XX. NWA 856

Basalt
320 grams

Figure XX-1*: Photograph of NWA 856 (Djel Ibone) kindly provided by Bruno Fectay and Carine Bidaut illustrating thin fusion crust and interior basaltic texture (scale is 1 cm).*

Introduction

Jambon *et al*. (2001, 2002) describe the discovery in March 2001 of another shergottite from Morocco. This sample was originally referred to as "Djel Ibone" and is officially known as NWA 856 (Russell *et al*. 2002). The original piece (~ 5 cm) had a thin black fusion fusion crust that was well preserved – see figure 1 in Jambon *et al*. (2002).

Petrography

This meteorite is a fine-grained basalt (figure XX-1) with gray acicular pyroxene phenocrysts up to 12 mm long (Jambon *et al.* 2002). Augite and pigeonite form as separate crystals. Plagioclase (maskelynite) laths are interstitial as is trace merrillite, apatite, pyrrhotite, chromite, Fe-Ti oxides, silica and baddeleyite.

Shock melt pockets are more abundant than in Shergotty or Zagami and this meteorite is highly fractured at all scales. However, a study of the pyroxenes in this rock indicated that it might not be highly shocked (Leroux et al. 2004).

Terrestrial calcite veins cross-cut this meteorite, but terrestrial weathering appears to be at a minimum because Cs, Ba, Sr and U are not elevated (Jambon *et al.* 2002).

Photos can also be seen at http://www.jpl.nasa.gov/snc/nwa856.html

Mineral Chemistry

Pyroxenes: As in the Shergotty meteorite, augite and pigeonite are present in NWA 856 as separate phases, with no pyroxenes of intermediate composition (figure

Mineralogical Mode	
	Jambon *et al.* 2002
Pyroxene	68 vol. %
Plagioclase	23
Phosphates	1
Oxides	2
Silica	1
Melt Pockets	2

XX-2). Pyroxenes are zoned; pigeonite ranges from $En_{59}Fs_{29}Wo_{12}$ to $En_{26}Fs_{59}Wo_{15}$ and augite from $En_{36}Fs_{32}Wo_{32}$ to $En_{48}Fs_{39}Wo_{13}$. The microstructure of pyroxenes in this rock were studied by Leroux et al. (2004).

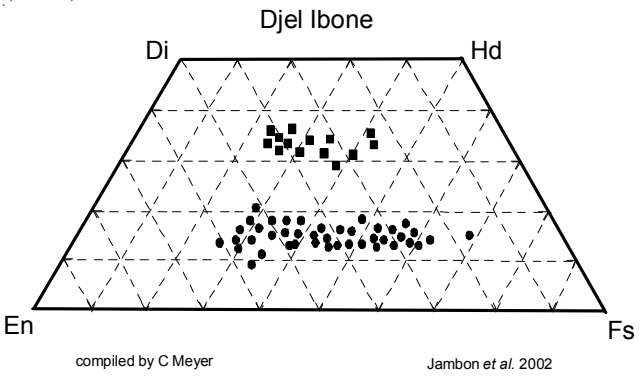

Figure XX-2*: Pyroxene composition diagram for NWA 856 (data replotted from Jambon et al. 2002).*

Maskelynite: Plagioclase has been shocked to maskelynite $Ab_{48}Or_2An_{50}$.

Phosphates: Both merrillite and Cl-apatite are present.

Stishovite: Relative abundant and large euhedral crystals or thin square needles of stishovite have been observed by Raman spectroscopy (Jambon *et al.* 2002) in melt pockets of NWA 856.

Baddelyite: Two minute baddelyite crystals are reported.

Amphibole: Minute amphibole is reported by Jambon *et al.* (2002) located in melt inclusions in pyroxene cores.

Whole-rock Composition

Table XX-1 gives the composition of NWA 856 as reported by Jambon *et al.* (2001, 2002). The REE pattern of NWA 856 is similar to those of Shergotty and Zagami (figure XX-3). The Ga/Al ratio (4.1×10^{-4}) indicates that this rock is Martian. Weathering does not appear to have left a significant chemical signature in this desert meteorite (Jambon *et al*. 2002).

Radiogenic Isotopes

Bandon et al. (2004) obtained a Sm-Nd internal mineral isochron of 186 ± 24 m.y. (figure XX-4). They also obtained a Rb-Sr age of 150 ± 32 m.y., although they found evidence of terrestrial weathering. The ages and corresponding initial isotopic ratios were consistent with those obtained for the other shergottites.

