78236

Shocked Norite
93.06 g, 7.5 x 5.5 x 2.0 cm

INTRODUCTION

Sample 78236 is a piece of the same norite as 78235 *(see section on the boulder at Station 8)*. It is a heavily shocked, coarse-grained, plutonic norite of cumulate origin. One side of this piece has a thick coating of black glass (Fig. 1), and the other side shows a coarse-grained igneous texture (Fig. 2).

78236 has been used extensively for age dating studies.

PETROGRAPHY

Nyquist et al. (1981) have discussed the petrography of 78236. Modal analysis and the mineralogy of their thin section of 78236 agreed with previous descriptions of 78235 and 78238. All minerals in 78236 have been shocked to a moderate degree (~30 GPa), with local areas of more intense shock (up to ~50 GPa). Veins of solidified melt have been developed *in situ.*

Carlson and Lugmair (1982) and Nyquist et al. have pointed out the importance of the minor phases to age dating studies. An important part of the Sm and Nd must be tied up in the whitlockite, and Rb must be present in the K-feldspar inclusions (Nyquist et al., 1981). Partially devitrified dark brown mesostasis occurs interstitially-mostly intergranular between pyroxene grains-and contains tiny clinopyroxene and opaque crystals. The shock event(s) that have

Figure 1: Photograph of 78236. Cube is 1 cm. S73-15394.

Figure 2: Photograph of 78236. Field of view is 5 x 7 cm. S73-17813.

partially altered the texture of this rock must have at least partially remobilized the radiogenic pairs in these minor phases. Some of the plagioclase has lost Ar while being converted to maskelynite.

WHOLE-ROCK CHEMISTRY

Blanchard and McKay (1981) have determined the major and trace element content of 78236 and found it to be the "same" as that of 78235 (Table 1 and Fig. 3).

RADIOGENIC ISOTOPES

Sample 78236 was used for age dating studies of the norite boulder. Aeschlimann et al. (1982) dated the plagioclase in 78236 by the ^{39}Ar-^{40}Ar plateau technique at 4.11 ± 0.02 (Fig. 4). Nyquist et al. (1981) also dated 78236 by the $^{39}Ar^{40}Ar$ plateau method, but they obtained an age of 4.39 for a sample of the whole rock (Fig. 5). The Ar released during the low temperatures has a younger age.

Carlson and Lugmair (1981) dated 78236 by the Sm-Nd.internal isochron method (Table 2). A crystallization age of 4.34 ± 0.05 is indicated by a best fit isochron (Fig. 6). However, one of the: hand-picked plagioclase and one of the pyroxene separates were outside of the ± 50 m.y. error envelope, and evidence of isotopic resetting was noted.

Nyquist et al. (1981) also dated 78236 by the Rb-Sr (Table 3) and Sm-Nd methods (Table 4). The Rb-Sr and Sm-Nd ages detenmined by the most retentive samples are 4.38 ± 0.02 b.y. (Fig. 7) and 4.43 ± 0.05 b.y. (Fig. 8), respectively. Nyquist et al. note that all of the isotopic systems in 78236 have been reset to some degree. They discuss this from two points of view-shock effects and slow cooling of the rock after crystallization.

Jost and Marti (1982) and Marti (1983) have recognized a low temperature release pattern of spallation Xe in plagioclase separates from 78236 that is different from the high temperature release pattern, possibly due to recoil events from adjacent mineral phases.

Sample 78235 has been dated by the U-Pb method (see section of 78235).

COSMOGENIC RADIOISOTOPES AND EXPOSURE AGES

Aeschlimann et al. (1982) report an Ar exposure age of 300 m.y. Drozd et al. (1977) have determined an exposure age of 292 ± 14 m.y. for 78235 using the ^{81}Kr-Kr method.

SURFACE STUDIES

The original catalog (Butler, 1973) notes that the glass coating on 78236 has been pitted by micrometeorites. The largest spall is 6 mm; the average pit size is reported to be 0.5 mm.

