

**14053**  
Basalt  
251.32 grams

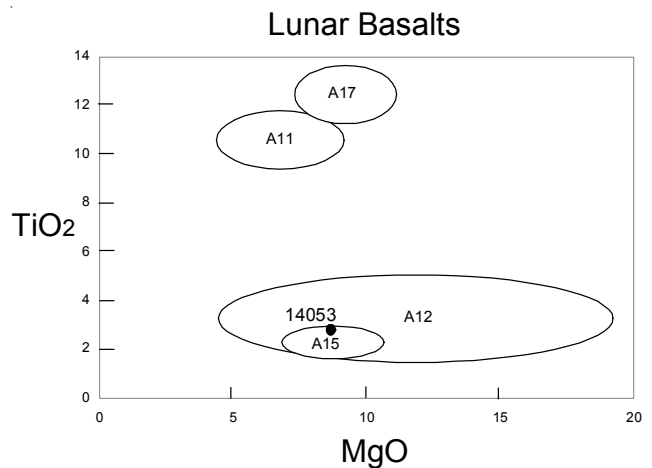


*Figure 1: PET photo of top surface of 14053 showing micrometeorite craters. Cube is 1 inch high. NASA photo # S71-35849.*

**Introduction**

14053 is an Al-rich mare basalt found perched on the side of a boulder at station C2 (see figure 55 in Swann et al. 1977). It is flat with one side (freshly broken) with the other side rounded and pitted by microcraters (figure 1). Breccia material was found attached to flat side, indicating that this basalt was a clast in the boulder (breccia)(Morrison 1972).

This basalt from Apollo 14 was found to have low siderophile content leading to the interpretation that it was yet another important type of mare basalt (also found as clasts in the Apollo 14 soil and breccia samples). The age determined for 14053 indicates that it is older than the Fra Mauro Formation (see discussion in Ridley 1975)..



*Figure 2; Composition of 14053 compared with other Apollo samples.*



Figure 3: Freshly sawn interior surface of 14053 showing basaltic texture. Cube is 1 cm. Photo # S75-33971.

A review of non-mare basalts is found in Irving (1975). Sample 14072 is another basalt, apparently similar to 14053.

### Petrography

LSPET (1971) and Gancarz et al. (1971) describe 14053 as an ophitic basalt with large, zoned, pyroxene grains surrounding laths of plagioclase (figure 3). Papike et al. (1976) describe 14053 as a medium-grained microgabbro with strongly zoned pyroxene grains up to 5 mm in length enclosing smaller subhedral laths of plagioclase (figure 4). Kushiro et al. (1972) reported small amount of olivine, both as subrounded phenocrysts and as fayalite located in the mesostasis (figure 4). The mesostasis includes chrome spinel, ilmenite, christobalite, troilite, phosphate, K-feldspar and K-Ba-rich residual glass.

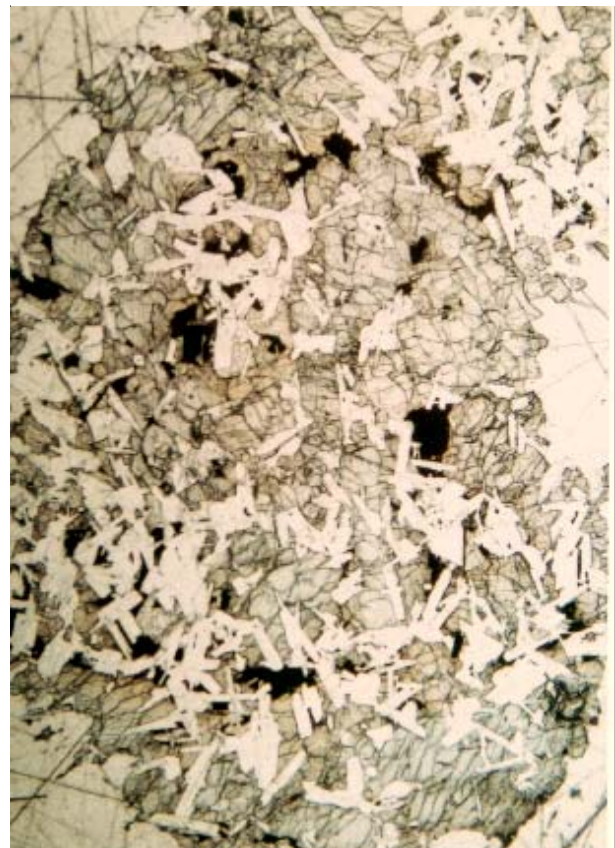


Figure 4: Thin section photomicrograph of 14053 showing ophitic texture. Photo # S71-23485. (Scale unknown, but probably ~3 mm top to bottom)

El Goresy et al. (1972), Haggerty (1972) and Taylor et al. (2004) found that 14053 was extremely reduced, with metallic iron in the mesostasis due to “subsolidus reduction.” Patchen and Taylor (2004) reported that the reduction is more pronounced in areas near the exterior of 14053, with both fayalite and ulvöspinel less reduced in the interior.

