Northeast Africa 003

Unbrecciated basalt (with basaltic breccia)

124 g

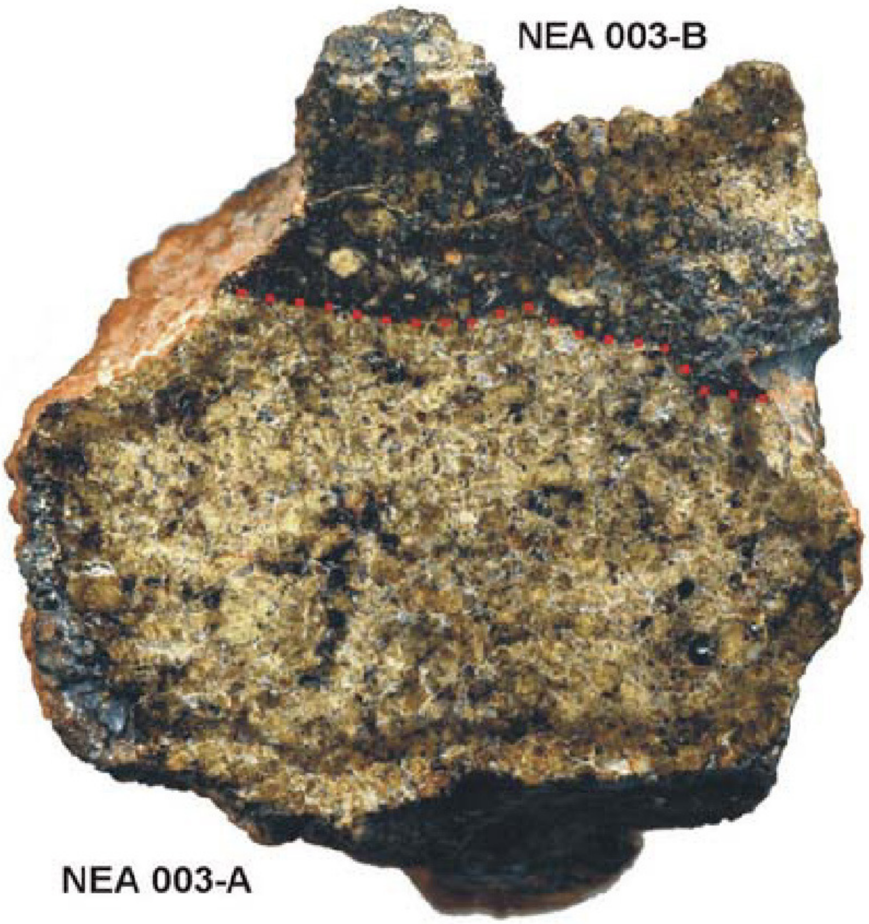


Figure 1: Northeast Africa 003 illustrating lithology A (basalt) and B (breccia). Image from Haloda et al. (2006a). Width of sample is10 cm.

Introduction

Northeast Africa (NEA) 003 was found in Northern Libya in an area about 200 km south of the coast and Tripoli (Figs. 1 and 2). It was recovered in two pieces in November 2000 (6 g) and December 2001 (118 g). This rock has two lithologies – 75% unbrecciated mare basalt (A) and 25% basaltic breccia (B). It is of low weathering grade and has some calcite and gypsum veinlets cross cutting the sample (Haloda et al., 2006a; 2009).

Petrography and mineralogy

The unbrecciated basalt is porphyritic (Fig. 3) and olivine-rich (17.5 % and zoned from Fo_{73} to Fo_{19}; Fig. 4). The pyroxene is zoned from $En_{5-71}Wo_{6-38}$ (Fig. 4) containing inclusions of olivine, chromite and ulvospinel. Plagiocase is An_{84} to An_{92} and is converted to maskelynite (Haloda et al., 2006a, 2009). The late stage mesostasis is comprised of silica, FeO-rich pyroxene, pyroxferrite, and minor plagioclase, ilmenite, troilite and apatite. Shock veins and impact melt pockets are common.

Lithology B, brecciated basalt, contains two large clasts of basalt that are porphyritic olivine, plagioclase and pyroxene and maskelynitized plagioclase (Haloda et al., 2006b). The clasts are very similar to each other in modal mineralogy: 10.6-12.2 % olivine, 56.7-59.5% pyroxene, 28.1-24.3% plagioclase, 1.5-1.4% ilmenite, 0.5% spinel, and 2.6-2.1% mesostasis/impact melt glass (Haloda et al., 2006b).

