XVI. Sayh al Uhaymir 005/094

Basalt, ~11 kg.

Apparent strewn field (about 9 pieces)

Figure XVI-1. *Photograph of Sayh al Uhaymir 094 as it was found in Oman. Note the luster.*

Introduction

In November 1999, five macroscopically identical stones were recovered at two sites about 1800 meters apart in Oman, at a location called Sayh al Uhaymir. These were labeled **SaU 005** and **SaU 008** and have a combined weight of 9923 grams (Zipfel 2000). Additional pieces, labeled **SaU 051** and **SaU 094**, were recovered by a Swiss expedition in January 2001 (Hofmann *et al.* 2001; Grossman and Zipfel 2001; Gnos *et al*. 2002) weighing 436 grams and 223 grams respectively, and the strewn field has been extended to 2.5 by 1.5 km. Four additional fragments **SaU 060** (42 g), **SaU 090** (95 g), **SaU120** (75g) and **SaU150** (107g) were reported by Russell *et al.* (2002, 2003).

SaU basaltic shergottites are very similar in mineralogy, texture, chemistry and exposure age to the DaG shergottites from Libya, but terrestrial weathering (caliche) appears to be much less pronounced (Zipfel 2000; Dreibus *et al*. 2000).

Two sides of SaU 094 (Gnos *et al*. 2002) are coated with very thin black fusion crust. Russell *et al.* 2003 report that SaU 120 has a "well preserved black fusion crust".

Petrography

SaU 005 has a porphyritic texture of large olivine phenocrysts set in a fine-grained groundmass of low

Mineralogical Mode

	Zipfel (2000)	Gnos *et al.* (2002)	Bartoschewitz (2003)
Pyroxene	48 vol. %	52 - 58	56
Olivine	25	22 - 31	23
Maskelynite	15	8.6 - 13	17
Opaques		~ 1	1
Sulfide		0.1 – 0.2	
Phosphates		<<0.1	
Melt Pockets		4.8 – 6.7	~3

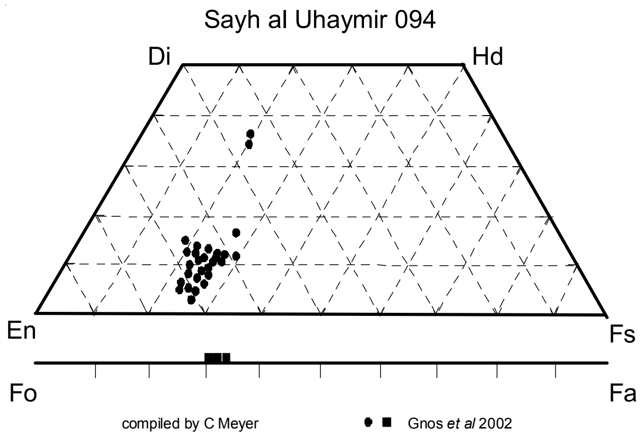

Figure XVI-2: Composition diagram for pyroxene and olivine from SaU 094 (data replotted from Gnos et al. 2002).

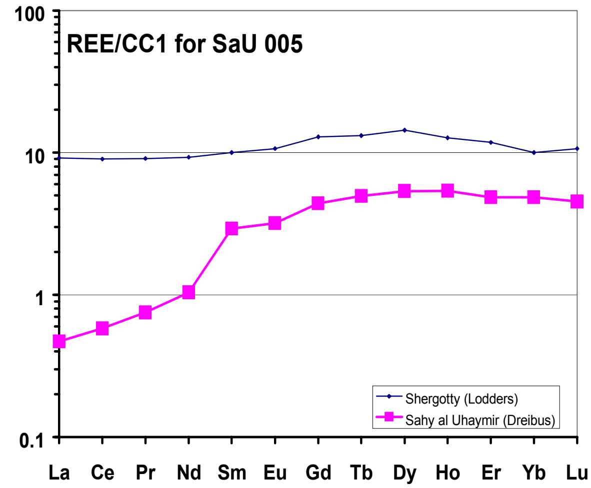

Figure XVI-3: Normalized rare earth element diagram for SaU 005 (Dreibus et al. 2000) compared with that of Shergotty (Lodders 1998).

