62236
Ferroan Noritic Anorthosite
57.3 grams

Figure 1: Photo of 62236. NASA S72-451777. Sample is 4.5 cm across.

Introduction
62236 and 62237 are chalky white rocks that were collected together along with incidental soil, from the rim of Buster Crater, station 2, Apollo 16, where they were found half buried in the regolith (Sutton 1981). The mineral mode and chemistry of these rocks appear similar to that of the light portions of 62255 and 62275.

62236 has been found to be a slowly-cooled plutonic rock (Takeda et al. 1979) with an age of ~4.3 b.y. (Borg et al. 1999). It has been subsequently been heavily shocked and has a cataclastic texture (figures 1 and 2). However, it is lacking in any meteoritic component and is considered "pristine".

Petrography
Nord and Wandless (1983) found that 62236 was a cataclastic mixture of troctolite, anorthosite and norite clasts. Original grain size is reported to be over 1 mm, but Nord and Wandless concluded it had been shocked to 200-300 kilobars pressure, which has crushed and granulated portions of the matrix.

Takeda et al. (1979) found that the pyroxene in 62236 was originally pigeonite that has "inverted" to orthopyroxene with exsolved blebs of augite. This is thought to be indicative of very slow cooling, such as in a plutonic environment. Nord and Wandless (1983) conclude that subtle variation in mineral chemistry from troctolite to norite "*is indicative of crystallization in an evolving silicate liquid, and therefore the crystallization of 62236 is a product of adcumulus growth*".

The mineral composition for 62236 is that of a ferroan anorthosite (figure 4), but with a higher percentage modal mafic mineral content. In fact, Warren and Wasson (1978) reported that thin sections from