### Mineralogy

**Olivine:** Fayalite is found intermixed with other accessory phases (SiO<sub>2</sub> etc) in the mesostasis. Mayne

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#### Mineralogical Mode for 14053

	Gancarz et al. 1971	Patchen and Taylor 2004 Interior	Patchen and Taylor 2004 exterior
Plagioclase	50 % vol.	42	39
Pyroxene	40	48	48
Olivine		1.6	3.9
Ilmenite	3	2.3	4.3
Silica	2	2.4	2.6
Fayalite		0.9	0.3
Fe metal		0.09	0.3

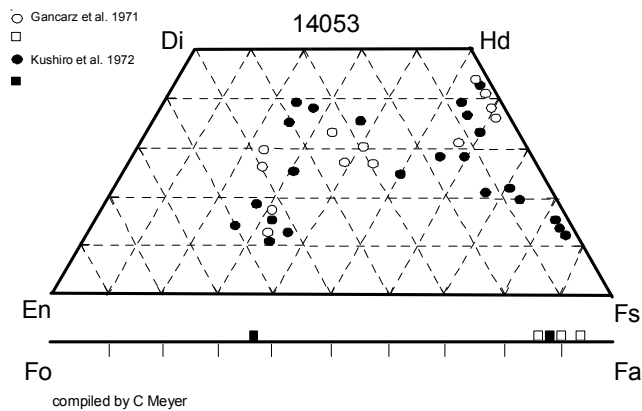


Figure 5: Composition diagram for pyroxene and olivine in 14053 (data replotted from Gancarz et al. 1971 and Kushiro et al. 1972 - see additional data in Bence and Papike 1975).

and Taylor (2003) and Patchen and Taylor (2004) find that there is more breakdown by reduction of the fayalite near the exterior of 14053 than in the interior.

**Pyroxene:** Bence and Papike (1972) provide a large number of analyses of pyroxene in 14053, including minor element substitution. Schürmann and Hafner (1972) discuss the site occupancy of cations. Clinopyroxene zones all the way to hedenburgite and pyroxferroite (figure 5). Ghose et al. (1972) and Finger et al. (1972) also discuss pyroxene in 14053.

**Plagioclase:** The composition of plagioclase is relatively homogeneous ( $An_{91-93}$ ) except near the rim ( $An_{70}$ ) where it is found adjacent to K-feldspar (Kushiro et al. 1972). Wenk et al. (1972) and Czank et al. (1972) also studied plagioclase in 14053.

**Opagues:** Chrome spinel has been studied (Haggerty 1972, El Goresy et al. 1972, Mayne and Taylor 2003). Ulvöspinel is seen to break down by reduction to chrome spinel, ilmenite and Fe metal. Ilmenite has been analyzed (Gancarz et al. 1971). Metal grains in 14053 have high Ni, but lower than for other Apollo 14 basalts (Gancarz et al. 1971, El Goresy et al. 1972) (figure 6). The metal is found finely mixed with troilite in unique “spongy masses” (see picture in Gancarz et al. 1971).

**Phosphates:** Gancarz et al. (1971) analyzed apatite and whitlockite in 14053. Taylor et al. (2004) studied phosphate reactions (reduction?).

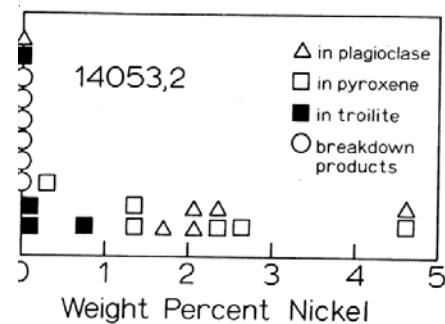


Figure 6: Ni content of metal grains in 14053 (from El Goresy et al. 1972).

**Glass:** K and Ba-rich residual melt are found as glass in the mesostasis (El Goresy et al. 1972).

### Chemistry

14053 has high Al content (table 1). Low siderophile elements were determined by Morgan et al. (1972).

### Radiogenic age dating

14053 has been dated with good precision by Rb-Sr and Ar-Ar and appears to be older than the Fra Mauro Formation (see figures and table).