Ca pyroxene and maskelynite (Zipfel 2000). Olivines showing mosaicism and planer features, severely fractured pyroxenes and maskelynitized feldpar indicate that this meteorite was highly shocked. Veins and pockets of "vesicular shock melt" were found to be abundant (~9 %!), with vesicles up to 3 mm in size.

Goodrich and Zipfel (2001a, b) have studied the melt inclusions in chromite and olivine. The glass in these inclusions is high Si = 70-74%.

Gnos *et al.* (2002) have studied the shock melt patches in SaU 094 and conclude that the shock pressure was locally as high as 80 GPa. Minute oblate vesicles are common in the glassy and recrystallized shock melts and have a preferred orientation.

Caliche from SaU 008 has been studied by Schwenzer *et al*. (2002).

Mineral Chemistry

Olivine: Large olivine phenocrysts (2 mm) are normal zoned from Fo_{71} to Fo_{65}. Olivines in groundmass are ~Fo_{65}.

Pyroxene: Pigeonite is $En_{70}Wo_6$ to $En_{61}Wo_{13}$ and augite is $En_{50}Wo_{32}$ (figure XVI-2). There is no orthopyroxene.

Feldspar: Maskelynite is An_{51-65} $Or_{0.3-0.9}$ and relatively homogeneous.

Oxides: Gnos *et al.* (2002) have reported detailed analyses of chromite, ulvöspinel and ilmenite.

Phosphate: Merrillite $Ca_9Na(Mg,Fe)(PO_4)_7$ contains considerable F and trace Cl.

Sulfides: Detailed analyses of sulfides are given in Gnos *et al.* (2002) who report a non-magnetic pyrrhotite $Fe_{10}S_{11}$ and some pentlandtite exsolution.

Glass: Boctor *et al.* (2001) have determined the chemical composition of the shock melt glass as MgO=23.8-34.6%, FeO=16.4-24.7%, CaO=2.1-10.6%, SiO_2=46.6-51.6%, Al_2O_3=1.3-1.8% and have reported the D/H ratio. Gnos *et al*. (2002) have also analyzed shock glass in this rock.

Figure XVI-4: Photograph of SaU 094 kindly provided by Edwin Gnos.

Table XVI-1: Composition of Sayh al Uhaymir.

reference	Dreibus 2000		Dreibus 2000		Gnos 2002	
weight	5.4 grams!				fusion crust	
SiO2 %	47.2	(a)			48.49	(e)
TiO2	0.42	(a)			0.41	(e)
Al2O3	4.53	(a)			4.97	(e)
FeO	18.34	(a)	17.8	(b)	16.34	(e)
MnO	0.46	(a)	0.45	(b)	0.43	(e)
CaO	5.74	(a)	5.18	(b)	5.62	(e)
MgO	20.49	(a)			20.54	(e)
Na2O			0.6	(b)	0.64	(e)
K2O			0.022	(b)		
P2O5	0.31	(a)				
sum						
Li ppm						
C %	0.11	(c)				
F			56	(b)		
S %	0.16	(c)			tr.	
Cl			143	(b)		
Sc			29.9	(b)		
V	136	(a)				
Cr					tr.	
Co			55	(b)		
Ni			310	(b)		
Cu						
Zn			61	(b)		
Ga			8.8	(b)		
Ge						
As			0.46	(b)		
Se						
Br			0.28	(b)		
Rb						
Sr						
Y						
Zr						
Nb						
I ppm			1.9	(b)		
Cs ppm						
Ba						
La	0.11	(d)	0.1	(b)		
Ce	0.35	(d)	<.6	(b)		
Pr	0.067	(d)				
Nd	0.47	(d)	<.65	(b)		
Sm	0.43	(d)	0.42	(b)		
Eu	0.18	(d)	0.2	(b)		
Gd	0.86	(d)				
Tb	0.18	(d)	0.19	(b)		
Dy	1.3	(d)	1.42	(b)		
Ho	0.3	(d)	0.3	(b)		
Er	0.77	(d)				
Tm						
Yb	0.79	(d)	0.81	(b)		
Lu	0.11	(d)	0.13	(b)		
Hf	0.43	(d)	0.39	(b)		
Ta						
Th ppm	0.012	(d)	<.1	(b)		
U ppm	0.05	(d)	0.05	(b)		

