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.

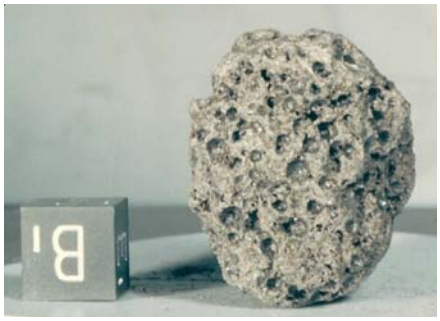

Figure 3: Photo of 15672. Scale and cube are 1 cm. S71-49820.

Mineralogical Mode

	15663	15672
Olivine	8 %	11
Pyroxene	58	58
Plagioclase	27	22
Opaques	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.

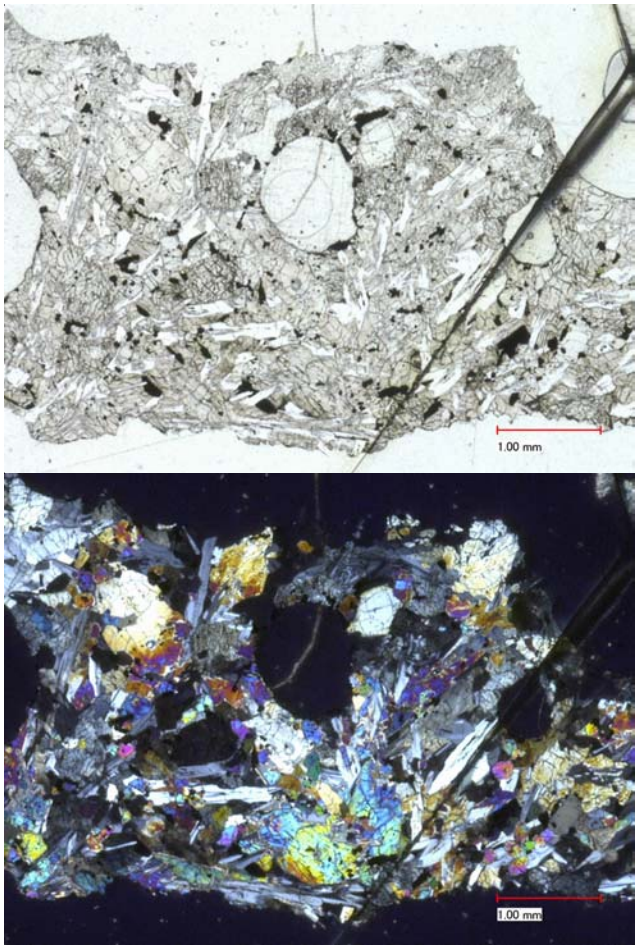

Figure 4: Photomicrographs of thin section 15659,10 (broken) by C Meyer @50x.

