalts with about medium grain size (figures 1 – 3). The average grain size is about 1 mm. 15659 has been dated at 3.34 ± 0.04 b.y.

Petrography

Dowty et al. (1973) and Nehru et al. (1974) described 15663 and 15672 as medium-grained, olivine-normative basalts and determined the composition of major minerals (figure 5b and 6b). The pyroxene and olivine in 15663 have a narrow range in composition. Ilmenite, chromite, ulvospinel, Ba-K feldspar, metallic Ni-Co-Fe grains, troilite, fayalite and silica are present as minor minerals (often found in residual patches). In 15672 one metallic grain was 4% Co and 22 % Ni!

Chemistry

The chemical composition of 15659, 15663 and 15672 is given in tables 1, 2 and 3 and figures 7, 8 and 10. The Mg content of these samples is high. The trace element content is similar to 15555 and the rest of the Apollo 15 basalts!

Radiogenic age dating

Husain (1974) has dated 15659 at 3.34 ± 0.04 b.y. by the Ar/Ar plateau technique (figure).

Cosmogenic isotopes and exposure ages

Husain (1974) determined an exposure age of 15659 of 394 m.y. using ^{38}Ar .

Processing

There is only one thin section of 15659, 4 thin sections for 15663 and 4 thin sections of 15672.

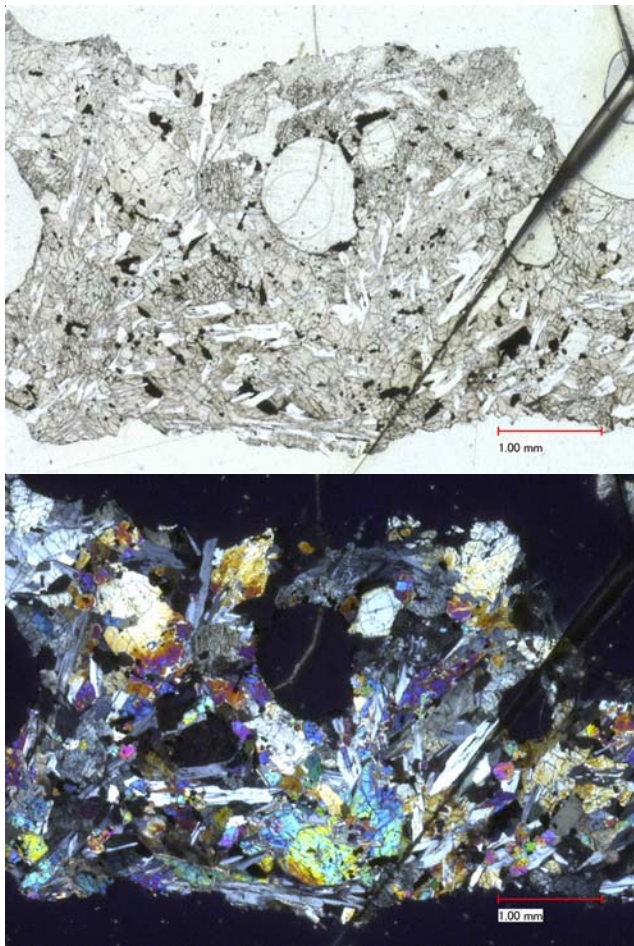


Figure 4: Photomicrographs of thin section 15659,10 (broken) by C Meyer @50x.