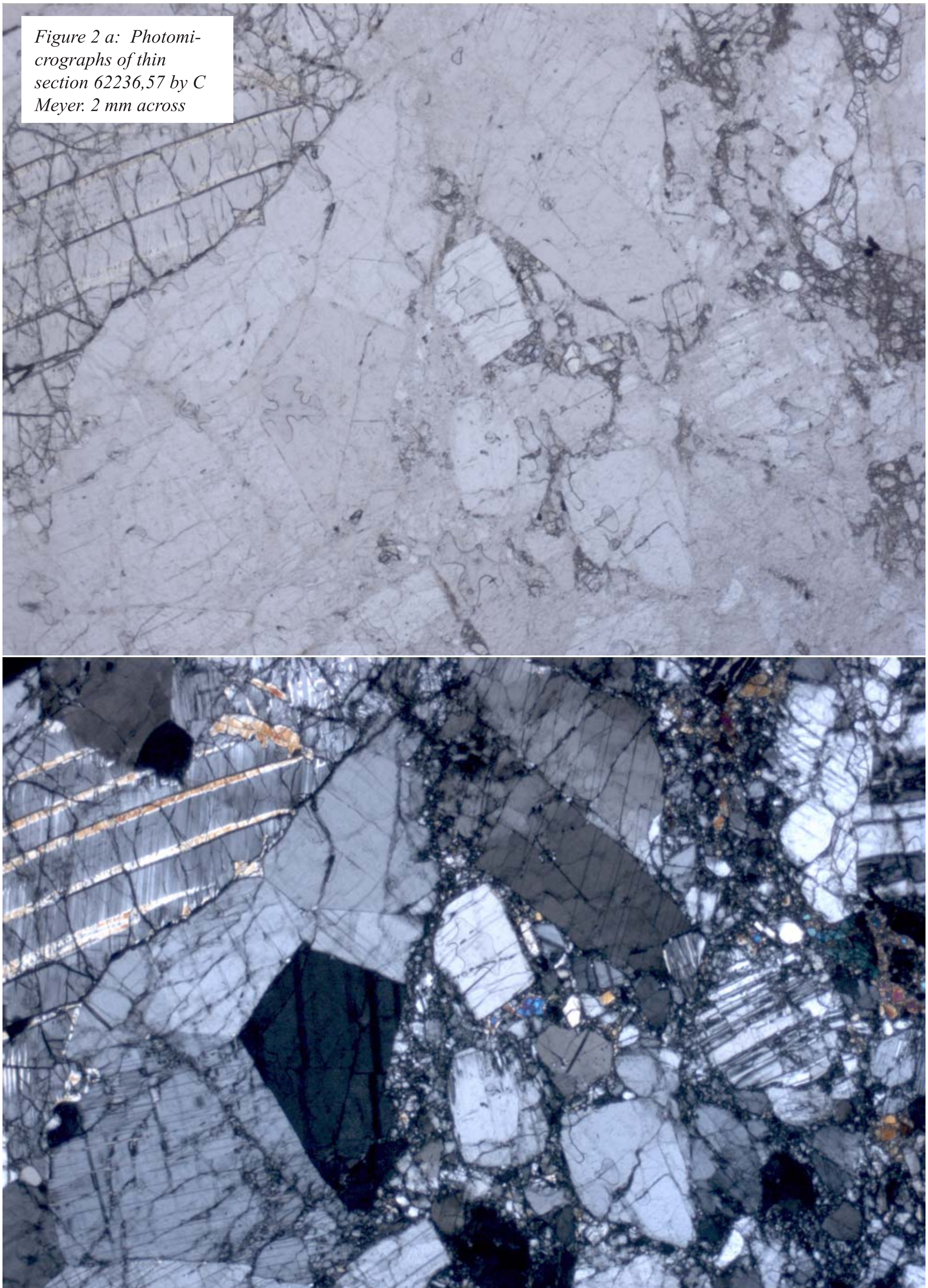


Figure 2 a: Photomicrographs of thin section 62236,57 by C Meyer. 2 mm across

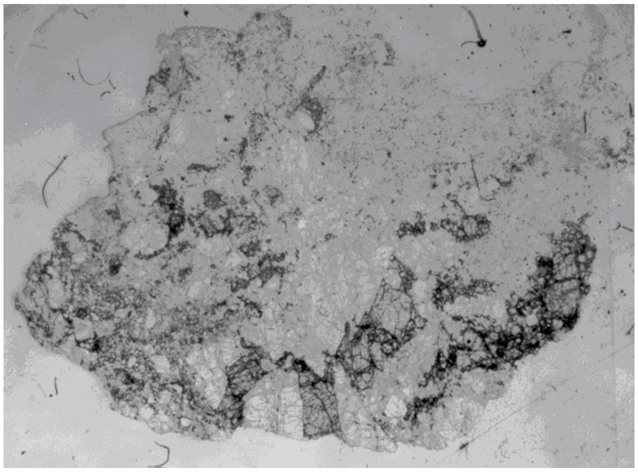


Figure 2b: Thin section photomicrograph of 62236. About 0.5 cm. NASA S72-52529.

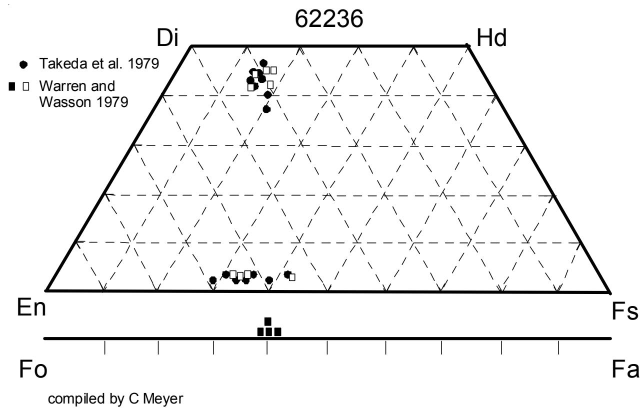


Figure 3: Pyroxene and olivine composition of 62236.

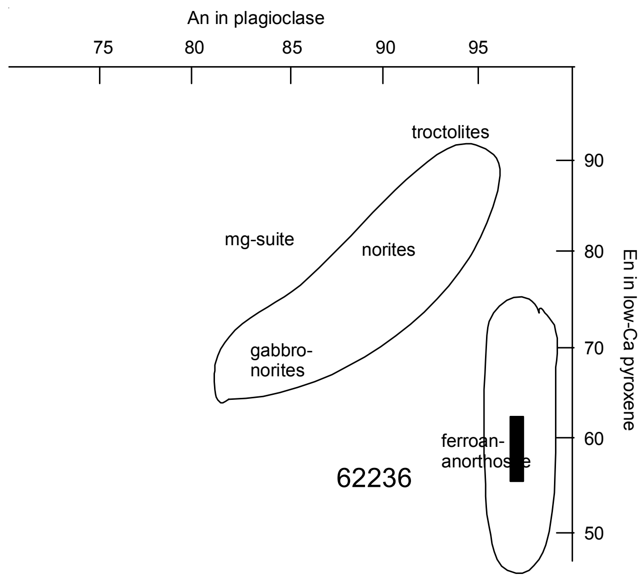


Figure 4: Plagioclase and pyroxene composition of 62236.

different portions of 62236 had widely different mineral modes.