However, in an effort to date the rock by Sm-Nd, Snyder and Taylor (2001) found that the Sm-Nd systematics were “disturbed”(perhaps because they were using a portion of the “reduced” edge material). Tera and Wasserburg (1972) and Tatsumoto et al. (1972) determined the U-Th-Pb systematics of 14053, but could not obtain an age.

### Cosmogenic isotopes and exposure ages

The  $^{38}\text{Ar}$  exposure age ( $21 \pm 5$  m.y.) of 14053 is discussed in Husain et al. (1972). Stettler et al. (1973) reported 25 m.y. Eugster et al. (1984) determined an exposure age of  $21.2 \pm 5.0$  m.y. by the  $^{81}\text{Kr}$  method. This is interpreted to be the age of Cone Crater (Arvidson et al. 1975).

### Other Studies

The composition of noble gasses in 14053 is given in Husain et al. (1972) and Eugster et al. (1984).

### Processing

There are 23 thin sections of 14053.

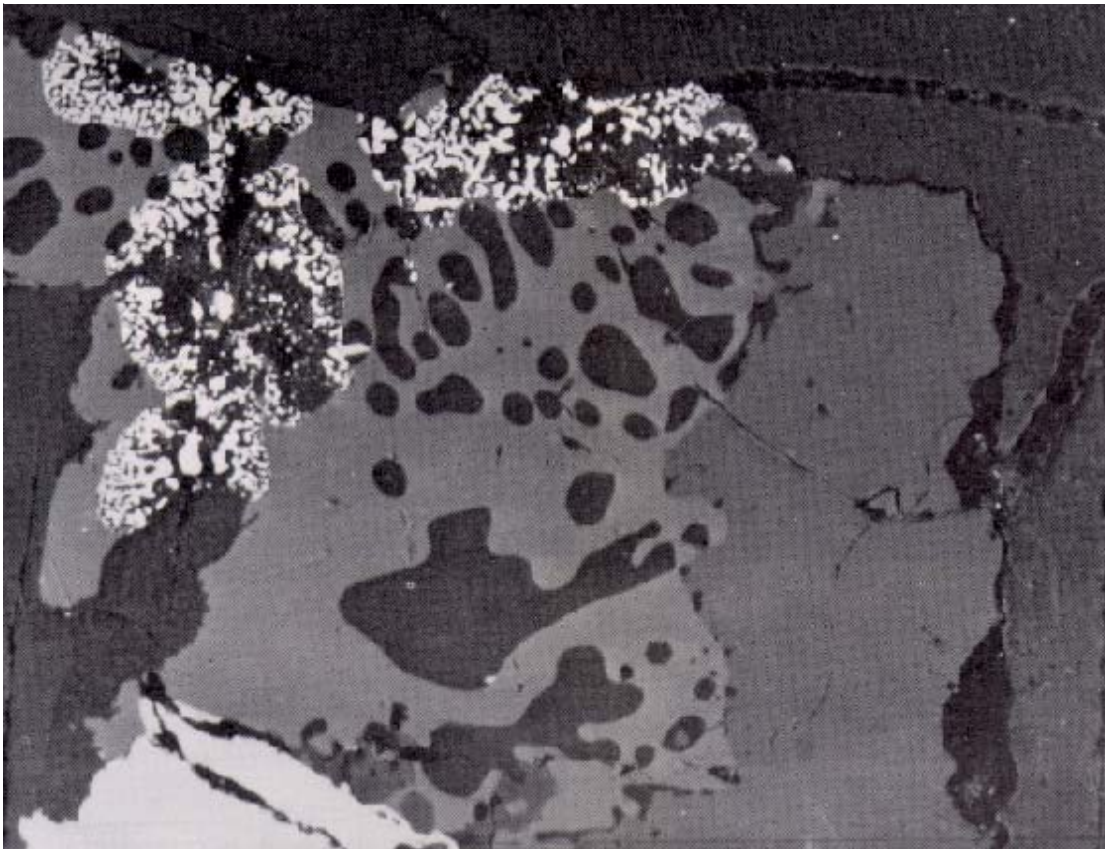


Figure 7: Reflected light photomicrograph of fayalite grain in process reduction to spongy Fe + silica (from El Goresy et al. 1971).