PROCESSING

The largest piece of 78236 remaining weighs 79 g. There are only two thin sections, but there are numerous sections of 78235.

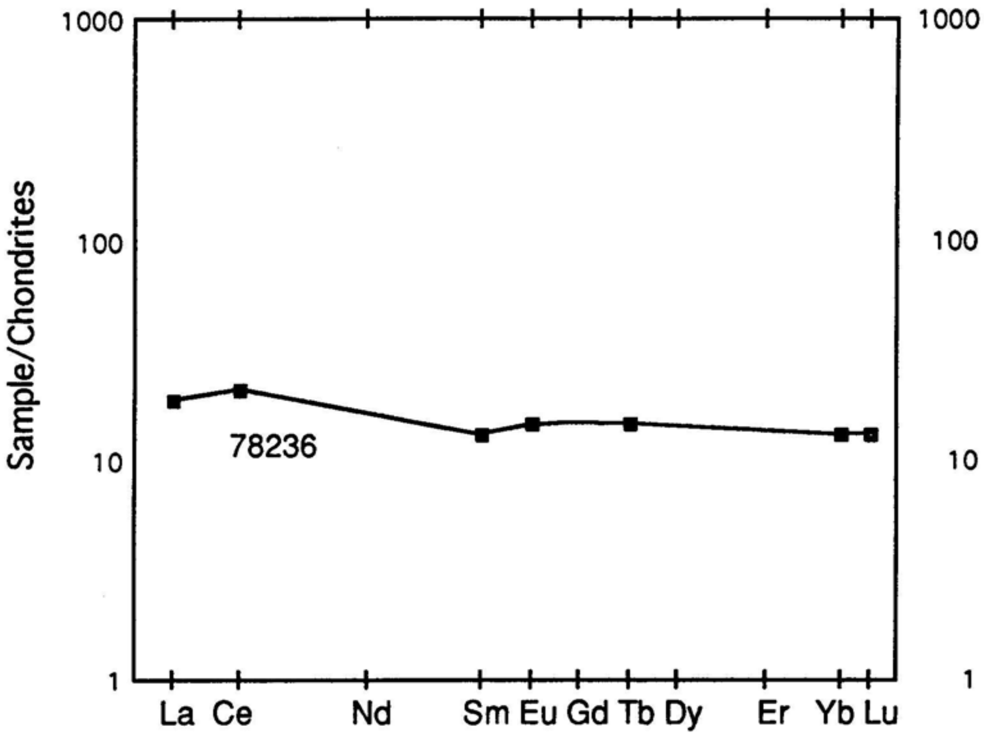

Figure 3: Normalized rare earth element diagram for 78236. Data from Blanchard and McKay (1981).