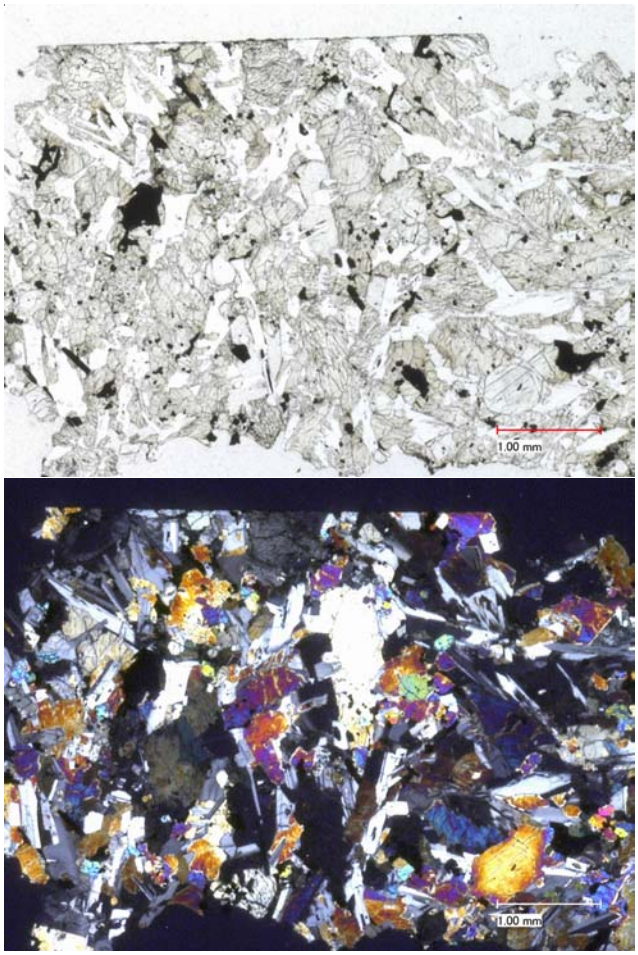

Figure 5a: Photomicrographs of thin section 15663,11 by C Meyer @ 50 x (bottom is with crossed polarizers).

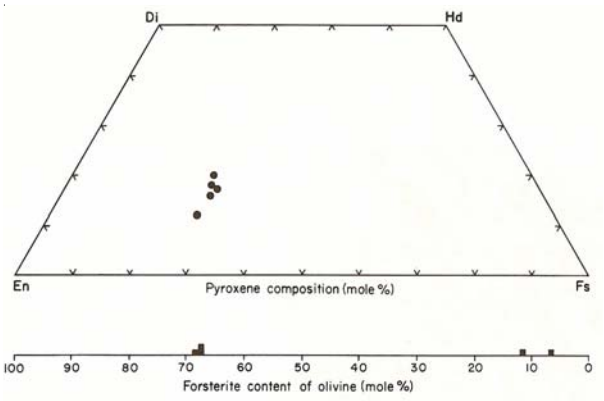

Figure 5b: Pyroxene and olivine composition of 15633 (Dowty et al. 1973).

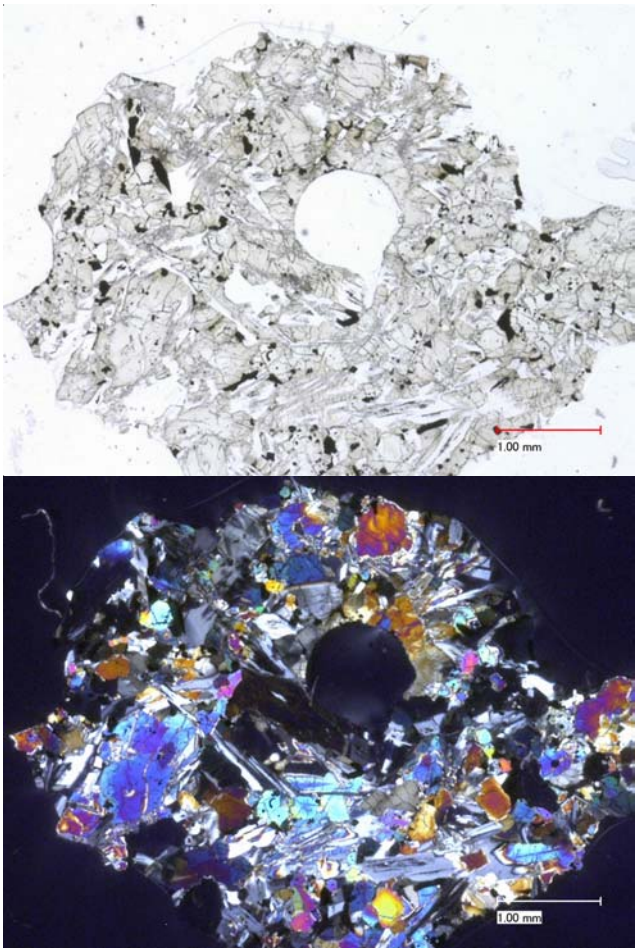

Figure 6a: Photomicrographs of thin section 15672,13 by C Meyer @ 50x.