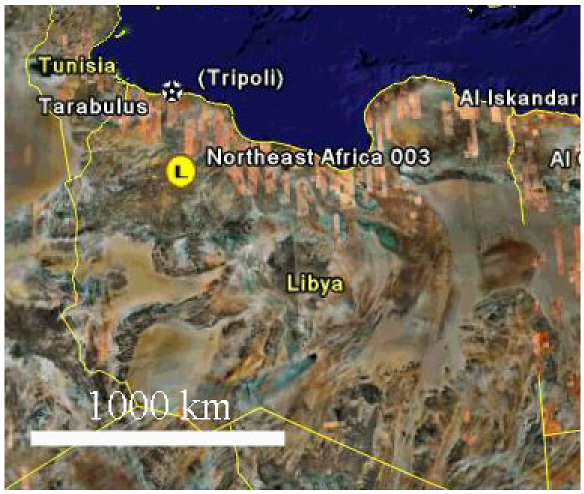


Figure 2: Region of Northeast Africa in which the sample was found.

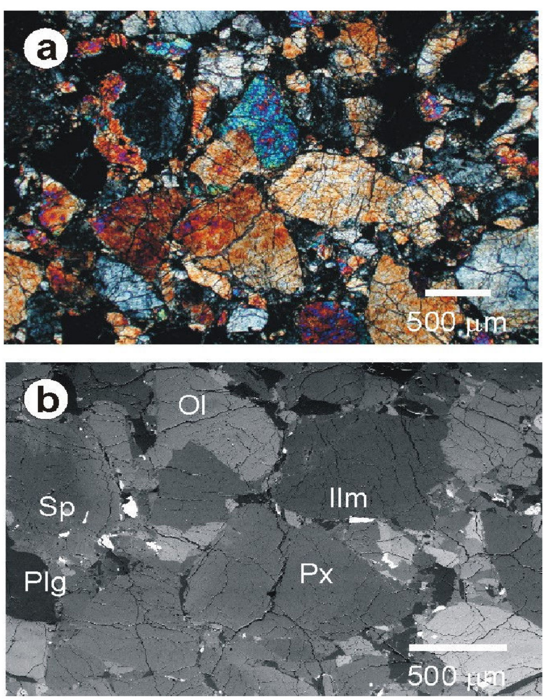


Figure 3: Crossed nicol (top) and back scattered electron (bottom) images of NEA 003 illustrating the coarse-grained texture of this basalt (lithology A; from Haloda et al., 2006a).

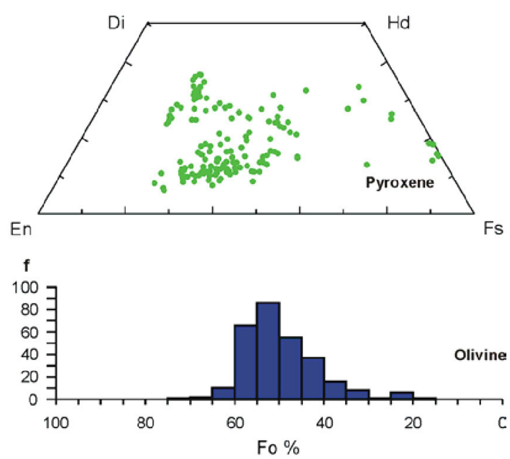


Figure 4: Olivine and pyroxene compositions from lithology A (basalt) of NEA 003 (from Haloda et al., 2006a).

Chemistry

NEA 003 is a high MgO and low TiO_2 basalt similar to some Apollo 12 and 15 basalts (Table 1 and Figure 5 and 6; Haloda et al., 2006a, 2009). It has the lowest and flattest REE pattern of all the lunar basaltic meteorites (Fig. 7). The two clasts from the breccia are both more evolved (lower MgO and higher TiO_2) and different in bulk composition from Lithology A (Table 1; Haloda et al., 2006b).