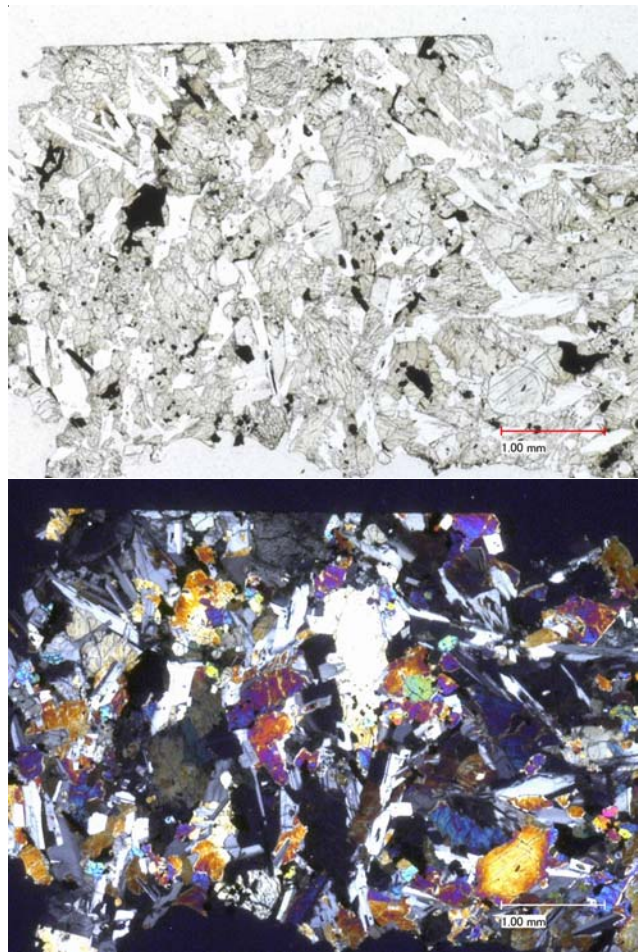


Figure 5a: Photomicrographs of thin section 15663,11 by C Meyer @ 50 x (bottom is with crossed polarizers).

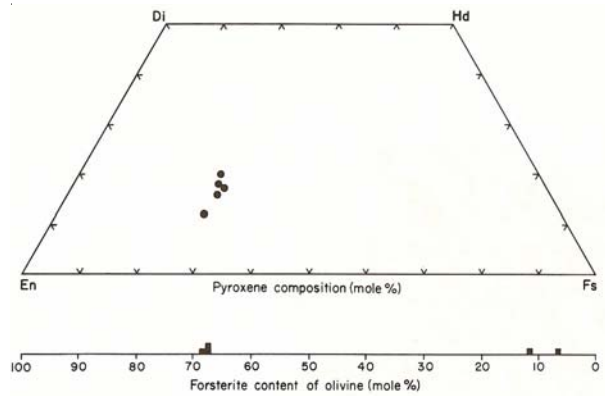


Figure 5b: Pyroxene and olivine composition of 15633 (Dowty et al. 1973).

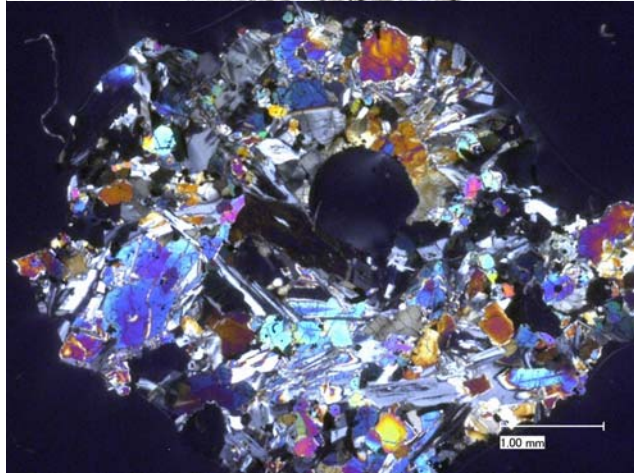


Figure 6a: Photomicrographs of thin section 15672,13 by C Meyer @ 50x.

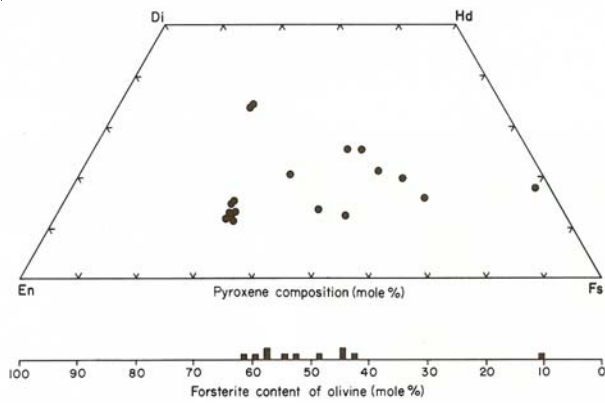


Figure 6b: Pyroxene and olivine composition of 15672 (Dowty et al. 1973).