technique (a) XRF, (b) INAA, (c) CSA, (d) MIC-SSMS, (e) electron probe

Whole-rock Composition

Dreibus *et al.* (2000) report that the chemical composition of SaU 005 (Table XVI-1) is similar to that of DaG 476 (figure XVI-3). The Ga/Al ratio is 4.4 x 10^{-4}. Gnos *et al.* (2002) determined the composition of the fusion crust.

Cosmogenic Isotopes and Exposure Ages

Pätsch *et al.* (2000) report an exposure age of 1.5 ± 0.3 Ma from $^{22}Ne/^{21}Ne$ measurements (similar to that of DaG476). Pätsch *et al.* also report a high ^{26}Al (37.4 dpm/kg), but low compared to the calculated saturation value. Park *et al.* (2001) report a ^{21}Ne exposure age of 0.7 Ma. Park *et al.* (2003) report additional exposure ages and K-Ar ages for SaU. Bastien *et al.* (2003) determined ^{10}Be (13.5 ± 0.4 dpm/kg), ^{26}Al (48.5 ± 1.7 dpm/kg) and ^{53}Mn (78.6 ± dpm/kg).

Park *et al.* (2003) calculate an ejection age of 0.81Ma.

Other Isotopes

Hoffmann *et al.* (2001) and Gnos *et al.* (2002) reported $\Delta^{17}O$ = +0.28 per mil (which is thought to be low because of terrestrial contamination). Grossman and Zipfel (2001) reported $\delta^{17}O$ as +2.51 per mil and $\delta^{18}O$ = +4.29 per mil (as determined by Franchi). Bartoschewitz and Appel (2003) reported $\delta^{17}O$ as +2.78 per mil and $\delta^{18}O$ = +4.74 per mil for SaU150.

Mohapatra and Ott (2000) and Mohapatra *et al.* (2001) have found that the high temperature fraction of the ^{15}N, ^{129}Xe and Kr/Xe ratio in gas released from the "shock melt glass" are representative of the Martian atmosphere. Schwenzer *et al.* (2002) have studied the nitrogen and noble gases in caliche from SaU 008. Nishiizumi *et al.* (2001) report preliminary analyses of ^{10}Be, ^{26}Al, ^{36}Cl and ^{21}Ne and find similarity with Dar al Gani 476.

Terrestrial Weathering

Calcite veinlets are common at the surface of the SaU 094 and patches of Fe hydroxide occur as fillings of cracks and as small pockets of finely layered oxidation products of mixed phases. However, pyrrhotite usually shows no sign of oxidation (but see detailed discussion in Gnos *et al.* (2002).

Extra-terrestrial Weathering

Hoffmann *et al.* (2001) mentioned probable "shocked Fe-carbonate", but this has not been confirmed.

Figure XVI-5. *Approximate location of meteorite recovery fields (see Meteorite Bulletin).*

Processing

These samples are reportedly* found on a Miocene fresh-water limestone gravel plateau about 43 km south of Al Ghabar, Oman.

X-ray tomograms of SaU 094 were made before slicing the sample – see Gnos *et al.* (2002).

* Rainer and Sven Bartoschewitz (see Russell *et al.* 2003).