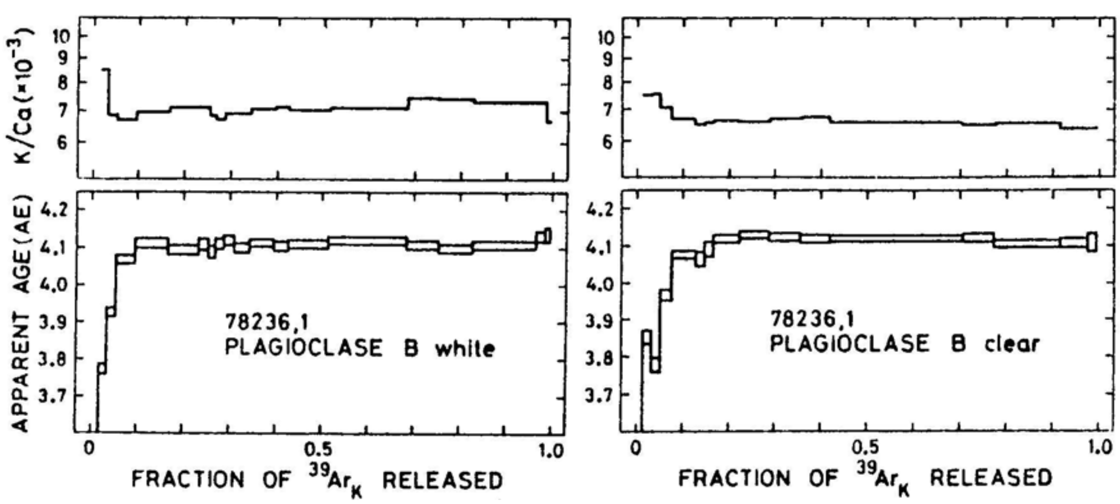

Figure 4: Temperature release data from the ^{39}Ar-^{40}Ar plateau age dating technique for plagioclase from 78236. From Aeschlimann et al. (1982).

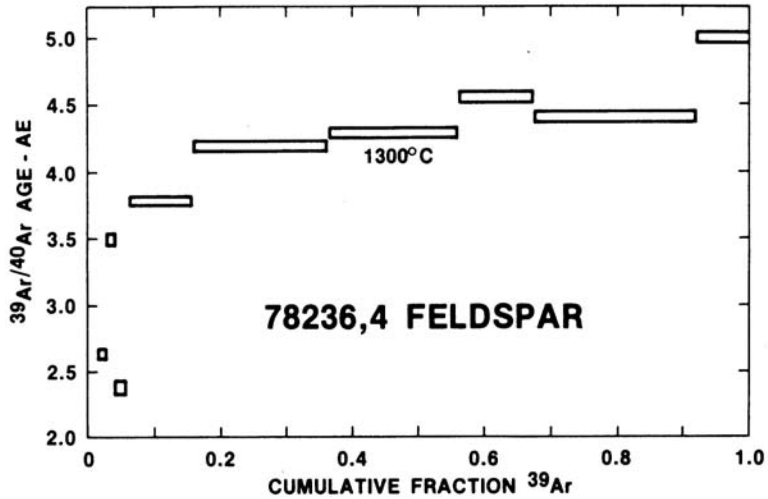

Figure 5: Data from ^{39}Ar-^{40}Ar plateau technique for 78236 feldspar. From Nyquist et al. (1981).

