Sayh al Uhaymir 300

Anorthositic impact melt breccia

152.6 g

Figure 1: Sayh al Uhaymir 300 in the desert in Oman (photo by R.. Bartoschewitz).

Introduction

Sayh al Uhaymir 300 (Fig. 1) was found in February 2004 in the Oman desert (Fig. 2). It is an olive-green flat and rounded rock with a resinous luster that may be due to desert weathering, since it has no fusion crust. The interior of the sample reveals a medium grey brecciated matrix with lighter clasts, metal flakes, and small vesicles (Russell et al., 2005; Bartoschewitz et al., 2005a). Some terrestrial alteration is present as white crystals in fractures - calcite and gypsum. Concentrations of Sr and Ba are higher in these samples than in non hot desert lunar meteorites, suggesting an origin from desert weathering (Korotev et al., 2009b).

Petrography and mineralogy

Clasts within the breccia include troctolite, anorthositic olivine gabbro, olivine gabbro, anorthosite, wehrlite, dunite, clinopyroxenite, and gabbro (Hudgins et al., 2007; Figure 3). These rock types exhibit hypidiomorphic-granular, subophitic, poikilitic, and granular textures. Plagioclase feldpar is anorthitic with An_{95-96}, and olivine varies from Fa_{15} to Fa_{39}. Accessory minerals are kamacite, chromite, spinel, ulvospinel, ilmenite, armalcolite, and troilite. Feldspathic glass is also present, with 24 wt% Al_2O_3, 7.4 wt% FeO and 4.7 wt% MgO. Like many other feldspathic breccia lunar meteorites, the plagioclase (An) and pyroxene (Mg#) compositions bridge the gap between the FAN and HMS fields (Hsu et al., 2007, 2008; Hudgins et al., 2007).

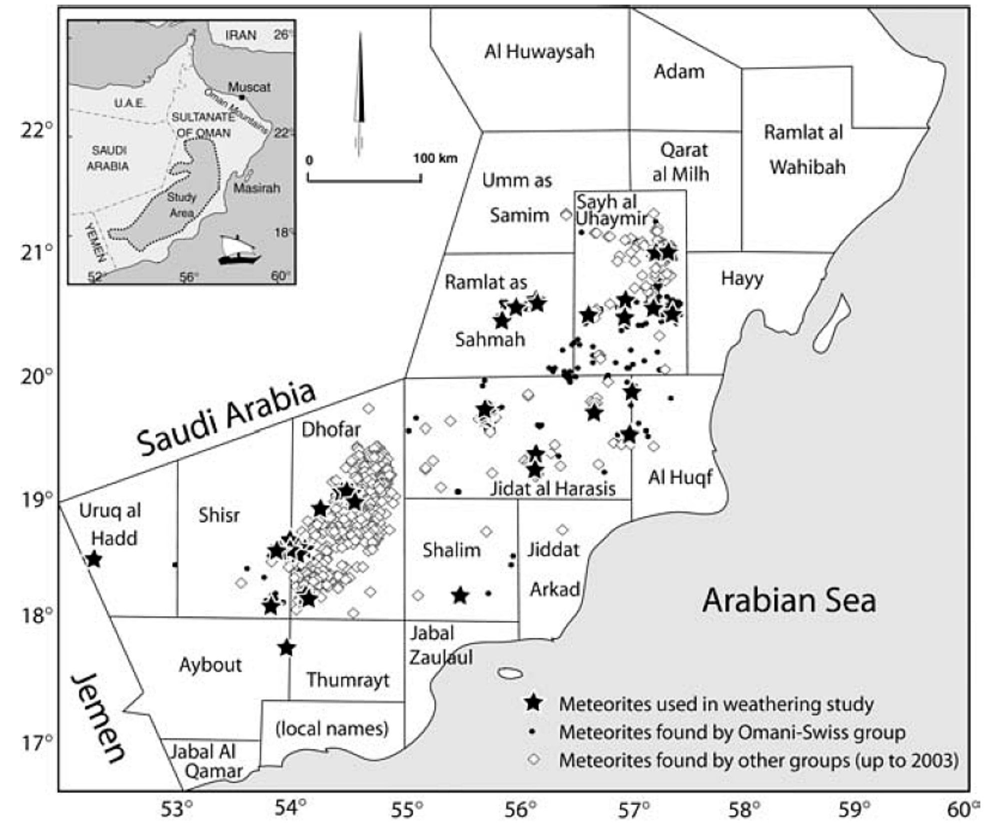

Figure 2: Map of Oman, sowing the Sayh al Uhaymir region just NE of center (from Al-Kathiri et al., 2005).