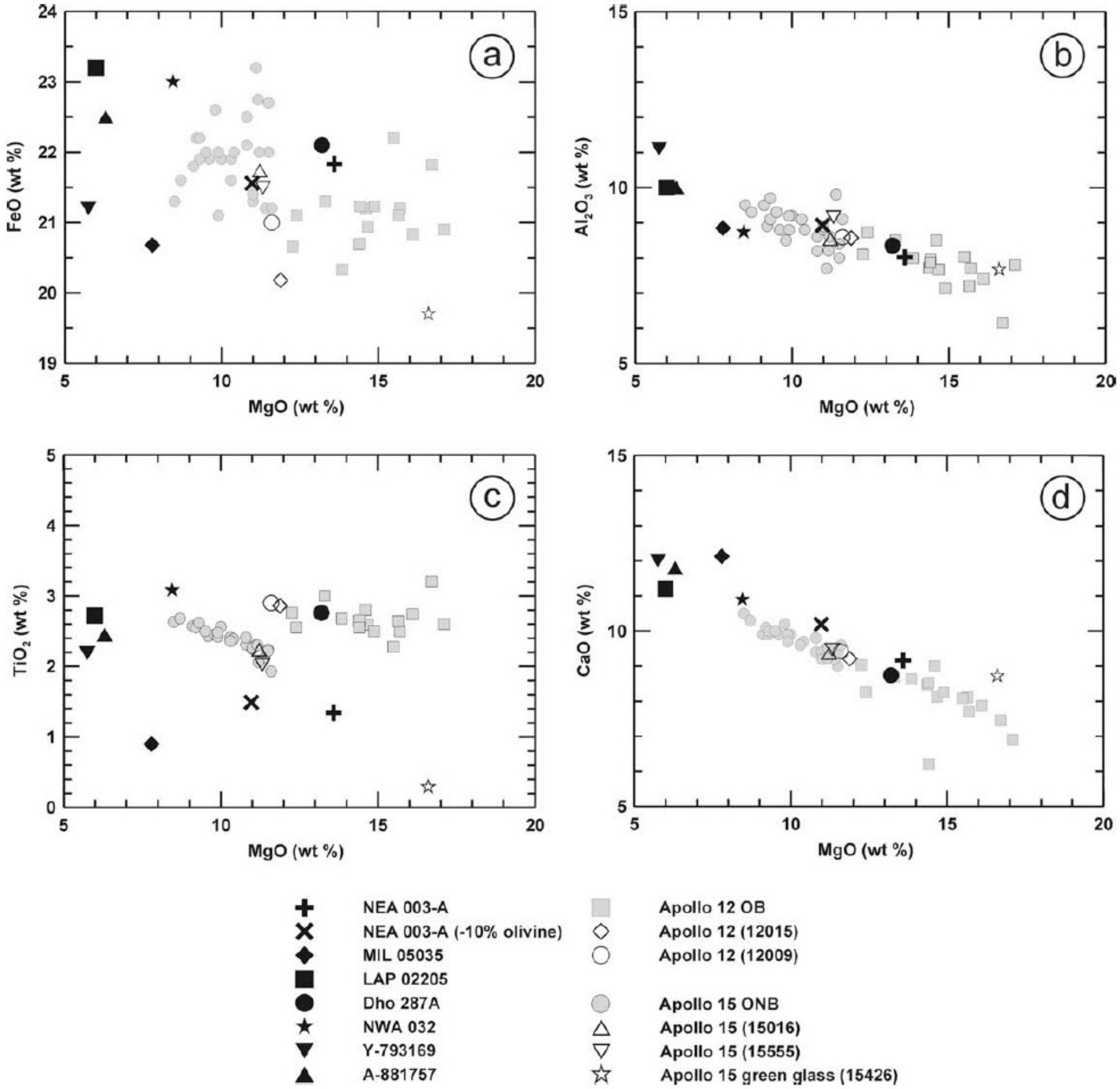


Figure 5: Bulk major element composition of NEA 003 (heavy cross) from Haloda et al. (2009) compared to other basaltic lunar meteorites and Apollo basalts.