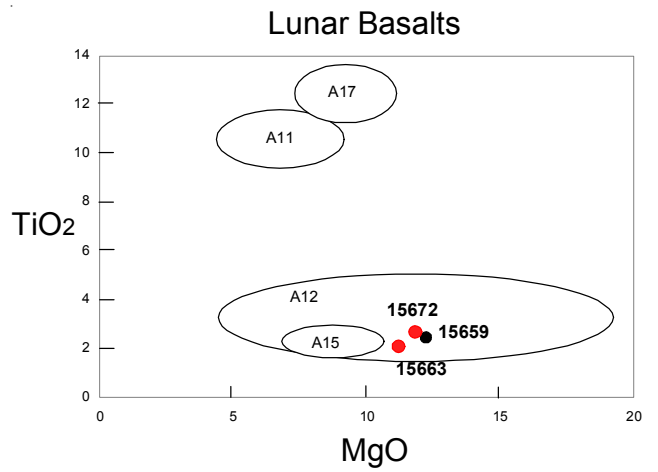


Figure 7: Chemical composition of 15659, 15663 and 15672 compared with that of Apollo basalts.

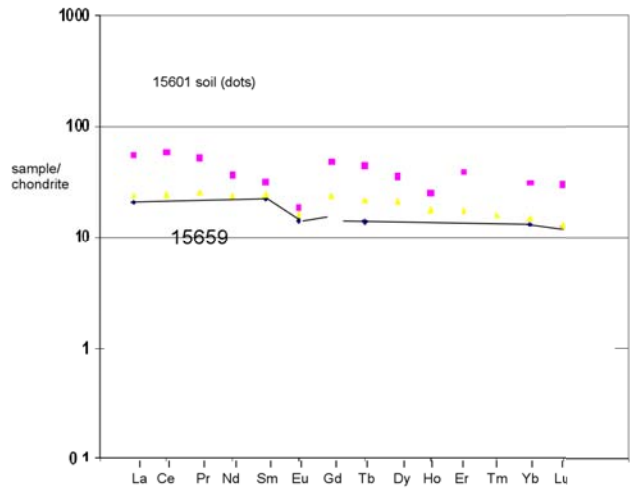


Figure 8: Normalized rare-earth-element composition of 15659 (data by Laul and Schmitt 1973).

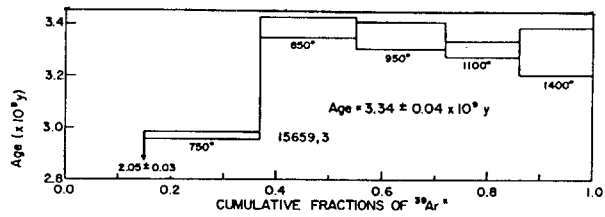


Figure 9: Ar/Ar plateau diagram for 15659 (from Husain 1974).