Petrographic studies have generally come to two different conclusions regarding this lunar meteorite. Initially the presence of clasts with basaltic affinity, as well as it intermediate bulk compositional properties (FeO and Al_2O_3) led some to call it a basalt-bearing feldspathic breccia (Hsu et al., 2006, 2007, 2008; Bartoschewitz et al., 2005a). However, additional studies of textures and bulk composition have led some to call it a polymict impact melt breccia, based on the abundance of impact melts, impact melt breccias, and the consistently high siderophile element concentrations that is perhaps linked to a high meteoritic metal content (Hudgins et al., 2007; Hsu et al., 2008; also see BSE images of many clasts reported by Hsu et al., 2008). The latter evidence is strong enough to persuade this writer that it should be called a polymict impact melt breccia.

The shock history proposed for this meteorite is in three major stages. The first stage included formation of the shock features in the lithic clasts in a shock pressure range of 5 to 28 GPa. The second stage consisted of > 60 GPa and formed the fine grained igneous matrix of the sample. And a third phase included formation of melt veins and pockets, as well as localized maskelynitization perhaps between 28 and 45 GPa (Hudgins et al., 2007).

Chemistry

Bulk analyses have revealed a composition that is intermediate between mafic breccias and feldspathic end members, with 20 to 24 wt% Al_2O_3, 18-22 ppm Sc, 0.26 to 0.27 wt% TiO_2 and 0.46 ppm Th (Figure 4; Bartoschewitz et al., 2005b; Hudgins et al., 2007; Hsu et al., 2008). Rare earth elements have been measured in mineral phases from some of the clasts and show an overall similarity to other lunar highlands breccias (Hsu et al., 2006, 2007). However, the lower Th and dearth of KREEP and mare basalt clasts has suggested a far side highlands terrane origin (Hsu et al., 2007; Hudgins et al., 2007). Siderophile elements (Co, Ni, Au and Ir) are in general very high for this sample (Bartoschewitz et al., 2005b; Hsu et al., 2008). Noble gases are low in this meteorite, and may have been driven off during metamorphism to granulite grade (Bartoschewitz et al., 2005c), although there is a small amount of some noble gas isotopes due to cosmogenic production in the lunar regolith.

Comparison of the composition of SaU 300 to other anorthositic breccias shows it is similar to NWA 4932 (with which it may be launch paired; Korotev et al., 2009b), and in general shares compositional traits with a small group of lunar meteorites. This group has an additional (fourth) component in the breccia that is not recognized in Apollo sample suites (Korotev et al., 2009b; Fig. 5). This important finding illustrated the potential for lunar meteorites providing more robust global constraints than the site specific Apollo or Luna collections.

Figure 3: Thin slice through SaU 300 illustrating the overall texture and size and nature of the clasts and fragments (from Hsu et al., 2008 and Bartoschewitz and Korotev, 2010).

