78527
Granulitic Noritic Breccia
5.16 grams

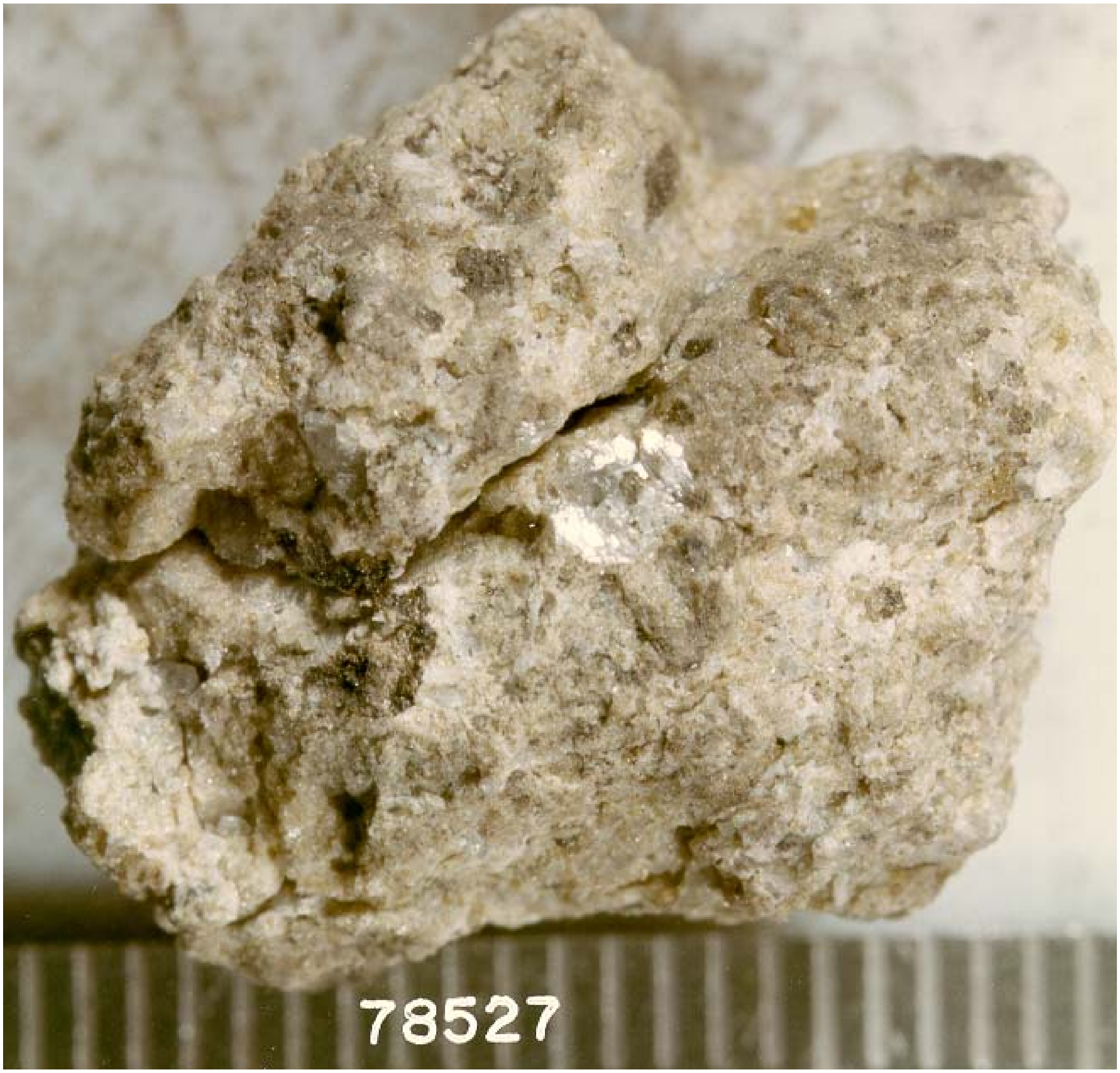

Figure 1: Photo of 78527 showing shocked norite. NASA S73-21026. Scale in mm. Note the zap pit. (the bright spot in the middle is an artifiact)

Introduction
Rake sample 78527 has the mineralogy of a norite, but Cushing et al. (1993, 1999) and Dalrymple and Ryder (1996) refer to this samples as a "granulite" and found that it had an old age (4.146 b.y.).