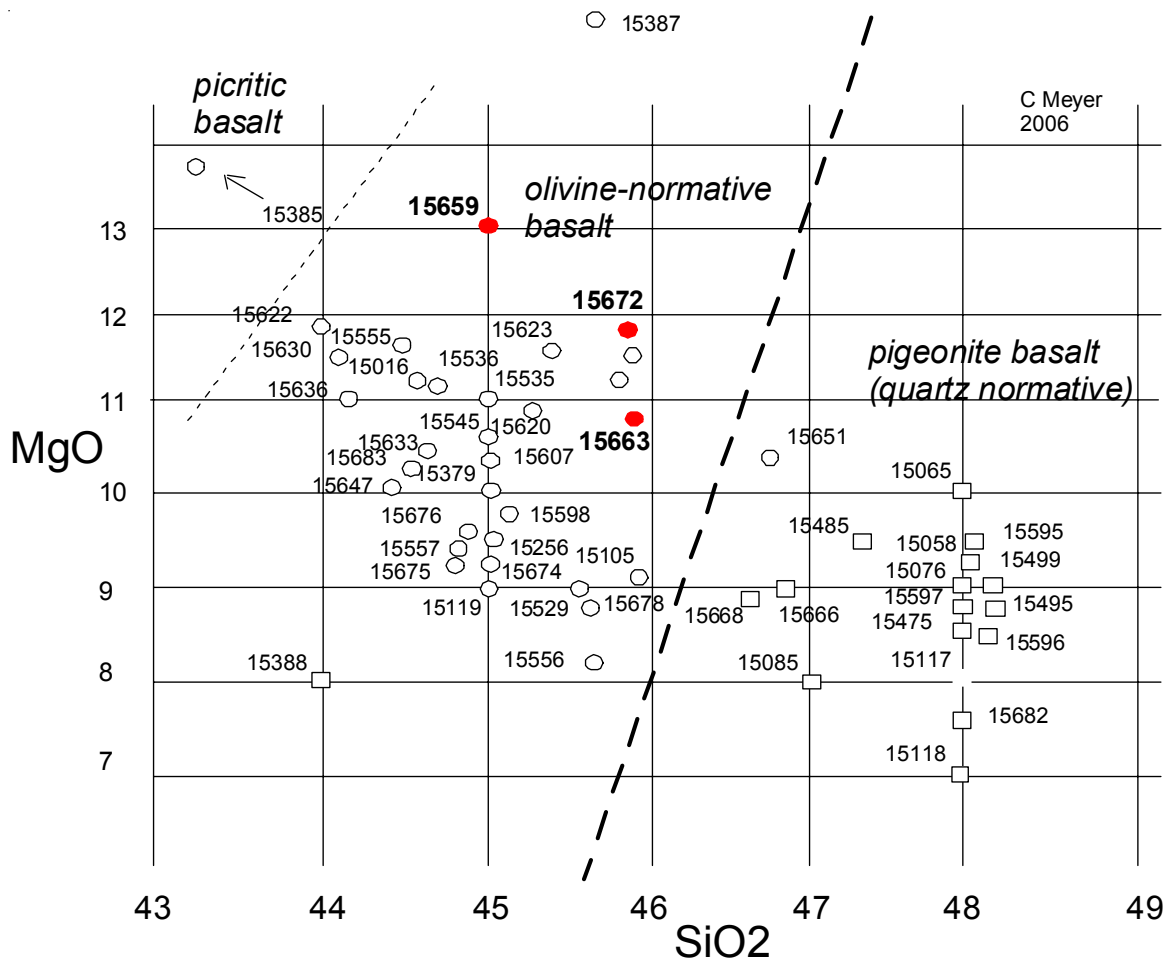


Figure 10: The whole story, the big picture.

Table 1. Chemical composition of 15659.

reference weight	Laul73	Cuttitta73	
SiO ₂ %		45.33	(a)
TiO ₂	2.4	(c) 2.25	(a)
Al ₂ O ₃	8	(c) 8.17	(a)
FeO	22	(c) 22.17	(a)
MnO	0.28	(c) 0.26	(a)
MgO	13	(c) 12.27	(a)
CaO	9.1	(c) 8.98	(a)
Na ₂ O	0.232	(c) 0.27	(a)
K ₂ O	0.042	(c) 0.06	(a)
P ₂ O ₅		0.12	(a)
S %			
sum			
Sc ppm	37	(c) 37	(b)
V	260	(c) 215	(b)
Cr	5820	(c) 3425	(b)
Co	55	(c) 66	(b)
Ni		87	(b)
Cu		32	(b)
Zn			
Ga		3.8	(b)
Ge ppb			
As			
Se			
Rb		1	(b)
Sr		130	(b)
Y		25	(b)
Zr	200	(c) 67	(b)
Nb		10	(b)
Mo			
Ru			
Rh			
Pd ppb			
Ag ppb			
Cd ppb			
In ppb			
Sn ppb			
Sb ppb			
Te ppb			
Cs ppm			
Ba	120	(c) 62	(b)
La	4.8	(c)	
Ce			
Pr			
Nd			
Sm	3.3	(c)	
Eu	0.79	(c)	
Gd			
Tb	0.5	(c)	
Dy			
Ho			
Er			
Tm			
Yb	2.1	(c)	
Lu	0.3	(c)	
Hf	2.5	(c)	
Ta	0.4	(c)	
W ppb			
Re ppb			
Os ppb			
Ir ppb			
Pt ppb			
Au ppb			
Th ppm			
U ppm			

