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-phyric Shergottite

Apparent strew 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 stores 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 feldpar indicate that this meteorite was highly shocked. Veins and

Mineralogical Mode for SaU

	Zipfel (2000)	**Gnos *et al.*** (2002)	**Bartoschewitz** (2003)	**Goodrich** (2003)	**Walton et al.** (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		<<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.*

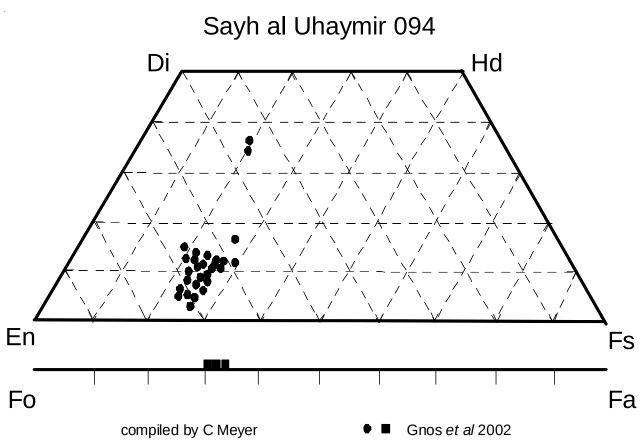

***Figure 5a**: Composition diagram for pyroxene and olivine from SaU 094 (data replotted from Gnos et al. 2002).*

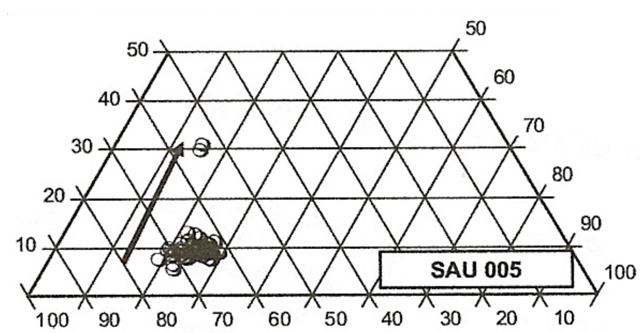

***Figure 5b:** Pyroxene composition reported by Papike et al. 2009.*

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

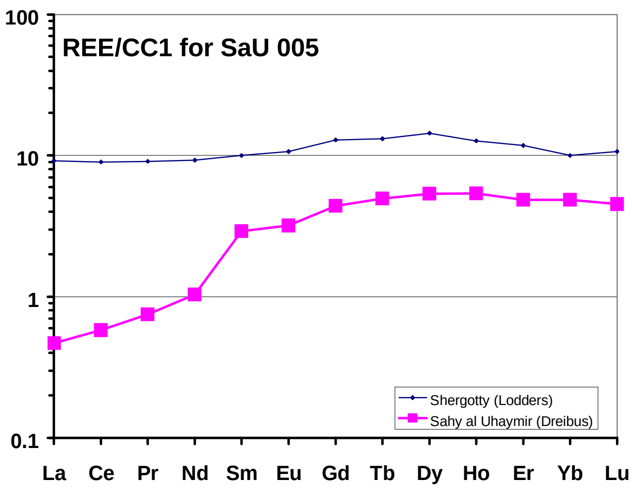

Figure 6: Normalized rare earth element diagram for SaU 005 (Dreibus et al. 2000) compared with that of Shergotty (Lodders 1998).

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 Fo_{71} to Fo_{65}. Olivines in groundmass are $\sim Fo_{65}$.

Pyroxene: Pigeonite is $En_{70}Wo_6$ to $En_{61}Wo_{13}$ and augite is $En_{50}Wo_{32}$ (figures 5 a,b). 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. Yu and Gee (2004) reported on spinel.

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.

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 form 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 ioschron 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 ration 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 $^{22}Ne/^{21}Ne$ measurements (similar to that of DaG 476). 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.

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	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)				
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 $\Delta^{17}O$ = +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).

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. 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

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 appologies).*