**List of Photo #s**

- S71-21353-357 B & W
- S71-30464-495 B & W
- S71-35849-854 Color
- S72-34773-778 Nice color
- S75-33968-973 Color saw cuts
- S75-34136-138 Color

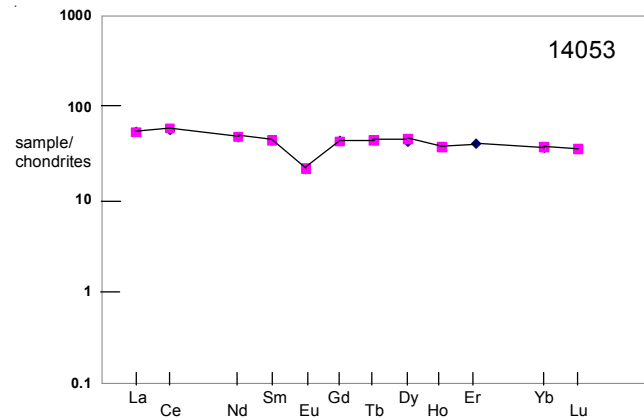


Figure 8: Normalized rare-earth-element diagram for 14053 (data from Hubbard et al. 1972 and Helmke et al. 1972).

**Table 1. Chemical composition of 14053.**

reference weight	LSPET 71	Willis 72	Helmke 72	Hubbard 72	Morgan 72	Neal2001		
SiO <sub>2</sub> %	48	(c) 46.08	(a)	46.3	46.4	(a)		
TiO <sub>2</sub>	1.5	(c) 2.91	(a)	2.79	2.64	(a)		
Al <sub>2</sub> O <sub>3</sub>	12	(c) 12.54	(a)	13.7	13.6	(a)		
FeO	16	(c) 16.97	(a)	17	16.8	(a)		
MnO	0.29	(c) 0.255	(a)		0.26			
MgO	8.4	(c) 8.97	(a)	8.54	8.48	(a)		
CaO	12	(c) 11.07	(a)	11.2	11.2	(a)		
Na <sub>2</sub> O	0.38	(c) 0.44	(a)	0.44		(a)		
K <sub>2</sub> O	0.14	(c) 0.097	(a)	0.11	0.1	(a)		
P <sub>2</sub> O <sub>5</sub>		0.114	(a)	0.11	0.09	(a)		
S %		0.132	(a)		0.14			
sum								
Sc ppm	90	(c)	55	(b)		54	(f)	
V	135	(c)				111	(f)	
Cr	3000	(c) 2874	(a)			2168	(f)	
Co	48	(c)				32	(f)	
Ni	14	(c)	14	(b)		13.6	(f)	
Cu	13	(c)				16.3	(f)	
Zn			3.4	(b)	2.1	(e) 23.7	(f)	
Ga			4.8	(b)		2.54	(f)	
Ge ppb								
As								
Se								
Rb	2	(c) 2.2	(a)		2.1	(e) 1.95	(f)	
Sr	180	(c) 98.6	(a)	98	(d)	95	(f)	
Y	90	(c) 54.7	(a)			50	(f)	
Zr	310	(c) 215	(a)			184	(f)	
Nb		15.7	(a)			15.4	(f)	
Mo								
Ru								
Rh								
Pd ppb								
Ag ppb					0.6	(e)		
Cd ppb					20	(e)		
In ppb								
Sn ppb								
Sb ppb					0.64	(e) 30	(f)	
Te ppb					15	(e)		
Cs ppm					0.09	(e) 0.1	(f)	
Ba	190	(c) 163	(a)	146	(d)	151	(f)	
La	10	(c)	12.8	(b)	13	(d)	12.4	(f)
Ce			36.4	(b)	34.5	(d)	36.5	(f)
Pr							4.63	(f)
Nd			22	(b)	21.9	(d)	22.5	(f)
Sm			6.5	(b)	6.56	(d)	6.6	(f)
Eu			1.23	(b)	1.21	(d)	1.06	(f)
Gd			8.5	(b)	8.59	(d)	8.33	(f)
Tb			1.62	(b)			1.52	(f)
Dy			11.1	(b)	10.5	(d)	9.36	(f)
Ho			2.1	(b)			2.05	(f)
Er					6.51	(d)	5.96	(f)
Tm							0.82	(f)
Yb	10	(c)	6.1	(b)	6	(d)	6.19	(f)
Lu			0.89	(b)			0.8	(f)
Hf			9.8	(b)			4.92	(f)
Ta							0.85	(f)
W ppb							220	(f)
Re ppb					0.007	(e)		
Os ppb								
Ir ppb					0.017	(e)		
Pt ppb								
Au ppb					0.11	(e)		
Th ppm					1.63	(d)	1.51	(f)
U ppm					0.6	(d)	0.48	(f)