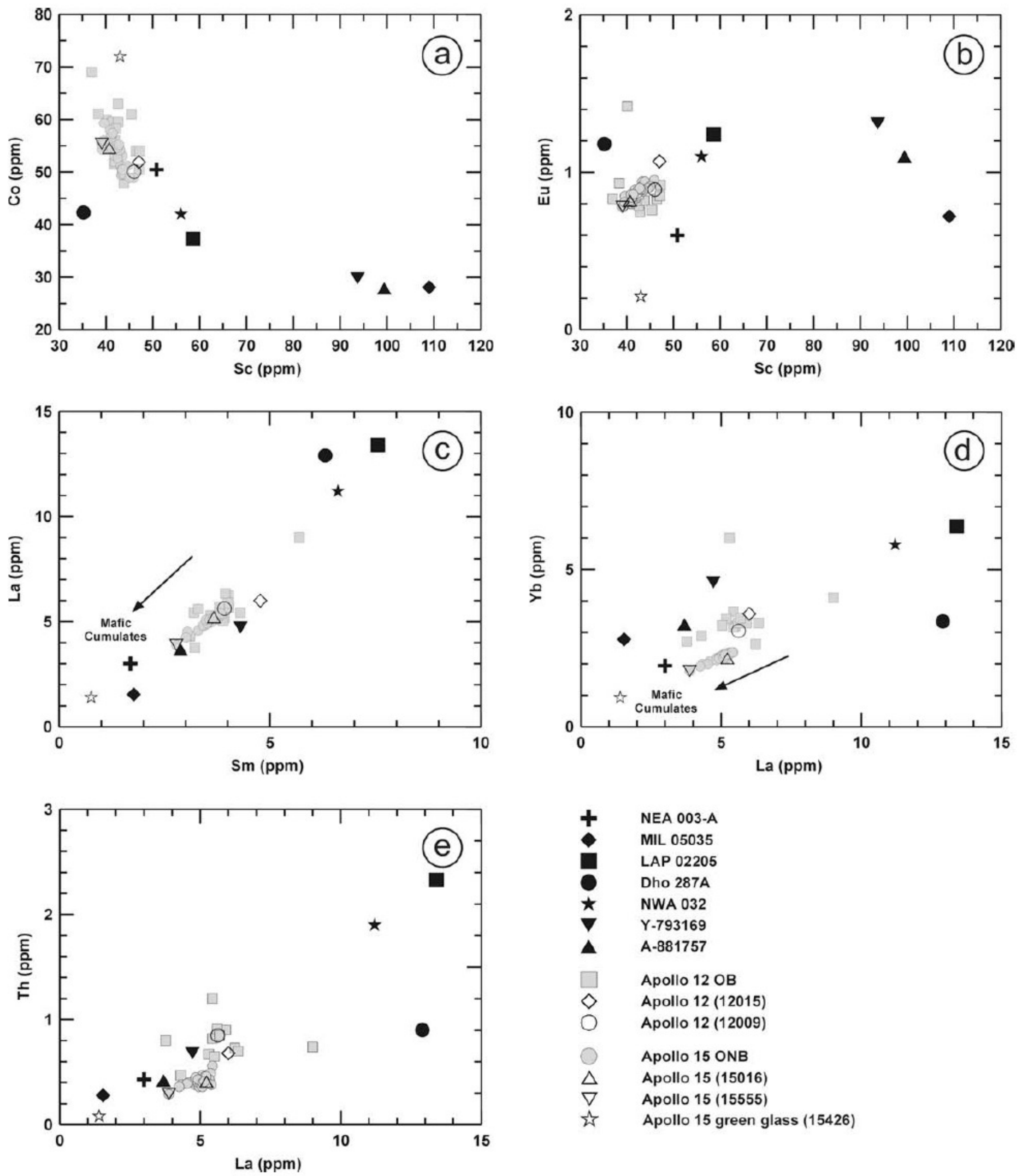


Figure 6: Bulk trace element composition of NEA 003 (heavy cross) from Haloda et al. (2009) compared to other basaltic lunar meteorites and Apollo basalts

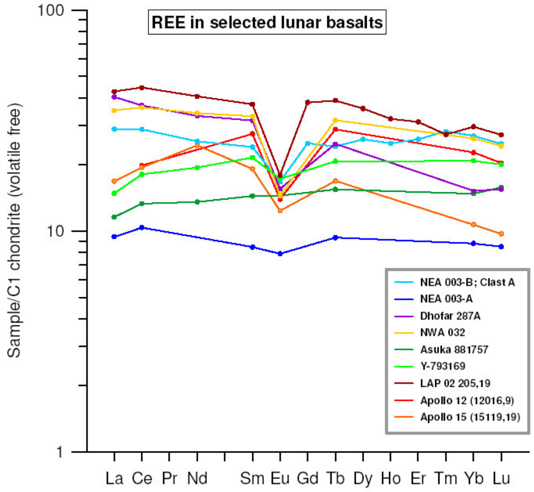
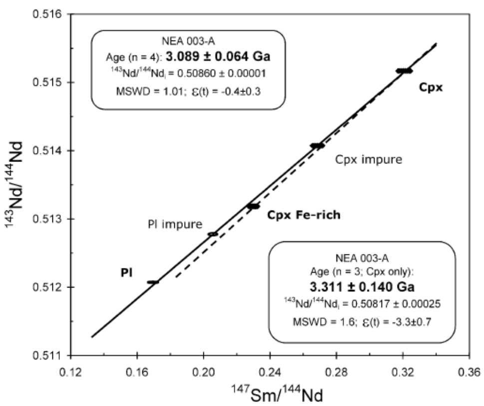