Petrography
Nehru et al. (1978) and Warner et al. (1978) describe rake sample 78527 as a recrystallized norite with approximately equal amounts of orthopyroxene and plagioclase. Minor phases include olivine, augite, armalcolite, ilmenite, rutile, chromite, baddeleyite, zirconolite, zircon, K-feldspar, metal and troilite.

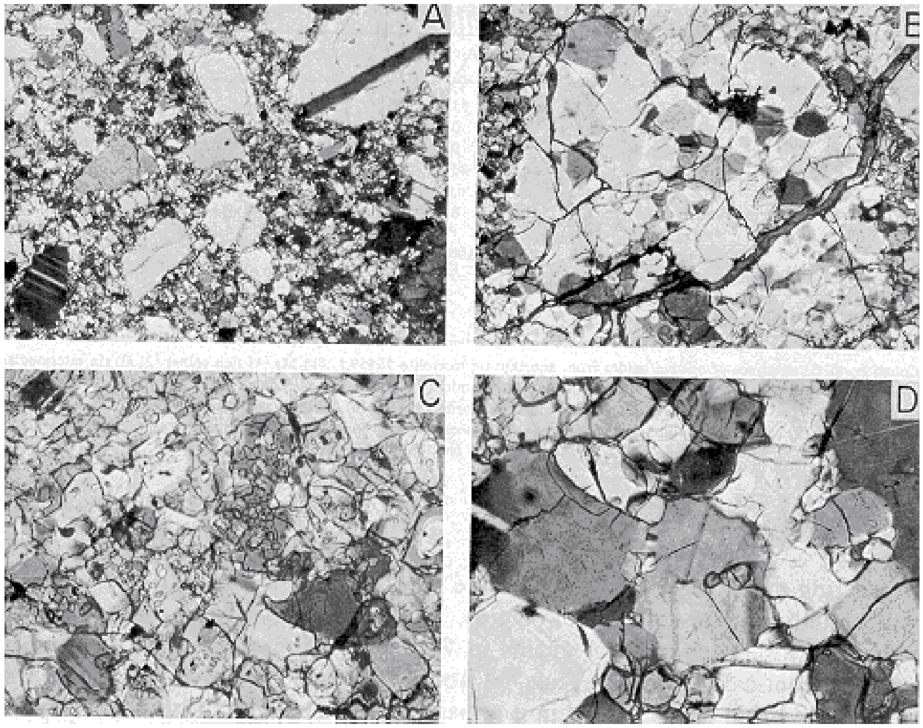

Figure 2: Photomicrographs of thin section of 78527, a) overall texture showing large, subrounded plagioclase in finer-grained matrix. Field of view is 2.4 mm. b) polygonized olivine grain 0.9 mm, c) matrix 0.45 mm. d) matrix 0.45 mm. From Nehru et al. 1978.

The rock consists of large seriate, subangular plagioclase (up to 2 mm) and orthopyroxene (up to 0.8 mm) crystals in a fine-grained recrystallized matrix (figure 2). Minor olivine occurs as large polygonized grains. Cushing et al. (1999) determined the "equilibrium temperature" of 78527 from pyroxene composition as 1061 deg. C.

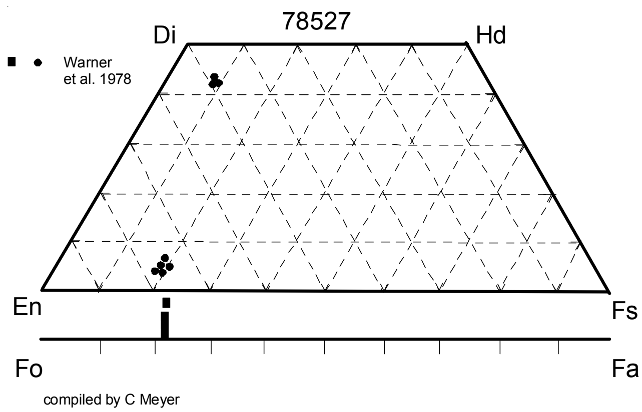

Figure 3: Pyroxene and olivine composition of 78527 (data replotted from Warner et al. 1978, Nehru et al. 1978).

Mineralogy

Olivine: The olivine in 78527 is Fo_{77} (Nehru et al. 1978).

Pyroxene: Warner et al. (1978) illustrate the pyroxene compositions in 78527 (figure 3). Cushing et al. (1999) precisely determined the composition of pyroxene pairs to get a temperature.