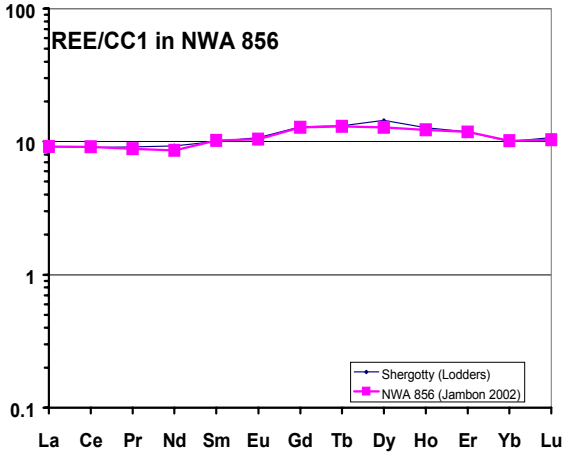

Figure XX-3*: Normalized rare earth element diagram for NWA 856 compared with that of Shergotty (data from Jambon et al. 2002 and Lodders 1998).*

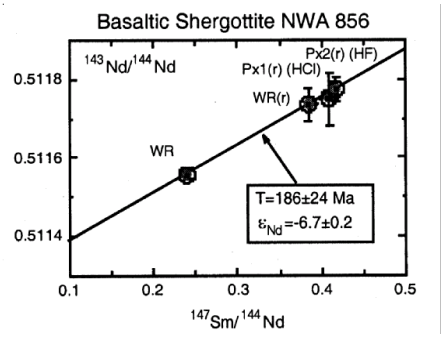

Figure XX-4: *Sm-Nd internal mineral isochron for NWA856 (from Brandon et al. 2004).*

Other Isotopes

Jambon *et al.* (2002) reported oxygen isotopes with $\Delta^{17}O = \sim 0.47$ ‰ .

Processing

Figure XX-5 shows details of the sawing of NWA 856 (several slabs).

Table XX-1: Chemical composition of NWA 856.

reference	Jambon 2001	Jambon 2002		Jambon 2002	
weight		500 mg.			
SiO2					
TiO2	0.81	0.81	(a)		
Al2O3	6.83	6.83	(a)		
FeO	17.8	17.81	(a)	19.97	(c)
MnO	0.49	0.49	(a)	0.54	(c)
CaO	10.2	10.24	(a)		
MgO	9.51	9.51	(a)		
Na2O	1.28	1.28	(a)		
K2O	0.13	0.13	(a)		
P2O5					
sum					
Li ppm		4.06	(b)		
Be		0.355	(b)		
F					
S					
Cl					
Sc		55.7	(b)	54.1	(c)
V		295	(b)		
Cr		3361	(b)	3942	(c)
Co		36.3	(b)	43	(c)
Ni	77	77	(b)	85	(c)
Cu		14	(b)		
Zn		59.1	(b)	66	(c)
Ga		14.66	(b)		
Ge					
As				0.18	(c)
Se					
Br				2.64	(c)
Rb		6.24	(b)	8.2	(c)
Sr		48.7	(b)	56	(c)
Y		18.81	(b)		
Zr		62.8	(b)	69	(c)
Nb		3.37	(b)		
Pd ppb					
Ag ppb				< 50	(c)
Sb ppb				14	(c)
Cs ppm		0.43	(b)	0.41	(c)
Ba		41.3	(b)	46	(c)
La	2.16	2.16	(b)	2.34	(c)
Ce		5.49	(b)	6.1	(c)
Pr		0.786	(b)		
Nd		3.88	(b)	3.9	(c)
Sm	3.88	1.5	(b)	1.68	(c)
Eu	1.5	0.582	(b)	0.62	(c)
Gd	0.58	2.51	(b)		
Tb		0.474	(b)	0.48	(c)
Dy		3.12	(b)		
Ho		0.677	(b)		
Er		1.87	(b)		
Tm					
Yb	1.64	1.64	(b)	1.76	(c)
Lu		0.251	(b)		
Hf		1.55	(b)	2.01	(c)
Ta		0.16	(b)	0.23	(c)
W ppb		430	(b)	520	(c)
Au ppb				4	(c)
Th ppm	0.4	0.398	(b)	0.442	(c)
U ppm		0.096	(b)	0.092	(c)

technique: a) ICP/AES, b) ICP/MS, c) INAA

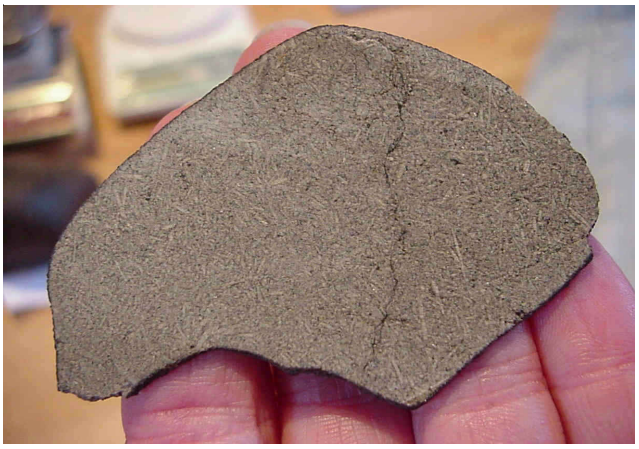

***Figure XX-5**: Close up of slab of Djel Ibone illustrating basaltic texture (whose nice clean fingers?).*