Reference List

NWA4468 – 675 grams
Enriched Olivine-phyric Shergottite

Figure 1: *Photo of NWA4468, before it was cut (from Hupe). It doesn't get any better than this!*

Introduction

Greg and Adam Hupe (2006) describe the acquisition of a large, round basaltic shergottite with a nearly complete fusion crust (figure 1) in Layounne, Morocco (see Meteortical Bulletin). It is 179 m.y. old, but a CRE age has not been reported.

Petrography

NWA4468 is described by Irving *et al.* (2007) and was made official by Connolly H.C. *et al.* (2007). It is coarse-grained with large pyroxene oikocrysts (0.2 x 1 cm), surrounding olivine and chromite grains, set in an interstitial matrix of olivine, pyroxene, plagioclase, opaque minerals and phosphates (figures 2, 3, 4).

Large melt inclusions, found in olivine, contain K-rich minerals.

NWA4468 has been highly shocked, and high pressure phases identified include: stishovite, Ca-Hollandite, Ringwoodite, tuite etc. (Spray and Boonsue 2011). Some of these phase are from the shock-melt pockets (figure 5).

Mineralogy

Olivine: Olivine centers (Fo_{71}) zone to more Fe-rich.

Pyroxene: Pigeonite oikocrysts are large, up to 1 cm in size (Irving et al.). Orthopyoxene cores ($Wo_{4.4}En_{71}$) zone to sub-calcic augite ($W_{33}En_{48}$).

Mineralogical Mode for NWA4468

	Irving et al. 2007
Olivine	35 %
Pyroxene	30
Plagioclase	25
Chromite	
Ilmenite	
Merrillite	
cl-apatite	
pyrrhotite	

Figure 2: *Photos of slice of NWA4468 (found using Google).*

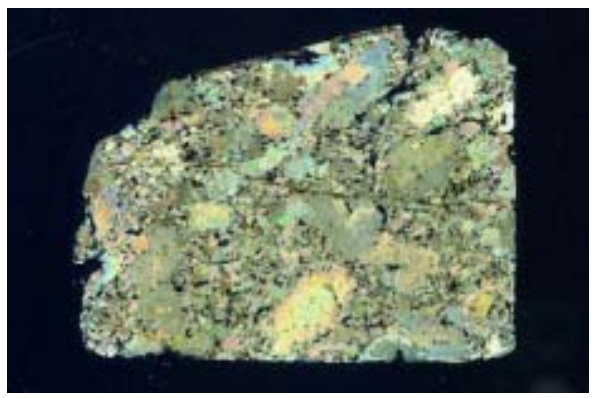

Figure 3: *Large area thin section of NWA4468 showing large oikocrysts of pigeonite (scale is 3.8 x 2.8 cm). (from Irving et al. 2007).*

Plagioclase: Plagioclase is shocked to maskelynite (An_{39-54}).

Phosphate: Boonsue and Spray (2011) reported three kinds of phosphate based on Raman spectra: apatite, merrillite and "tuite".

Chemistry

Irving *et al.* (2007) give the composition (table and figure 6). Brandon *et al.* (2012) determined the all-important PGE and Re (figure 7).