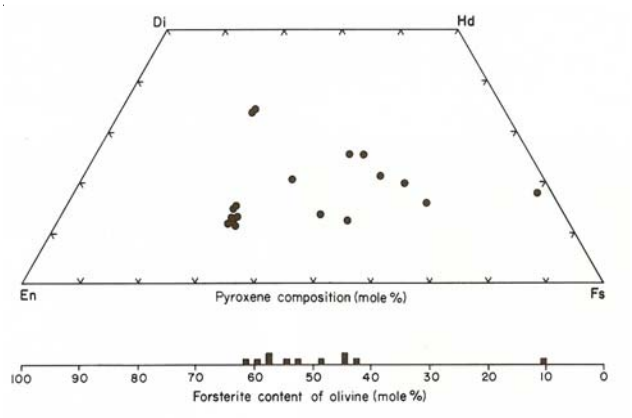

Figure 6b: Pyroxene and olivine composition of 15672 (Dowty et al. 1973).

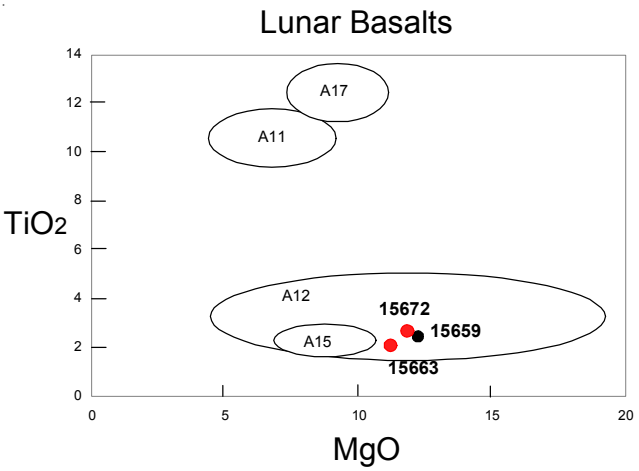

Figure 7: Chemical composition of 15659, 15663 and 15672 compared with that of Apollo basalts.

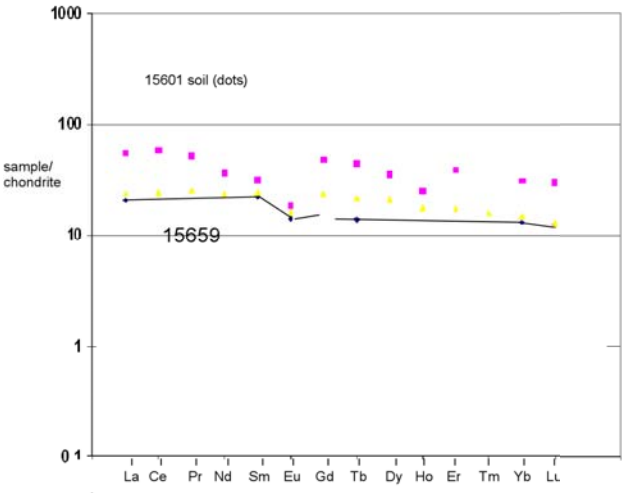

Figure 8: Normalized rare-earth-element composition of 15659 (data by Laul and Schmitt 1973).

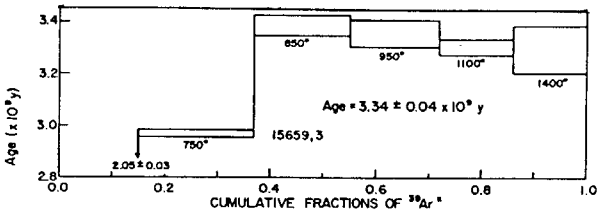

Figure 9: Ar/Ar plateau diagram for 15659 (from Husain 1974).

