

SaU005 – 1.34 kilograms

SaU008 – 8.58 kilograms

SaU051 - 436 grams

SaU060 – 42.3 grams

SaU090 – 94.8 grams

SaU094 – 223 grams

SaU120 – 75 grams

SaU125 – 31.7 grams

SaU130 – 279 grams

SaU150 – 107.7 grams

Depleted Olivine-phryic Shergottite

Apparent strewn field (about 9 pieces)



Figure 2: Photograph of SaU 094 kindly provided by Edwin Gnos.



Figure 1. Photograph of Sayh al Uhaymir 094 as it was found in Oman. Note the luster caused by wind erosion.

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. Two additional fragments **SaU 060** (42 g) and **SaU 090** (95 g) were reported by Russell *et al.* (2002) *and they keep coming!*



Figure 3: Photo of small slab of SaU005 by Peter Marmet.

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 so it was apparently a large meteorite shower and more fragments will probably continue to be found as the sand shifts.

The SaU meteorites have been dated at 445 ± 18 m.y., with an exposure to cosmic rays of ~ 1 m.y. They come from a mantle source that is highly depleted in elements that are otherwise incompatible with silicate minerals (Cs, Rb, LREE etc).

Petrography

SaU 005 has a porphyritic texture of large olivine phenocrysts set in a fine-grained groundmass of low Ca pyroxene and maskelynite (Zipfel 2000). Olivines showing mosaicism and planer features, severely fractured pyroxenes and maskelynitized feldspar indicate that this meteorite was highly shocked. Veins and

Mineralogical Mode for SaU

	Zipfel (2000)	Gnos <i>et al.</i> (2002)	Bartoschewitz (2003)	Goodrich (2003)	Walton <i>et al.</i> (2005)
Pyroxene	48 vol. %	52 - 58	56	48 + 7	49.8 - 54.6 %
Olivine	25	22 - 31	23	21-29	17.2 - 23.1
Maskelynite	15	8.6 - 13	17	15	13.8 - 15.5
Opaques		~ 1	1		1.6 - 3.8
Sulfide		0.1 - 0.2			
Phosphates		$\ll 0.1$			
Melt Pockets		4.8 - 6.7	~ 3		10.2 - 11.3 %



Figure 4: Photo of another small slab of SaU005 by Don Edwards.

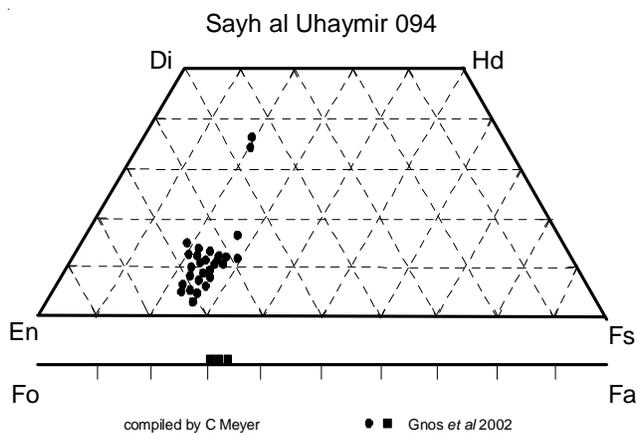


Figure 5a: Composition diagram for pyroxene and olivine from SaU 094 (data replotted from Gnos et al. 2002).

pockets of “vesicular shock melt” were found to be abundant (~9 %!), with vesicles up to 3 mm in size.

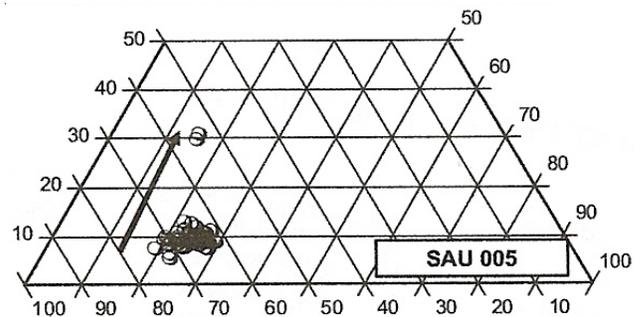


Figure 5b: Pyroxene composition reported by Papike et al. 2009.

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) and Walton et al. (2005) have studied the shock melt patches in SaU 094 and SaU150 concluding that the shock pressure was locally high.