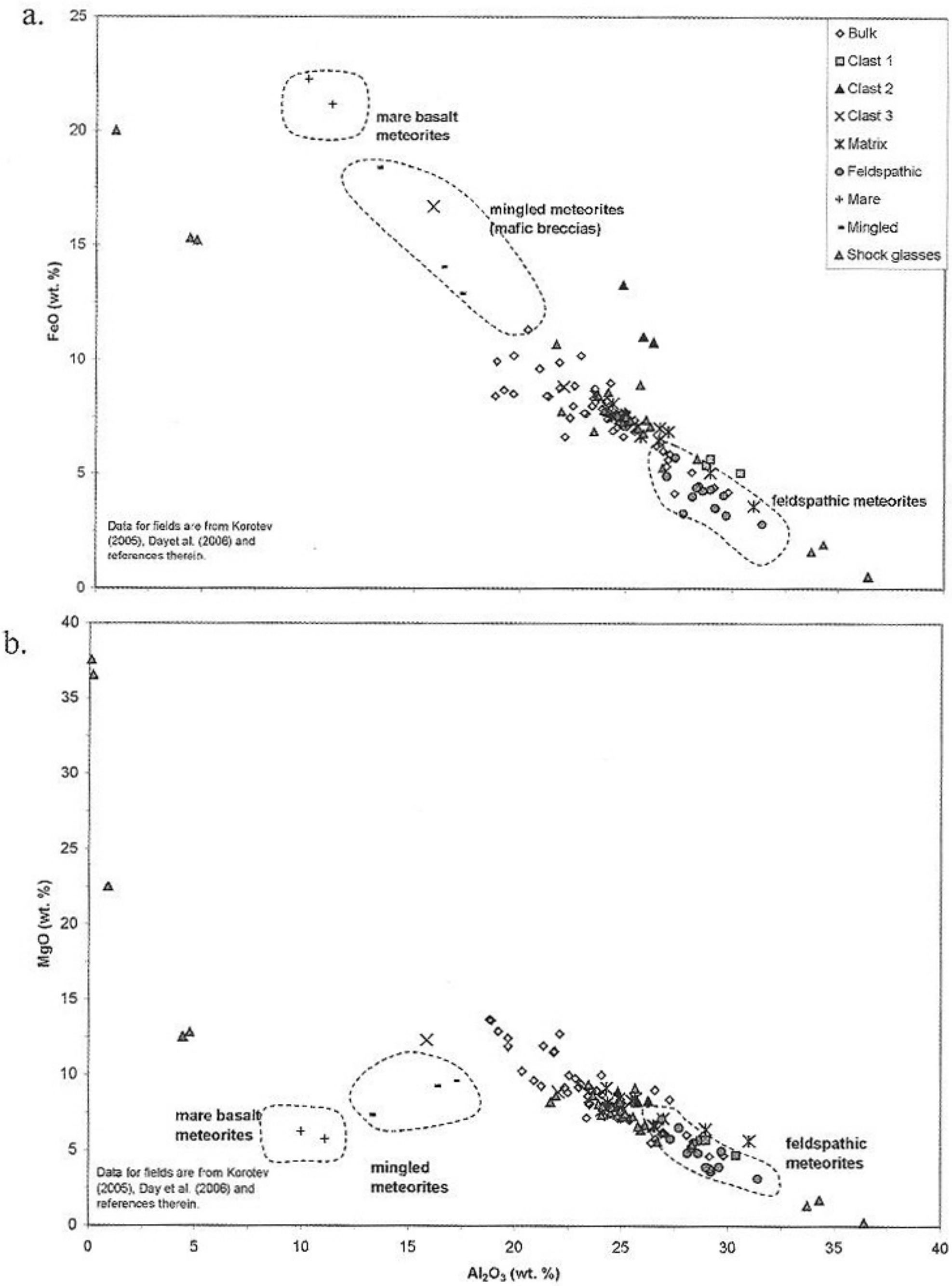

Figure 4: Bulk compositions of clasts and matrix from SaU 300 illustrating the overall feldspathic composition of this crystalline impact melt breccia (from Hudgins et al., 2007).