Figure 4: *Another slab of NWA4468 (a la Hupe).*

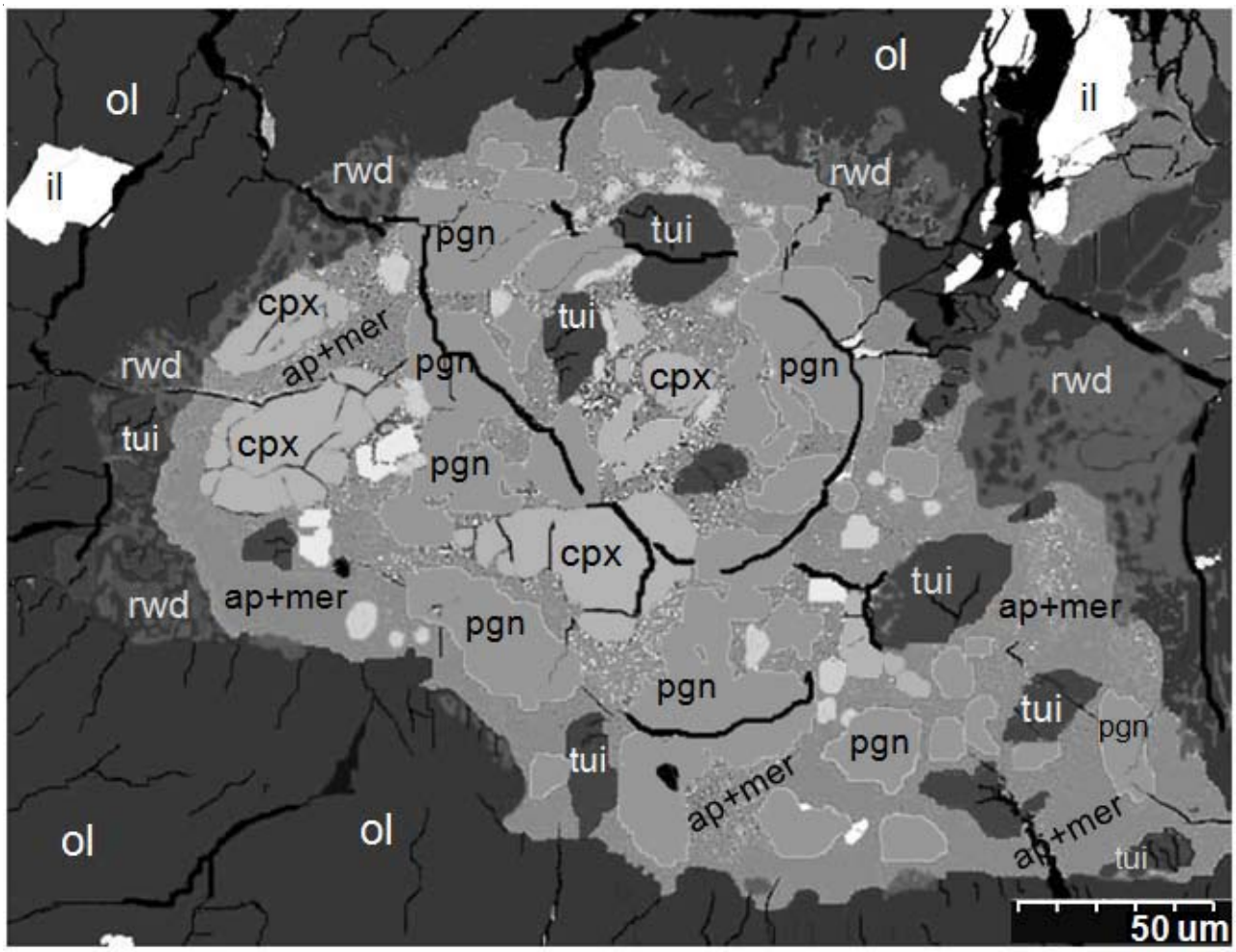

Figure 5: *SEM photo of melt pocket in NWA4468 (Boonsue and Spray 2011). rwd = ringwoodite and tui = tuite*

Radiogenic age dating

Borg *et al*. (2008) reported a preliminary Sm/Nd isochron age of 150 ± 29 m.y. (figure 8). Lapan et al. (2009) obtained 179 ± 27 m.y. by the Lu-Hf method (figure 9). Marks *et al.* (2010) obtained 187 ± 6 m.y. by Rb-Sr. But all these isochrons are based on only two points. In any case, the isotope data prove that this sample is from an "enriched" mantle source.

Cosmogenic isotopes and exposure ages

Not yet

Other Studies

Rumble and Irving (2009) determined the isotopic composition of oxygen (Delta ^{17}O = 0.29 ‰).

Processing

This very nice specimen (figure 1) has apparently been sliced-up like boloney (figure 2). The very nice large-area thin section (figure 3) was prepared by Michael DePanger.

References for NWA4469

Table 1. Chemical composition of NWA4468.

reference	Irving2007
weight	
SiO2 %	
TiO2	
Al2O3	
FeO	23
MnO	
MgO	
CaO	
Na2O	1.09
K2O	
P2O5	
S %	
sum	
Sc ppm	25.6
V	
Cr	5780
Co	72.4
Ni	325
Cu	
Zn	75
Ga	
Ge ppb	
As	
Se	
Rb	
Sr	
Y	
Zr	
Nb	
Mo	
Ru	
Rh	
Pd ppb	
Ag ppb	
Cd ppb	
In ppb	
Sn ppb	
Sb ppb	
Te ppb	
Cs ppm	0.27
Ba	
La	1.92
Ce	5.1
Pr	
Nd	
Sm	1.06
Eu	0.42
Gd	
Tb	0.32
Dy	
Ho	
Er	
Tm	
Yb	1.13
Lu	0.17
Hf	1.5
Ta	
W ppb	
Re ppb	
Os ppb	
Ir ppb	
Pt ppb	
Au ppb	
Th ppm	0.32
U ppm	
technique:	*(a) INAA*