Plagioclase: Plagioclase in 78527 is An_{93-94} (Nehru et al. 1978).

Opaques: The composition of ilmenite, armalcolite and chromite are given in Warner et al. (1978).

Metallic iron: Metal grains in 78527 are all high in Ni (25-53%) and Co (1.9-2.2%).

Mineralogical Mode for 78527

	Warner et al. 1978
Olivine	1.9 %
Pyroxene	45.6
Plagioclase	52.2
Opaque	0.1
Other	0.2

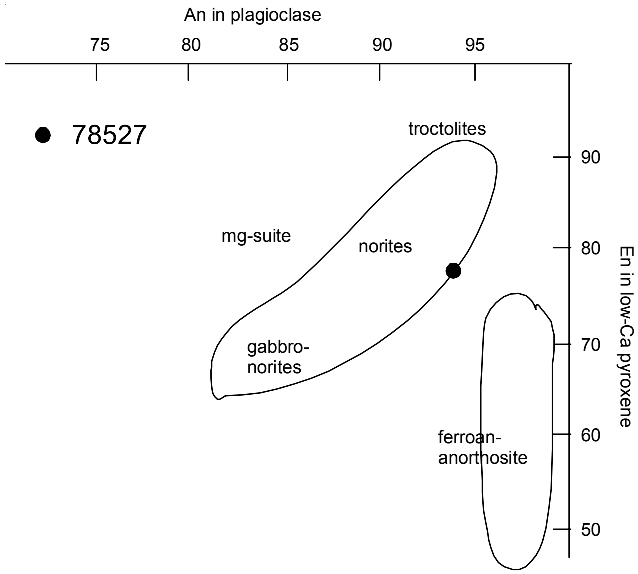

Figure 4: Plagioclase/pyroxene composition for 78527 norite (Nehru et al. 1978).

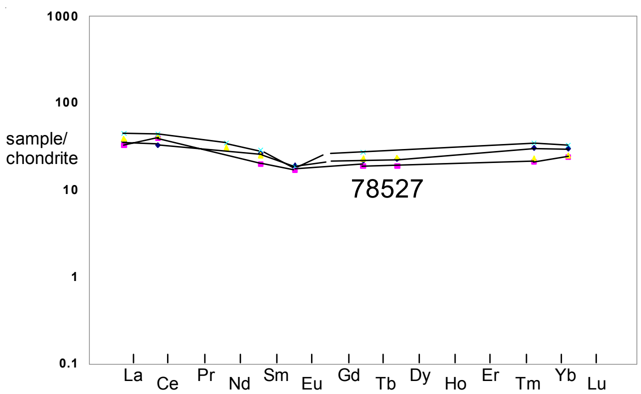

Figure 5: Normalized rare-earth-element diagram for 78527 (data from Laul and Schmitt 1975, Murali et al. 1977, Warren et al. 1983 and Dalrymple et al. 1996).

Chemistry

Laul and Schmitt (1975), Murali et al. (1978), Warren et al. (1983) and Dalrymple and Ryder (1996) analyzed 78527 (table 1, figure 5). They found high Ir *(leading Paul Warren to declare that 78257 is "marginally probably pristine").*

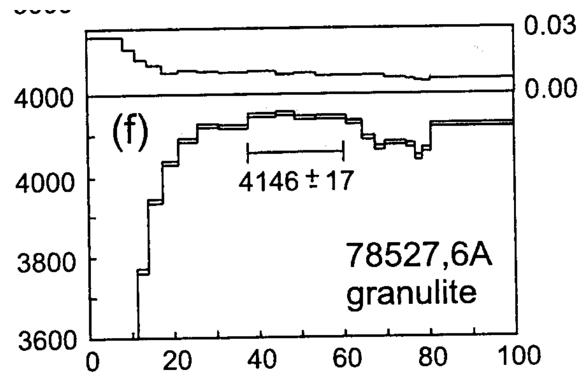

Figure 6: Ar/Ar release pattern for 78527 (from Dalrymple and Ryder 1996).

Summary of Age Data for 78527

	Ar/Ar
Dalrymple and Ryder 1996	4.146 ± 0.017 b.y.

Radiogenic age dating

Dalrymple and Ryder (1996) dated 78527 as 4.146 b.y. by the Argon 39/40 release plateau (figure 6).

Processing

Meyer (1994) reviewed what is known about 78527. It was chipped to produce allocations and has 4 thin sections.