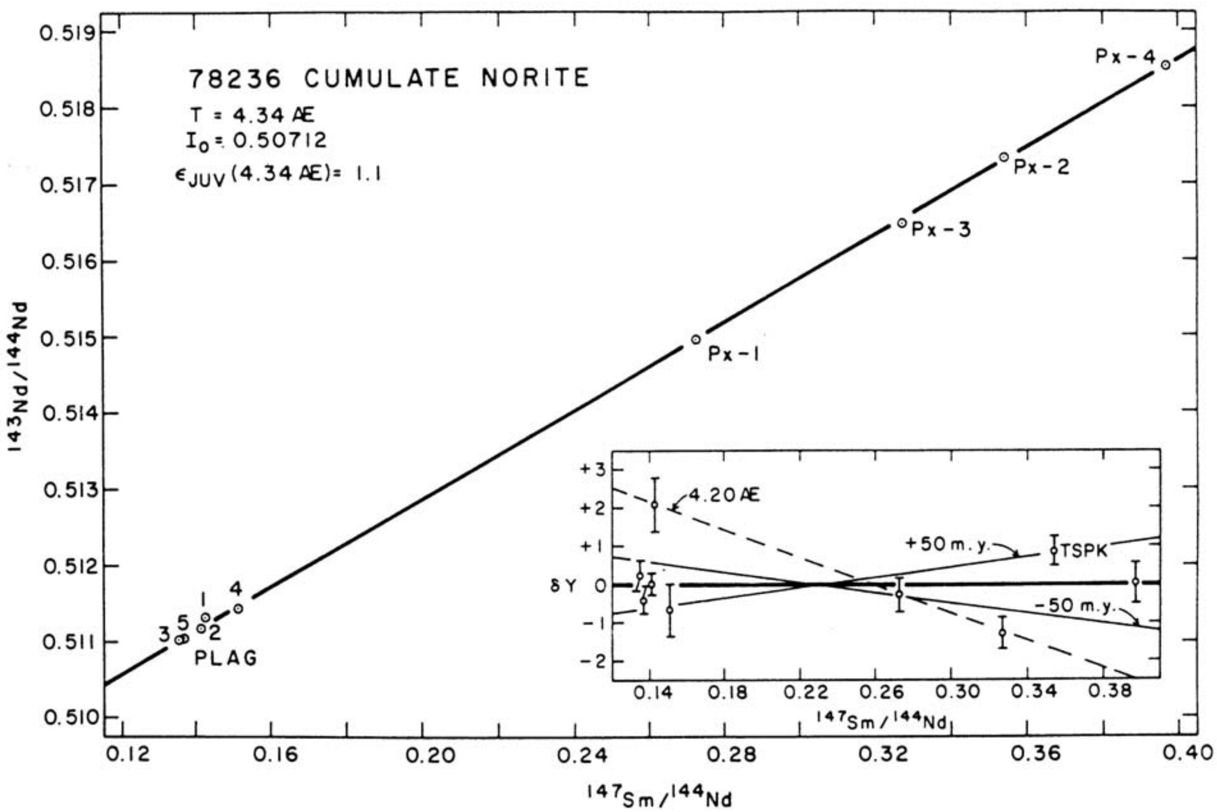

Figure 6: Sm-Nd internal isochron for 78236. From Carlson and Lugmair (1981).

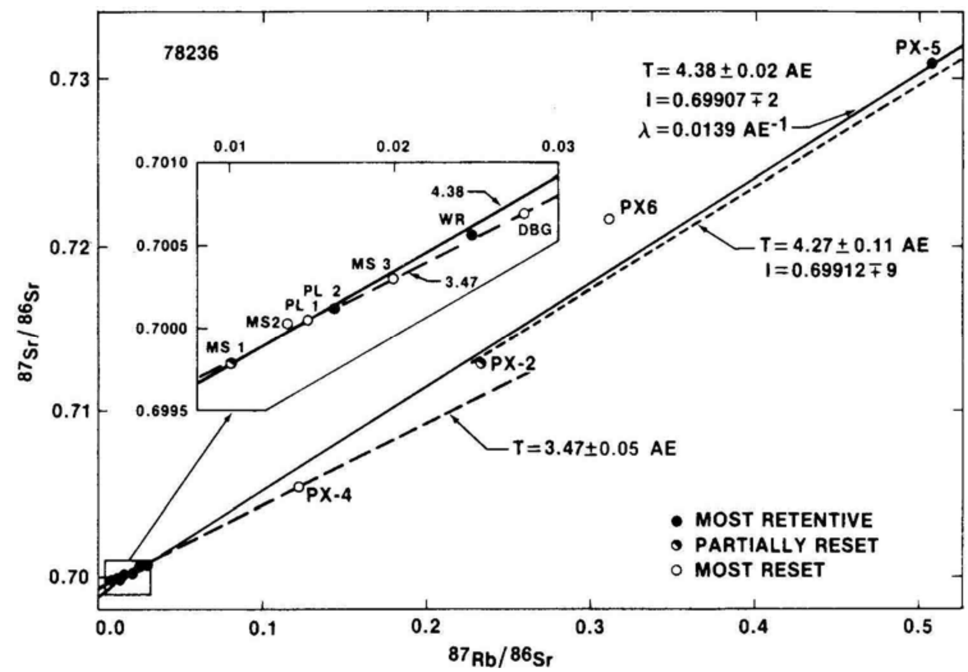

Figure 7: Rb-Sr internal isochron for mineral separates from 78236. From Nyquist et at. (1981).