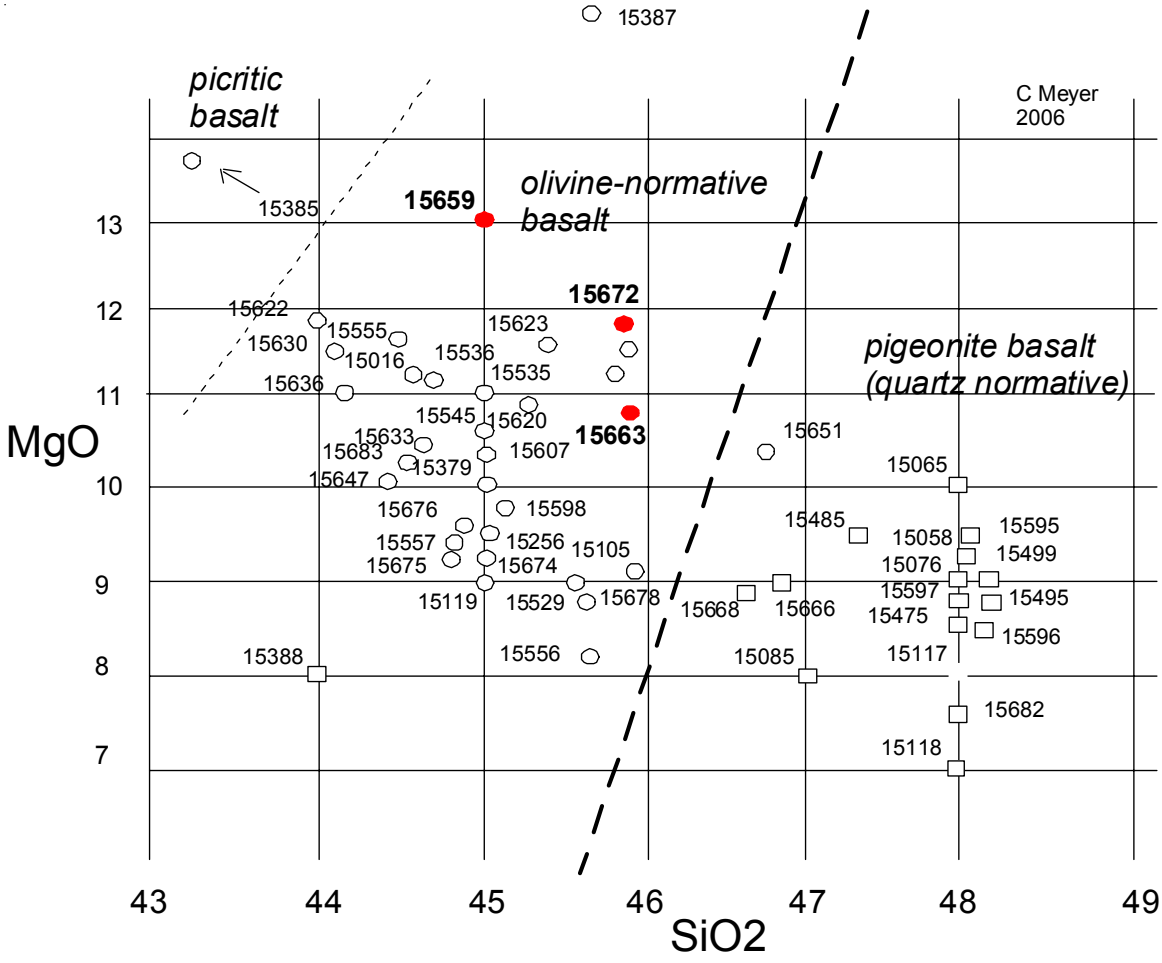

Figure 10: The whole story, the big picture.