Mineralogy

Olivine: Olivine in 62236 is Fo_{59} (Takeda et al. 1979), Fo_{59-61} (Warren and Wasson 1979) and $Fo_{60-63.5}$ (Nord and Wandless 1983). Olivine in companion rock 62237 was found to be exceptionally low in Ca (Dymek 1975).

Pyroxene: The equilibration temperature for coexisting orthopyroxene and augite in 62236 (figure 3) is calculated as 860-875 deg. C. Pyroxene crystals in 62236 as large as 2.3 x 0.9 mm have been studied crystallographically by Takeda et al. (1979) and by TEM by Nord and Wandless (1983). Bersch et al. (1991) and Warren and Wasson (1979) also reported the pyroxene composition.

Note that there is a slight range in Mg/Fe ration of pyroxene in both 62236 and 62237. This indicates that these samples may be mixtures of norites, troctolite and anorthosites (as observed by Nord and Wandless on a microscopic scale).

Plagioclase: Warren and Wasson (1979) and Takeda et al. (1979) found plagioclase was An_{96-98}.

Chromite: Nord and Wandless (1983) report analyses of two grains of chromite found at the mineral boundaries of plagioclase and pyroxene.

Chemistry

Chemical analyses (table 1, figure 5) based on small splits of coarse-grained rocks are problematical.

Mineralogical Mode of 62236

	Warren and Wasson 1978	Warren and Wasson 1978	Nord and Wandless 1983	Nord and Wandless 1983
Olivine	5 wt. %		10	1
Pyroxene				
Opx.	7	20	0.5	5
Cpx.	5		3	2
Plagioclase	83	80	87	91
Ilmenite	tr.			
Chromite	tr.			

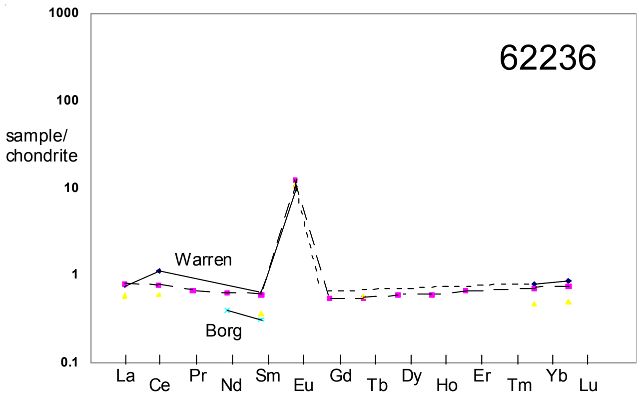


Figure 5: Normalized rare-earth-element diagram for 62236 (data from table 1).

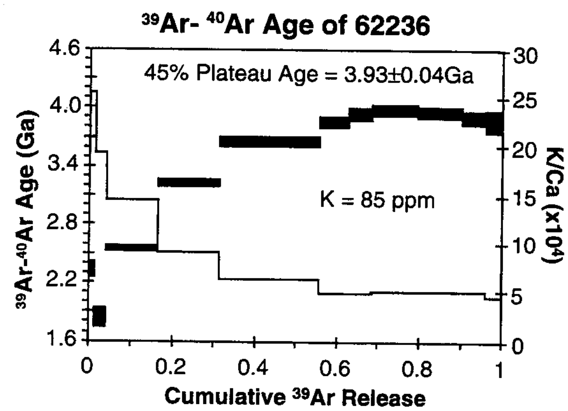


Figure 6: Ar/Ar plateau diagram for age of 62236 (from Borg et al. 1999).