technique (a) XRF, (b) INAA, (c) emiss. Spec., (d) IDMS, (e) RNAA, (f) ICP-MS

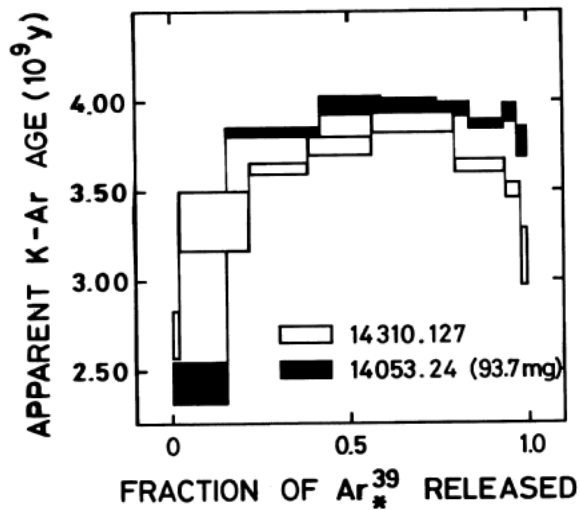


Figure 9: Ar plateau age of 14053 (from Stettler et al. 1973).

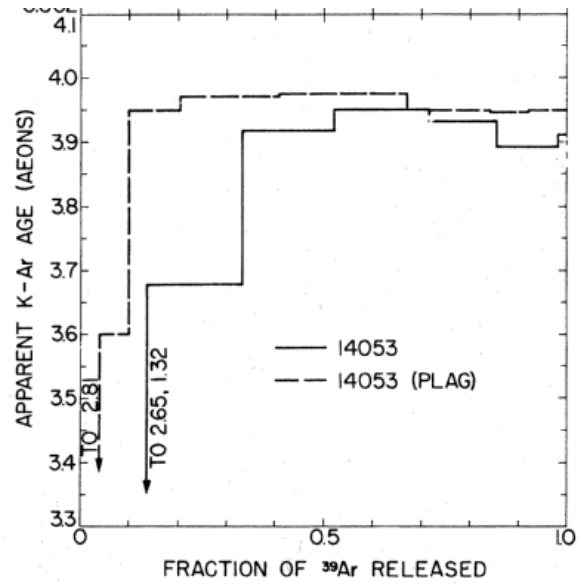
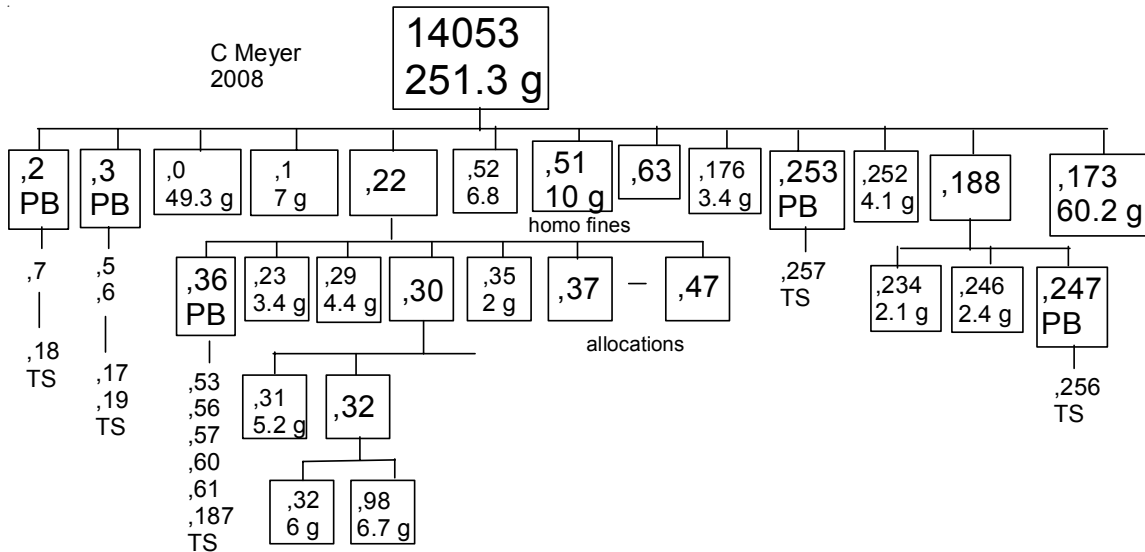


Figure 10: Ar plateau age of 14053 (from Turner et al. 1971).



### Summary of Age Data for 14053

	Rb-Sr	Ar plateau
Papanastassiou and Wasserburg 1971	$3.96 \pm 0.04$ b.y.	
Stettler et al. 1973		$3.94 \pm 0.04$ b.y.
Turner et al. 1971		$3.94 \pm 0.05$
Husain et al. 1972		$3.92 \pm 0.08$

Caution: Be careful with decay constants.

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