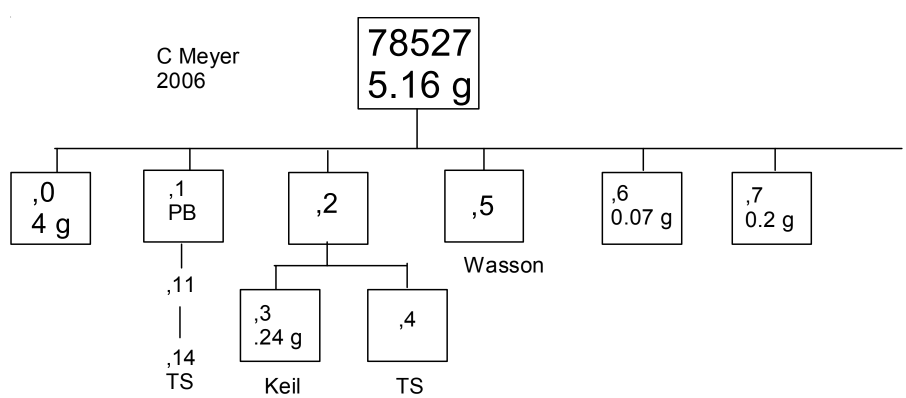

Table 1. Chemical composition of 78527.

reference	Laul 75	Murali 77		Warren83		Dalrymple96	
weight	*Nehru 78*			clast?			
SiO2 %	*49.2*			45.5	(b)	48	(b)
TiO2	0.6	0.38	(a)	0.37	(b)	0.5	(a)
Al2O3	16.8	13.3	(a)	14.9	(b)	14.4	(a)
FeO	7.4	8.3	(a)	9.9	(b)	9.2	(a)
MnO	0.09	0.087	(a)	0.12	(b)	0.13	(a)
MgO	15	14	(a)	19.75	(b)	18.9	(a)
CaO	9.2	7.8	(a)	8.12	(b)	8.1	(a)
Na2O	0.42	0.36		0.35	(a)	0.37	
K2O	0.065	0.054		0.07	(b)	0.09	
P2O5							
S %							
sum							
Sc ppm	9.4	8	(a)	9.4	(a)	12.2	(a)
V							
Cr	1437	1307	(a)	1470	(a)	1763	(a)
Co	31.6	35	(a)	47	(a)	40	(a)
Ni	120	170	(a)	102	(a)	142	(a)
Cu							
Zn				3.3	(a)		
Ga				3.2	(a)		
Ge ppb				86	(a)		
As							
Se							
Rb							
Sr						119	(a)
Y							
Zr				<350	(a)	132	(a)
Nb							
Mo							
Ru							
Rh							
Pd ppb							
Ag ppb							
Cd ppb				3.8	(c)		
In ppb							
Sn ppb							
Sb ppb							
Te ppb							
Cs ppm						0.16	(a)
Ba	150	110	(a)	140	(a)	130	(a)
La	8.5	7.9	(a)	9.3	(a)	10.6	(a)
Ce	20	25	(a)	25.5	(a)	26.9	(a)
Pr							
Nd				14	(a)	15.8	(a)
Sm	3.9	2.9	(a)	3.72	(a)	4.3	(a)
Eu	1.07	0.97	(a)	0.98	(a)	1.04	(a)
Gd							
Tb	0.8	0.7	(a)	0.83	(a)	1	(a)
Dy	5.5	4.7	(a)	5.7	(a)		
Ho				1.3	(a)		
Er							
Tm							
Yb	5	3.4	(a)	3.76	(a)	5.7	(a)
Lu	0.73	0.59	(a)	0.61	(a)	0.8	(a)
Hf	2.9	3.2	(a)	2.76	(a)	3.9	(a)
Ta	0.3	0.33	(a)	0.33	(a)	0.36	(a)
W ppb							
Re ppb				<0.4	(c)		
Os ppb							
Ir ppb		6	(a)	2.8	(c)	9.1	(a)
Pt ppb							
Au ppb				0.23	(c)	2	(a)
Th ppm	1.4	0.7	(a)	1.6	(a)	1.7	(a)
U ppm				0.29	(a)	0.35	(a)

technique: (a) INAA, (b) fused bead emp, (c) RNAA

References for 78527

Butler P. (1973) **Lunar Sample Information Catalog Apollo 17.** Lunar Receiving Laboratory. MSC 03211 Curator's Catalog. pp. 447