However, the bulk analyses of the whole rock (Clark and Keith 1973) are in reasonable agreement with those obtained by Warren and Wasson (1978, 1979) and Norman et al. (2003). The analyses of 62236 also agree well with those of 62237. Although these rocks a cataclastic in nature, they are both found to be chemically pristine, lacking any evidence of a meteoritic component.

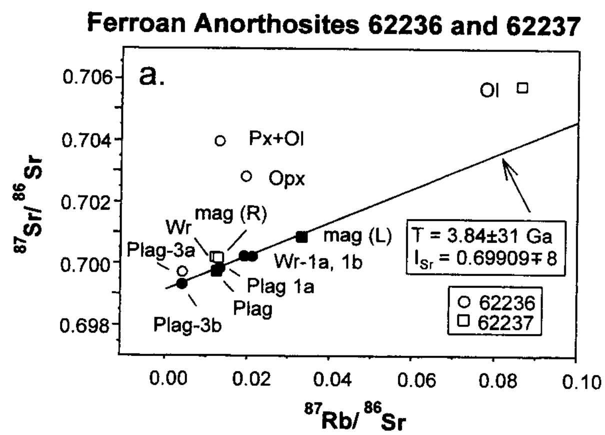


Figure 7: Rb/Sr diagram for 62236 and 62237 (Borg et al. 1999).

Radiogenic age dating

Borg et al. (1999) determined the Ar/Ar age to be 3.93 b.y. (figure 6), the Rb/Sr age to be 3.84 b.y. (figure 7), and by Sm-Nd isochron 4.3 b.y. (figure 8). Borg et al. (2002) and Norman et al. (2003) provided further discussion. By combining Sm-Nd data for mafic minerals from 62236, 67215, 67016 and 60025, Norman et al. (2003) obtained a "robust" age of 4.46 ± 0.04 b.y. for ferroan anorthosites (i.e. the lunar crust).

Cosmogenic isotopes and exposure ages

Clark and Keith (1973) determined the cosmic ray induced activity of ^{26}Al =119 dpm/kg., ^{22}Na = 53 dpm/kg., ^{54}Mn =17 dpm/kg. ^{56}Co = 36 dpm/kg and ^{46}Sc = 5 dpm/kg.

Other Studies

Nord and Wandless (1983) studied submicroscopic defect structures in minerals, due to pigeonite inversion and shock history.

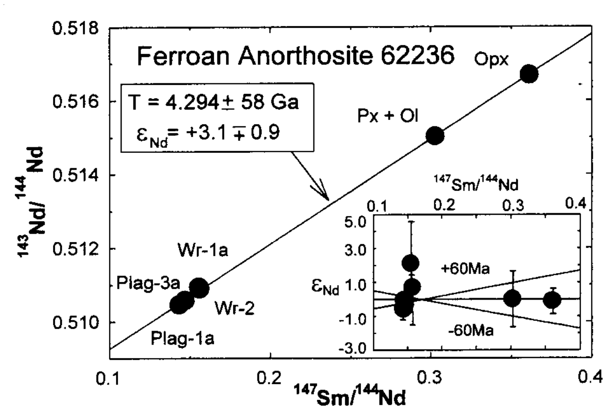


Figure 8: Sm-Nd mineral isochron for age of 62236 (Borg et al. 1999).

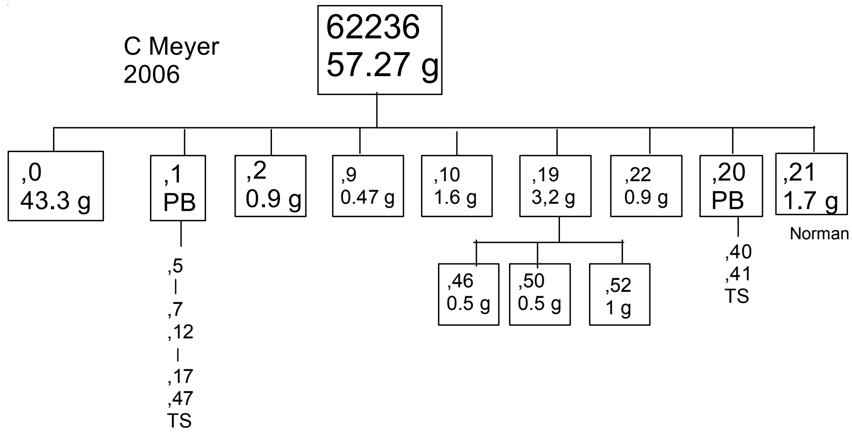
Summary of Age Data for 62236

	Ar/Ar	Rb/Sr	Sm/Nd
Borg et al. 1999	3.93 ± 0.04 b.y.		
Borg et al. 1999		3.84 ± 0.031	
Borg et al. 1999			4.294 ± 0.058