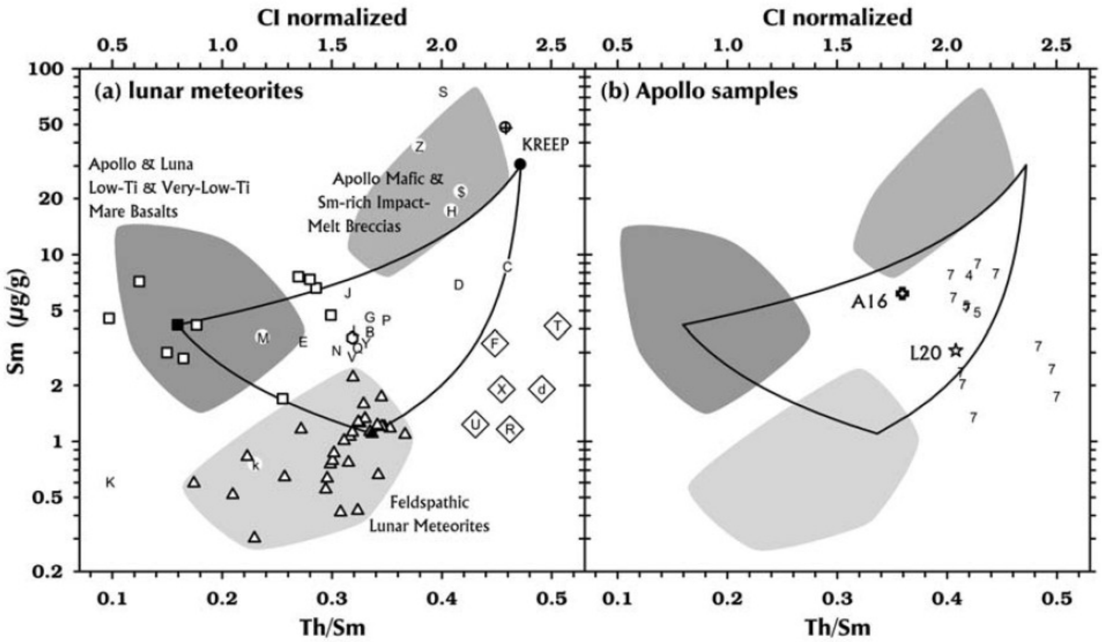

Figure 5: Bulk composition of SaU 300 (symbol U) illustrating the distinct compositional character of this sample and a small group of samples (F, T, X, d and R in diamonds (from Korotev et al., 2009b). They lie outside the three components that can explain most other variation within the lunar meteorites.

Radiogenic age dating

None yet reported.

Cosmogenic isotopes and exposure ages

None yet reported.

Table 1a:Chemical composition of SaU 300

reference	1	1	2	2	2	2
weight	20-60	321	0.0301	0.0301	0.0605	0.0563
technique	d	e	b	g	e	a,b
SiO_2 %	45					
TiO_2	0.3		1590	1500	1560	1640
Al_2O_3	23		9.43		12.2	12.73
FeO	7.82		6.08	6.5	6.2	6.6
MnO	0.12		865	870	910	
MgO	9		5.06		5.1	6.51
CaO	13.9		9.28	10.1	8.8	9.76
Na_2O	0.31		2170		2510	2610
K_2O	0.05		507		575	<100
P_2O_5	0.04		147			
S %				2000		
sum	99.7					
Sc ppm		17.9	14.9		18.9	22
V			50.4	46	50	
Cr		1470	1480	1510	1450	
Co		34.5	36.8		38	<100
Ni		440	463	470	465	500
Cu			5.94	6.9		
Zn			<2.5	2.2	<2.4	
Ga			2.58	1.9	<3.3	
Ge						
As		0.46	<3	<1.0	0.52	
Se		0.48				
Rb		<4	0.91	0.8	<2.0	1.3
Sr		730	540	540		589
Y				18		11
Zr		31	51.2		50	41
Nb			1.91	<2		
Mo			0.76	<2	0.65	
Ru						
Rh			0.019			
Pd ppb			0.32			
Ag ppb						
Cd ppb						
In ppb						
Sn ppb			50	<3000	<200	
Sb ppb					26	
Te ppb						
Cs ppm		<0.1			<0.08	0.063

Ba	47	57.4	63	54	38.3
La	2.57	2.38		2.5	1.388
Ce	6.6	4.31		6.1	5.78
Pr		0.83		<3	
Nd	3.6	3.72		3.88	
Sm	1.233	1.07		1.11	
Eu	0.631	0.604		0.64	
Gd		1.42			
Tb	0.289	0.2555		0.24	
Dy		1.74		2.2	
Ho		0.373		<0.6	
Er		1.15			
Tm		0.168			
Yb	1.275	1.2		1.3	
Lu	0.183	0.167		0.17	
Hf	0.97			0.9	
Ta	0.132			0.108	
W ppb					
Re ppb					
Os ppb					
Ir ppb	19.1	21		19	
Pt ppb		38		<4	
Au ppb	5.5	0.581	<1.2		
Th ppm	0.53	0.473	<1.0		
U ppm	0.25			0.22	

technique (a) ICP-AES, (b) ICP-MS, (c) wet chemistry (d) FB-EMPA, (e) INAA, (f) RNAA, (g) XRF

Table 1b. Light and/or volatile elements for SaU 300

Li ppm	
Be	
C	
S	
F ppm	
Cl	
Br	0.67
I	
Pb ppm	
Hg ppb	
Tl	
Bi	

references: 1) Korotev et al. (2009b); 2) Hsu et al. (2008)