Table 1. Chemical composition of 15659.

reference	Laul73		Cuttitta73	
weight				
SiO2 %			45.33	(a)
TiO2	2.4	(c)	2.25	(a)
Al2O3	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)
Na2O	0.232	(c)	0.27	(a)
K2O	0.042	(c)	0.06	(a)
P2O5			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

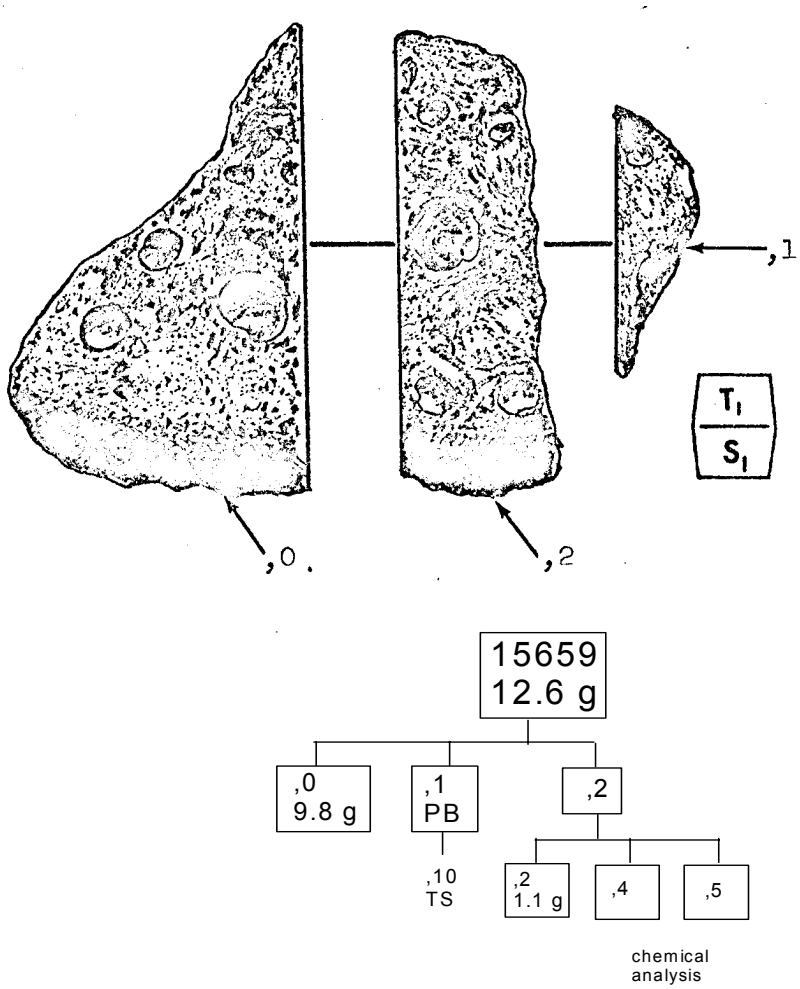

Table 2. Chemical composition of 15663.

reference	Helmke73		Ryder88			Dowty73	
weight							
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)
S %							
sum							
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)					
Ge ppb							
As							
Se							
Rb	0.5	(a)					
Sr							
Y							
Zr							
Nb							
Mo							
Ru							
Rh							
Pd ppb							
Ag ppb							
Cd ppb							
In ppb							
Sn ppb							
Sb ppb							
Te ppb							
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							
W ppb							
Re ppb							
Os ppb							
Ir ppb							
Pt ppb							
Au ppb							
Th ppm			0.529	0.6	(a)		
U ppm							

technique: (a) INAA, (b) fused-bead XRF, (c) broad-beam e-probe

Table 3. Chemical composition of 15672.

reference	Neal2001		Laul73		Ma76			Cuttitta73		Ryder2001		Ryder88	
weight	5 gram									5 gram		0.5 gram	
SiO2 %								44.8	(c)	44.7	(d)	45.7	(d)
TiO2			2.1	(b)	2.2	1.9	(b)	2.16	(c)	2	(d)	2	(d)
Al2O3			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)
Na2O			0.24	(b)	0.26	0.24	(b)	0.28	(c)	0.228	(d)	0.26	(d)
K2O			0.035	(b)	0.035	0.032	(b)	0.06	(c)	0.038	(d)		
P2O5								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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