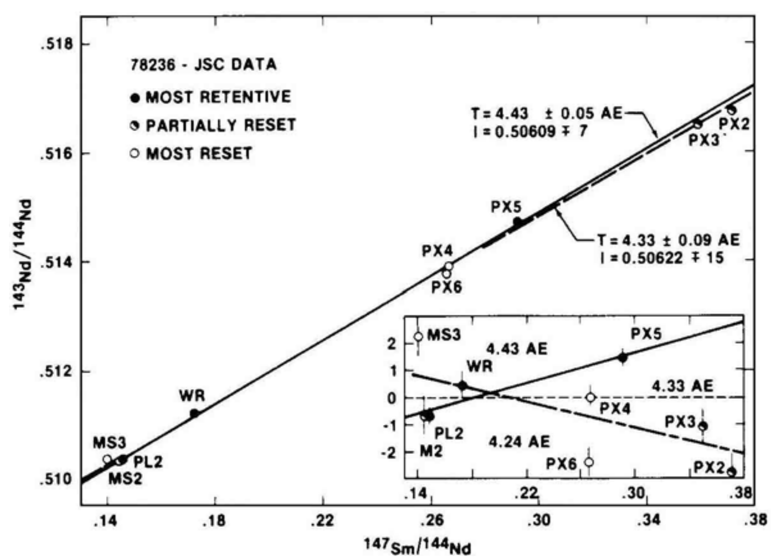

Figure 8: Sm-Nd internal isochron for mineral separates from 78236. From Nyquist et al. (1981).

Table 1: Whole-rock chemistry of 78236.
a) Blanchard and McKay (1981); b) Dymek et al. (1975)

Split Technique	,3 (a) XRF, INAA	78235 (b) calculated
SiO_2 (wt%)	50.15	49.8
TiO_2	0.18	0.08
Al_2O_3	17.66	18.4
Cr_2O_3	0.31	0.31
FeO	6.49	6.02
MnO	0.12	0.10
MgO	14.28	14.5
CaO	10.12	10.5
Na_2O	0.31	0.30
K_2O	0.04	0.05
P_2O_5	0.08	
S	0.02	
Nb (ppm)		
Zr		
Hf	1.7	
Ta	0.2	
U		
Th	0.6	
Ni		
Co	28.2	
Sc	11.2	
La	4.47	
Ce	12.8	
Nd		
Sm	1.93	
Eu	0.82	
Gd		
Tb	0.53	
Dy		
Er		
Yb	2.12	
Lu	0.32	
Ge (ppb)		
Ir		
Au		

Table 2: Sm-Nd analytical data for 78236.
From Carlson and Lugmair (1981).

Separate	Weight (mg)	[Sm] (ppm)	[Nd] (ppm)	$^{147}Sm/^{144}Nd$ [a]	$^{143}Nd/^{144}Nd$ [a]
Pl-1	12.16	1.47	6.24	0.1426 2	0.511333 40
Pl-2	20.08	1.40	5.99	0.1412 1	0.511186 16
Pl-3	17.43	1.62	7.24	0.1352 1	0.511026 19
Pl-4	24.22	0.466	1.86	0.1513 2	0.511442 36
Pl-5	18.17	1.59	7.02	0.1369 1	0.511041 18
Px-1	46.35	0.814	1.81	0.2726 3	0.514956 24
Px-2	67.45	0.812	1.39	0.3540 3	0.517354 20
Px-3	71.41	0.785	1.45	0.3270 3	0.516466 25
Px-4	74.22	0.774	1.18	0.3968 3	0.518543 29

[a]Quoted uncertainties are $2\sigma_{mean}$; the Nd data are first corrected for isotopic fractionation to $^{148}NdO/^{144}NdO = 0.242436$ and thereafter for oxygen ($^{148}Nd/^{144}Nd = 0.241572$).

Table 3: K, Rb, and Sr analytical results for 78236.
From Nyquist et al. (1981).