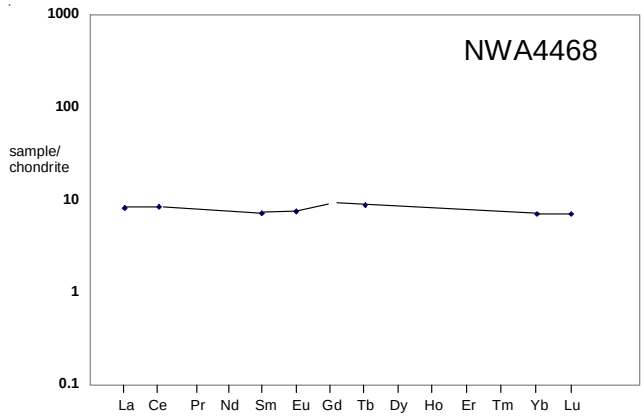

Figure 6: *Normalized rare-earth-element diagram for NWA4468.*

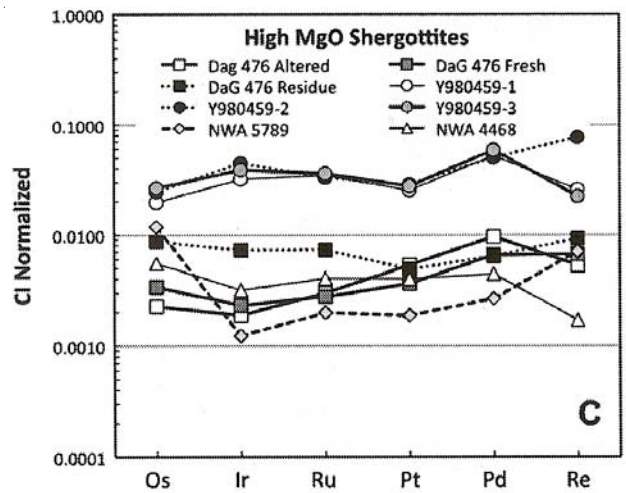

Figure 7: *PGE for some shergottites (Brandon et al. 2012).*

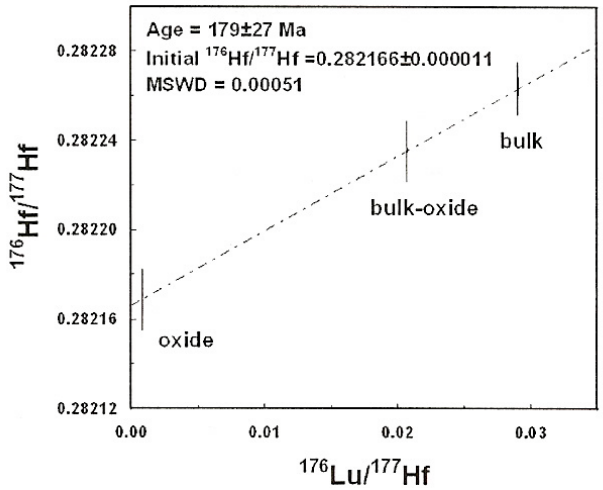

Figure 8: *Lu-Hf intermal isochron by Lapan et al. 2009.*

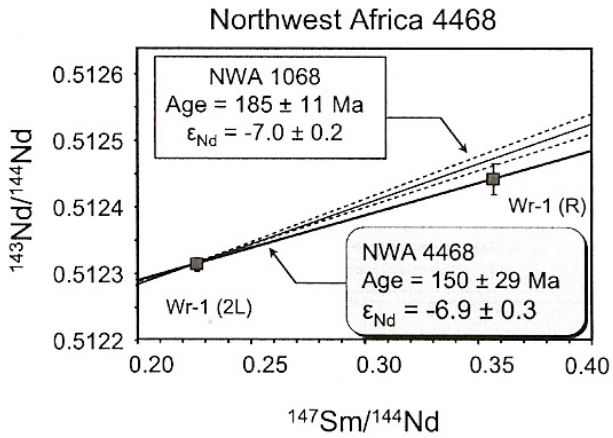

Figure 9: *Sm-Nd isochon for NWA 4468 (Borg et al. 2008).*