technique: (a) XRF, (b) OES, (c) INAA

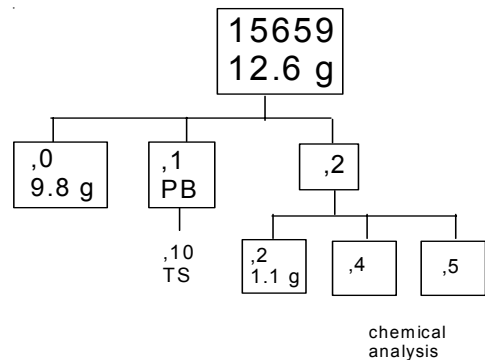
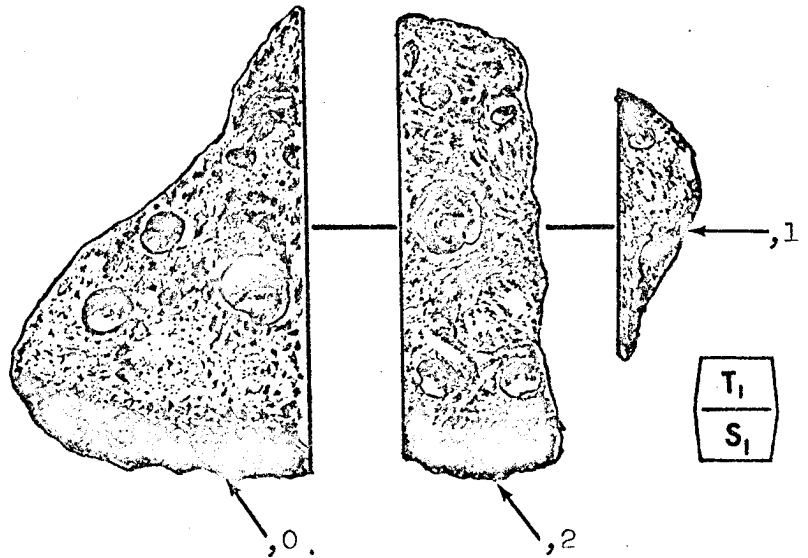


Table 2. Chemical composition of 15663.

reference	Helmke73	Ryder88	Dowty73	
<i>weight</i>				
SiO2 %		45.8	(b) 44.5	(c)
TiO2		2.05	(b) 2.89	(c)
Al2O3		8.3	(b) 8.4	(c)
FeO		21.8	22.3	(b) 22.2 (c)
MnO	0.28	(a) 0.34		(b) 0.26 (c)
MgO		10.8		(b) 10.3 (c)
CaO		9.1		(b) 10.1 (c)
Na2O		0.23	0.25	(b) 0.37 (c)
K2O				0.08 (c)
P2O5		0.1		(b) 0.07 (c)
<i>S %</i>				
<i>sum</i>				
Sc ppm	47	(a) 39.9	44.6	(a)
V				
Cr	3930	(a) 3865	4333	(a)
Co	56	(a) 53.7	54.7	(a)
Ni				
Cu				
Zn				
Ga	2.9	(a)		
<i>Ge ppb</i>				
As				
Se				
Rb	0.5	(a)		
Sr				
Y				
Zr				
Nb				
Mo				
Ru				
Rh				
<i>Pd ppb</i>				
<i>Ag ppb</i>				
<i>Cd ppb</i>				
<i>In ppb</i>				
<i>Sn ppb</i>				
<i>Sb ppb</i>				
<i>Te ppb</i>				
Cs ppm	0.017	(a)		
Ba				
La	4.93	(a) 4.81	5.23	(a)
Ce	13.4	(a) 11.2	15.4	(a)
Pr				
Nd	10.8	(a)		
Sm	3.54	(a) 3.2	3.52	(a)
Eu	0.88	(a) 0.813	0.867	(a)
Gd	4.6	(a)		
Tb	0.81	(a) 0.814	0.888	(a)
Dy	5.7	(a)		
Ho	1.04	(a)		
Er	3	(a)		
Tm				
Yb	2.26	(a) 2.06	2.4	(a)
Lu	0.328	(a) 0.313	0.334	(a)
Hf	2.5	(a) 2.2	2.57	(a)
Ta				
<i>W ppb</i>				
<i>Re ppb</i>				
<i>Os ppb</i>				
<i>Ir ppb</i>				
<i>Pt ppb</i>				
<i>Au ppb</i>				
Th ppm		0.529	0.6	(a)
<i>U ppm</i>				
<i>technique: (a) INAA, (b) fused-bead XRF, (c) broad-beam e-probe</i>				