Figure 7: Rare earth element pattern for NEA 003 (blue lines) compared to other basaltic meteorites and Apollo 12 and 15 samples (from Haloda et al., 2006b).

Radiogenic age dating

Sm-Nd isochron for NEA 003 was reported by Haloda et al. (2009) and yielded and age of 3.089 with clinopyroxene and plagioclase and 3.311 for clinopyroxene only (Fig. 8). This must represent a crystallization age compared to the much younger Ar-Ar ages on bulk, plagioclase and pyroxene also reported by Haloda et al. (2009) of 1.5 to 2.5 Ga (Fig, 9)



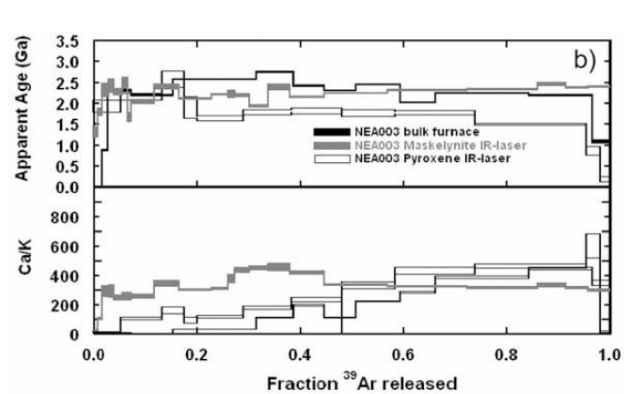


Figure 8 (left) Sm-Nd isochron for NEA 003 from Haloda et al. (2009)
Figure 9 (right): Ar-Ar plateau ages for bulk, plagioclase, and pyroxene from NEA 0003 (Haloda et al., 2009).

Cosmogenic isotopes and exposure ages

None yet reported.

Table 1. Chemical composition of Northeast Africa 003

Reference	1,3	2	2	2
Weight				
Method	d	e	e	e
	Lith. A	clast A	clast B	impact melt
SiO_2 %	44.72	44.6	45	43.6
TiO_2	1.34	1.9	1.8	2.1
Al_2O_3	8.02	9.7	10.1	8.6

FeO	21.83	21	20.9	22.8
MnO	0.27	0.3	0.3	0.3
MgO	13.59	10.9	9.9	12.9
CaO	9.16	10.5	10.7	8.5
Na_2O	0.31	0.4	0.2	0.2
K_2O	0.1	0.2	0.1	0.1
P_2O_5				
S %				
sum				
Sc ppm	50.8			
V				
Cr	7600			
Co	50.5			
Ni	84			
Cu				
Zn				
Ga				
Ge				
As				
Se				
Rb				
Sr	117			
Y				
Zr				
Nb				
Mo				
Ru				
Rh				
Pd ppb				
Ag ppb				
Cd ppb				
In ppb				
Sn ppb				
Sb ppb				
Te ppb				
Cs ppm				
Ba	252			
La	3	9.2		
Ce	8.5	23.6		
Pr				
Nd	4.5	15.6		
Sm	1.69	4.8		
Eu	0.6	1.2		
Gd		6.6		
Tb	0.46	1.2		
Dy		8.6		
Ho		1.9		
Er		5.6		

Tm		0.9
Yb	1.94	6
Lu	0.28	0.8
Hf	1.1	
Ta	0.15	
W ppb		
Re ppb		
Os ppb		
Ir ppb		
Pt ppb		
Au ppb		
Th ppm	0.43	
U ppm	0.29	

technique (a) ICP-AES, (b) ICP-MS, (c) IDMS, (d) INAA, (e) EMPA

References: 1) Haloda et al. (2006a); 2) Haloda et al. (2006b); 3) Haloda et al. (2009)