Sample	wt. (mg)	K (ppm)	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$ (a)	$^{87}Sr/^{86}Sr$ (b)
WR(c)	35.3	–	0.862	104.0	0.02398 ± 17	0.70057 ± 4
Plag 1(d)	8.7	844	1.056	207.1	0.01475 ± 11	0.70005 ± 6
Plag 2(d)	79.9	–	1.168	206.9	0.01634 ± 12	0.70011 ± 5
Mask 1(d)	8.7	789	0.796	209.9	0.01097 ± 8	0.69979 ± 7
Mask 2(d)	41.2	–	0.966	206.5	0.01354 ± 10	0.70003 ± 5
Mask 3(e)	23.4	–	1.450	210.3	0.01995 ± 15	0.70030 ± 5
Px 1(d)	19.6	42.6	0.237	1.56	0.44	–
Px 2(d)	120.2	–	0.195	2.42	0.233 ± 2	0.71282 ± 8
Px 3(e)	58.5	–	0.25(g)	2.03	–	0.72135 ± 9
Px 4(c)	55.5	–	0.259	6.20	0.1208 ± 9	0.70531 ± 6
Px 5(c)	55.3	–	0.407	2.32	0.508 ± 4	0.73095 ± 8
Px 6(c)	70.9	–	0.526	4.86	0.313 ± 3	0.72176 ± 5
DBG(c)	3.3	–	0.956	99.06	0.0279 ± 2	0.70069 ± 6
NBS 987(f)						0.71021 ± 3

(a) Uncertainties correspond to last figures.
(b) Uncertainties correspond to last figures and are $2\sigma_m$. Normalized to $^{88}Sr/^{86}Sr$ = 8.37521.
(c) Final Rb-Sr procedure.
(d) Initial Rb-Sr procedure.
(e) Interim Rb-Sr procedure.
(f) Average of 8 analyses from April, 1980 to April, 1981.
(g) Rb content calculated assuming a 4.3 AE age.

Table 4: Sm-Nd analytical data for 78236.
From Nyquist et al. (1981).

Sample	wt. (mg)	Sm(a) (ppm)	Nd (ppm)	$\frac{^{147}Sm}{^{144}Nd}$ (b)	$\frac{^{143}Nd}{^{144}Nd}$ (c)	$\frac{^{145}Nd}{^{144}Nd}$	$\frac{^{144}Sm}{^{144}Nd}$ (d) (x 10^{-5})
WR	35.3	2.001	7.020	0.1724 ± 2	0.511191 ± 29	0.34896 ± 3	0.8
Plag 2	79.9	1.640	6.811	0.1456 ± 2	0.510363 ± 18	0.34897 ± 5	0.5
Mask 2	41.2	1.122	4.697	0.1445 ± 2	0.510334 ± 39	0.34894 ± 4	0.2
Mask 3	23.4	1.400	6.050	0.1399 ± 2	0.510354 ± 34	0.34897 ± 5	0.2
Px 2	120.2	0.9361	1.526	0.3710 ± 4	0.516731 ± 85	0.34890 ± 10	7.2
Px 3	58.5	0.9211	1.552	0.3589 ± 4	0.516475 ± 36	0.34902 ± 4	0.8
Px 4	55.5	1.027	2.329	0.2667 ± 3	0.513883 ± 21	0.34898 ± 4	0.2
Px 5	55.3	0.9783	2.026	0.2920 ± 3	0.514678 ± 18	0.34900 ± 3	0.4
Px 6	70.9	0.9800	2.228	0.2660 ± 3	0.513738 ± 31	0.34902 ± 4	0.3
Ames Nd(e)					0.511146 ± 28	0.34898 ± 3	
La Jolla Nd(f)					0.511116 ± 33	0.34893 ± 3	

(a) Calculated using measured Sm isotopic composition.
(b) Uncertainties correspond to last figures and do not include the ≤0.1% uncertainty in the Sm/Nd ratio of the spike.
(c) Uncertainties are $2\sigma_m$ and correspond to last figures. Normalized to $^{148}Nd/^{144}Nd = 0.24308$.
(d) Estimated assuming mass 147 due entirely to ^{147}Sm.
(e) Average of 4 analyses for January, 1980 to July, 1980.
(f) Single analysis—January, 1981.