Table 3. Chemical composition of 15672.

reference weight	Neal2001 5 gram	Laul73	Ma76	Cuttiitta73	Ryder2001 5 gram	Ryder88 0.5 gram
SiO ₂ %				44.8	(c) 44.7	(d) 45.7 (d)
TiO ₂		2.1	(b) 2.2	1.9	(b) 2.16	(c) 2 (d) 2 (d)
Al ₂ O ₃		8.7	(b) 9	8.4	(b) 8.62	(c) 9.54 (d) 8.9 (d)
FeO		22.5	(b) 21.2	21.1	(b) 21.78	(c) 20.97 (d) 21.6 (d)
MnO		0.266	(b) 0.264	0.263	(b) 0.27	(c) 0.27 (d) 0.28 (d)
MgO		12	(b) 11.9	12.2	(b) 11.98	(c) 11.65 (d) 11.7 (d)
CaO		8.6	(b) 9.1	9.2	(b) 9.44	(c) 9.26 (d) 8.9 (d)
Na ₂ O		0.24	(b) 0.26	0.24	(b) 0.28	(c) 0.228 (d) 0.26 (d)
K ₂ O		0.035	(b) 0.035	0.032	(b) 0.06	(c) 0.038 (d)
P ₂ O ₅				0.12	(c) 0.062	(d) 0.12 (d)
S %						
sum						
Sc ppm	40.3	(a) 40	(b) 39	40	(b) 31	(c) 39.2 (b) 39 (b)
V	255	(a) 200	(b) 229	230	(b) 180	(c)
Cr	4840	(a) 4406	(b) 3900	3500	(b)	4750 (b) 3963 (b)
Co	57	(a) 53	(b) 49	40	(b) 66	(c) 54.3 (b) 54 (b)
Ni	74	(a)	79	77	(b) 69	(c) 86 (b)
Cu	12	(a)			0.11	(c)
Zn	17	(a)				
Ga	3.21	(a)			4.5	(c)
Ge ppb						
As						
Se						
Rb	0.82	(a)				
Sr	96.4	(a)			120	(c) 95 (b)
Y	27	(a)			24	(c) 25
Zr	93	(a) <180	(b)		59	(c) 90
Nb	5.8	(a)				
Mo	0.04	(a)				
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb						
In ppb						
Sn ppb						
Sb ppb						
Te ppb						
Cs ppm	0.02	(a)				
Ba	49	(a) 60	(b) 32	21	(b) 56	(c) 42 (b)
La	4.98	(a) 4.5	(b) 4.2	3.9	(b)	4.52 (b) 4.82 (b)
Ce	13.5	(a)				13.5 (b) 13.5 (b)
Pr	2.07	(a)				
Nd	9.21	(a)				10 (b)
Sm	3.23	(a) 3	(b) 2.9	2.6	(b)	3.04 (b) 3.23 (b)
Eu	0.79	(a) 0.86	(b) 0.77	0.66	(b)	0.78 (b) 0.805 (b)
Gd	4.1	(a)				
Tb	0.7	(a) 0.6	(b) 0.49	0.53	(b)	0.68 (b) 0.79 (b)
Dy	4.63	(a) 4.2	(b) 3.8	4	(b)	
Ho	0.9	(a)				
Er	2.52	(a)				
Tm	0.34	(a)				
Yb	2.16	(a) 2.1	(b) 1.9	1.8	(b)	1.99 (b) 2.27 (b)
Lu	0.26	(a) 0.3	(b) 0.33	0.37	(b)	0.27 (b) 0.313 (b)
Hf	2.39	(a) 2.5	(b) 2.2	2.1	(b)	2.22 (b) 2.37 (b)
Ta	0.44	(a) 0.5	(b) 0.31	0.34	(b)	0.32 (b)
W ppb						
Re ppb						
Os ppb						
Ir ppb						
Pt ppb						
Au ppb						
Th ppm						0.39 (b) 0.637 (b)
U ppm						

technique: (a) ICP-MS, (b) INAA, (c) "microchemical", (d) fused-bead e-probe

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