Cushing J.A., Taylor G.J., Norman M.D. and Keil K. (1993a) The granulite suite: Impact melts and metamorphic breccias of the early lunar crust (abs). Lunar Planet. Sci. XXIV, 369-370. Lunar Planet. Institute, Houston

Cushing J.A., Taylor G.J., Norman M.D. and Keil K. (1993b) Refining the granulite suite. In Workshop on Geology of the Apollo 17 Landing Site. LPI Tech. Rpt. 92-09.4-5. Lunar Planet. Institute, Houston

Cushing J.A., Taylor G.J., Norman M.D. and Keil K. (1999) The granulitic impactite suite: Impact melts and metamorphic breccias of the early lunar crust. Meteoritics & Planet. Sci. 34, 185-195.

Dalrymple G.B. and Ryder G. (1996) Argon-40/argon-39 age spectra of Apollo 17 highlands breccia samples by laser step heating and the age of the Serenitatis basin. J. Geophys. Res. 101, 26069-26084.

Keil K., Dowty E. and Prinz M. (1974) Description, classification and inventory of 113 Apollo 17 rake samples from stations 1A, 2, 7 and 8. Curator's Catalog, pp. 149.

Laul J.C. and Schmitt R.A. (1975c) Chemical composition of Apollo 17 samples: Boulder breccias (2), rake breccias (8), and others. Lunar Planet. Sci. VI, 489-491. Lunar Planetary Institute, Houston.

Lindstrom M.M. and Lindstrom D.J. (1986) Lunar granulites and their precursor anorthositic norites of the early lunar crust. Proc. 16th Lunar Planet. Sci. Conf. in J. Geophys. Res. 91, D263-D276.

Meyer C. (1994) Catalog of Apollo 17 rocks. Vol. 4 North Massif

Muehlberger et al. (1973) Documentation and environment of the Apollo 17 samples: A preliminary report. Astrogeology 71 322 pp superceeded by Astrogeolgy 73 (1975) and by Wolfe et al. (1981)

Muehlberger W.R. and many others (1973) Preliminary Geological Investigation of the Apollo 17 Landing Site. *In* **Apollo 17 Preliminary Science Report.** NASA SP-330.

Murali A.V., Ma M.-S., Laul J.C. and Schmitt R.A. (1977a) Chemical composition of breccias, feldspathic basalt and anorthosites from Apollo 15 (15308, 15359, 15382, and 15362), Apollo 16 (60618 and 65785), Apollo 17 (72434, 72536, 72559, 72735, 72738, 78526, and 78527) and Luna 20 (22012 and 22013) (abs). Lunar Sci. VIII, 700-702. Lunar Planetary Institute, Houston.

Nehru C.E., Warner R.D., Keil K. and Taylor G.J. (1978) Metamorphism of brecciated ANT rocks: Anorthositic troctolite 72559 and norite 78527. Proc. 9th Lunar Planet. Sci. Conf. 773-788.

Warner R.D., Keil K., Taylor G.J. and Nehru C.E. (1978c) Petrology of recrystallized ANT rocks from Apollo 17 rake samples: 72558 (anorthositic troctolite) and 78527 (norite) (abs). Lunar Planet. Sci. IX, 1220-1222. Lunar Planetary Institute, Houston

Warner R.D., Keil K., Nehru C.E. and Taylor G.J. (1978) Catalogue of Apollo 17 rake samples from Stations la, 2, 7, and 8. Spec. Publ. #18, UNM Institute of Meteoritics, Albuquerque. 88 pp.

Warren P.H., Taylor G.J., Keil K., Kaltemeyn G.W., Rosener P.S. and Wasson J.T. (1983c) Sixth foray for pristine nonmare rocks and an assessment of the diversity of lunar anorthosites. Proc. 13th Lunar Planet. Sci. Conf. , in J. Geophys. Res. 88, A615-A630.

Warren P.H. (1993) A concise compilation of petrologic information on possibly pristine nonmare Moon rocks. Am. Mineral. 78, 360-376.

Wolfe E.W., Bailey N.G., Lucchitta B.K., Muehlberger W.R., Scott D.H., Sutton R.L and Wilshire H.G. (1981) The geologic investigation of the Taurus-Littrow Valley: Apollo 17 Landing Site. US Geol. Survey Prof. Paper, 1080, pp. 280.