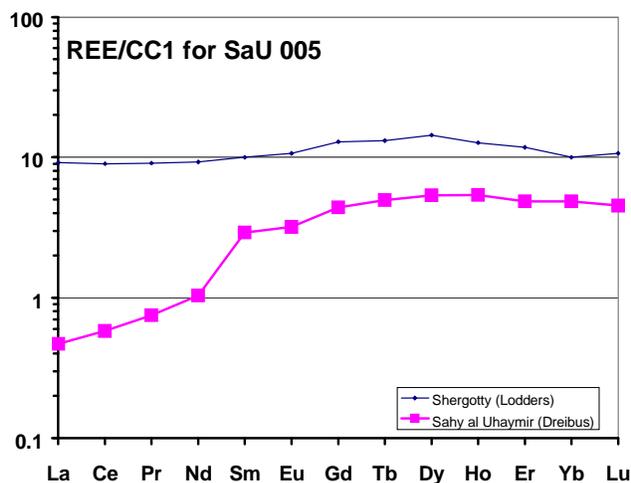


Figure 6: Normalized rare earth element diagram for SaU 005 (Dreibus *et al.* 2000) compared with that of Shergotty (Lodders 1998).

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 Fo₇₁ to Fo₆₅. Olivines in groundmass are ~Fo₆₅.

Proxene: Pigeonite is En₇₀Wo₆ to En₆₁Wo₁₃ and augite is En₅₀Wo₃₂ (figures 5 a,b). There is no orthopyroxene.

Feldspar: Maskelynite is An₅₁₋₆₅Or_{0.3-0.9} and relatively homogeneous.

Oxides: Gnos *et al.* (2002) have reported detailed analyses of chromite, ulvöspinel and ilmenite. Yu and Gee (2004) reported on spinel.

Phosphate: Merrillite Ca₉Na(Mg,Fe)(PO₄)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 Fe₁₀S₁₁ and some pentlandite 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%, SiO₂=46.6-51.6%, Al₂O₃=1.3-1.8% and have reported

the D/H ratio. Gnos *et al.* (2002) have also analyzed shock glass in this rock.

Whole-rock Composition

Dreibus *et al.* (2000) report that the chemical composition of SaU 005 (Table 1) is similar to that of DaG 476. The Ga/Al ratio is 4.4 x 10⁻⁴. Gnos *et al.* (2002) determined the composition of the fusion crust. Walton *et al.* (2005) calculated the composition from mineral analysis and mineral mode. The SaU shergottites are found to be depleted in large ion lithophile elements (figure 6).

Radiometric age dating

Shih *et al.* (2007) presented an abstract with isochron diagrams for Rb-Sr and Sm-Nd systematic. While no meaningful age could be obtained by Rb-Sr, they were able to obtain a crystallization age of 445 ± 18 m.y. by the Sm-Nd method (figure 7). The initial isotopic ratio of Nd indicates that the SaU magma was derived from a source that was “depleted” in Sm compared to Nd.

Cosmogenic Isotopes and Exposure Ages

Pätsch *et al.* (2000) report an exposure age of 1.5 ± 0.3 Ma from ²²Ne/²¹Ne measurements (similar to that of DaG 476). Pätsch *et al.* also report a high ²⁶Al (37.4 dpm/kg), but low compared to the calculated saturation value. Park *et al.* (2001) report a ²¹Ne exposure age of 0.7 Ma.

Shock Metamorphism

Walton *et al.* (2005) studied the shock features and “melt pockets” found in SaU150.

Figure 7: Shih *et al.* (2007) have shown us how to, and how not to, date the SaU shergottites!

Table 1: Composition of Sayh al Uhaymir.

reference weight	Dreibus 2000	Dreibus 2000	Gnos 2002 fusion crust	
SiO ₂ %	47.2	(a)	48.49	(e)
TiO ₂	0.42	(a)	0.41	(e)
Al ₂ O ₃	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)
Na ₂ O			0.6 (b)	0.64 (e)
K ₂ O		0.022	(b)	
P ₂ O ₅	0.31	(a)		
Li ppm				
C %	0.11	(c)		
F		56	(b)	
S %	0.16	(c)		tr.
Cl		143	(b)	
Sc		29.9	(b)	
V	136	(a)		
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		Brandon12		
Ru ppb		1.7		
Nb				
Mo				
Pd ppb		3.95		
Ag ppb				
Cd ppb				
Sb ppb				
Te ppb				
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				
W ppb		Brandon12		
Re ppb		0.5		
Os ppb		0.7		
Ir ppb		0.7		
Pt ppb		4.6		
Au ppb				
Tl ppb				
Bi ppb				
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

Other Isotopes

Hoffman *et al.* (2001) and Gnos *et al.* (2002) reported $\Delta^{17}\text{O} = +0.28$ 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 $^{18}\text{O} = +4.29$ per mil (as determined by Franchi).

Mohapatra and Ott (2000) and Mohapatra *et al.* (2001) have found that 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. Schwenger *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

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

Processing

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

References for SaU Shergottite



Figure 8: Photo of largest sample (SaU 008) (from internet), about 17 cm across.



Figure 9. Approximate location of meteorite recovery fields in Oman (see Meteorite Bulletin).

Figures 10 a,b,c: Photo of slabs cut from one of the SaU samples (which) - as found in internet (with apologies).