Table 1. Chemical composition of 62236.

reference	Clark 73		Warren 78			Norman2003							Borg 99		
weight	54 g			Warren79		WR		WR		plag	mafic		WR	WR	
SiO2 %			44.3	44.1	(c)	43.89	(b)								
TiO2															
Al2O3			29.7	30.6	(c)	27.63	(b)								
FeO			4	3.34	(c)	6.16	(b)	8.09	(c)	1.15	32.6	(c)			
MnO			0.06	0.05	(c)	0.05	(b)								
MgO			3.8	3.3	(c)	5.96	(b)								
CaO			17.3	17.8	(c)	15.77	(b)	15.7	(c)	19.6	0.53	(c)			
Na2O			0.21	0.22	(c)	0.18	(b)	0.184	(c)	0.223	0.0084	(c)			
K2O	0.014	(d)	0.016	0.011	(c)										
P2O5															
S %															
sum															
Sc ppm			5.3	6.3	(c)	5.2	(a)	3.46	(c)	1.03	10.7	(c)			
V						14	(a)								
Cr			510	460	(c)			492	(c)	153	864	(c)			
Co			9	6.8	(c)	8.5	(a)	19	(c)	2.8	75	(c)			
Ni			3.5	4.4	(c)	8.7	(a)	23	(c)						
Cu						3.2	(a)								
Zn			2	1.5	(c)	1.8	(a)								
Ga			3		(c)	2.7	(a)								
Ge ppb			16.3	3.4	(c)										
As															
Se															
Rb						0.65	(a)						0.843	0.946	(e)
Sr						149	(a)	128	(c)	157	<80	(c)	124.5	129	(e)
Y						0.95	(a)								
Zr						1.9	(a)								
Nb						0.1	(a)								
Mo															
Ru															
Rh															
Pd ppb															
Ag ppb															
Cd ppb			0.75	0.84	(c)										
In ppb			1.3	1.2	(c)										
Sn ppb						20	(a)								
Sb ppb															
Te ppb															
Cs ppm						0.144	(a)	0.087	(c)	0.092	0.12	(c)			
Ba				<60		7.3	(a)			15					
La			0.18	0.18	(c)	0.188	(a)	0.139	(c)	0.162	0.017	(c)			
Ce			0.68		(c)	0.464	(a)	0.37	(c)	0.42					
Pr						0.06	(a)								
Nd						0.286	(a)						0.1796	0.179	(e)
Sm			0.092	0.093	(c)	0.088	(a)	0.055	(c)	0.055	0.031	(c)	0.0462	0.0462	(e)
Eu			0.59	0.64	(c)	0.685	(a)	0.593	(c)	0.742		(c)			
Gd						0.109	(a)								
Tb						0.02	(a)	0.021	(c)	0.008					
Dy						0.145	(a)								
Ho						0.034	(a)								
Er						0.106	(a)								
Tm															
Yb			0.13	0.16	(c)	0.117	(a)	0.077	(c)	0.037	0.18	(c)			
Lu			0.021	0.022	(c)	0.018	(a)	0.012	(c)	0.004	0.031	(c)			
Hf						0.049	(a)								
Ta						0.006	(a)								
W ppb															
Re ppb			0.013		(c)										
Os ppb															
Ir ppb			0.0075	0.028	(c)										
Pt ppb															
Au ppb			0.0076	0.0036	(c)										
Th ppm			0.04		(c)	0.011	(a)								
U ppm	0.016	(d)				0.0023	(a)								

technique: (a) ICP-MS, (b) EMP, (c) INAA,RNAA, (d) radiation counting, (e) IDMS


C Meyer
2006
62236
57.27 g
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43.3 g
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PB
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TS
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Norman