

63545
Basaltic Impact Melt
16 grams



Figure 1: Photo of 63545 after early allocation. Scale in cm/mm. S72-55402.

Introduction

63545 was collected as a rake sample from station 13, Apollo 16 (figure 2). It is a coherent impact melt rock with numerous zap pits (figure 1). It has been dated at 3.9 b.y. and is the type example of VHA basalt (Hubbard et al. 1973; Irving 1975).

Petrography

63545 is a subophitic impact melt rock with a few relict clasts (figure 3). It is a fine-grained, impact melt rock made up of pink spinel, plagioclase, olivine, pyroxene, ilmenite and metal (with residual interstitial glass). It has clasts of mostly plagioclase (unstudied).

The major element composition plots within the spinel liquidus field on the low-pressure pseudoternary Walker diagram. 63545 has pleonaste spinel as its liquidus phase at the pressure interval 0 to 30 kbars (Delano 1977).

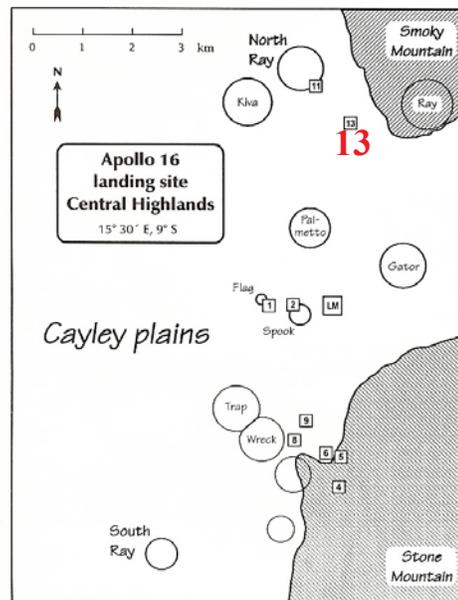


Figure 2: Map of A16 site with station 13 shown (from Korotev 1994).



Figure 3: Photomicrographs of thin section 63545,6 by Delano (1977). Field of view is 0.5 mm. Note the apparent relict clast in lower view.

Mineralogy

The mineralogical mode and composition of minerals in 63545 have not been reported (Ryder and Norman 1980). Several investigators have reported pink spinel, but give no details.

Chemistry

Hubbard et al. (1973) published analysis of 63545 and grouped it in their VHA basalt type. Stoffler et al. (1985) determined the composition by broad beam electron probe analyses. Korotev (1994) apparently chemically grouped 63545 with other samples termed "2NR". However, it has the lowest Sc and Sm of this group (figure 4) and is petrographically distinct. The critical siderophile element content has not been determined.

Radiogenic age dating

Norman et al. (2006) dated 63545 at 3.84 b.y. by Ar 39-40.(figures 5 a,b). Nyquist et al. (2011) determined 3.91 b.y. by Sm-Nd and 3.84 b.y. by Rb-Sr internal mineral isochrones (figures 6 a,b). Figure 7 is a summary of Apollo 16 ages by Ar/Ar (Norman et al. 2006).

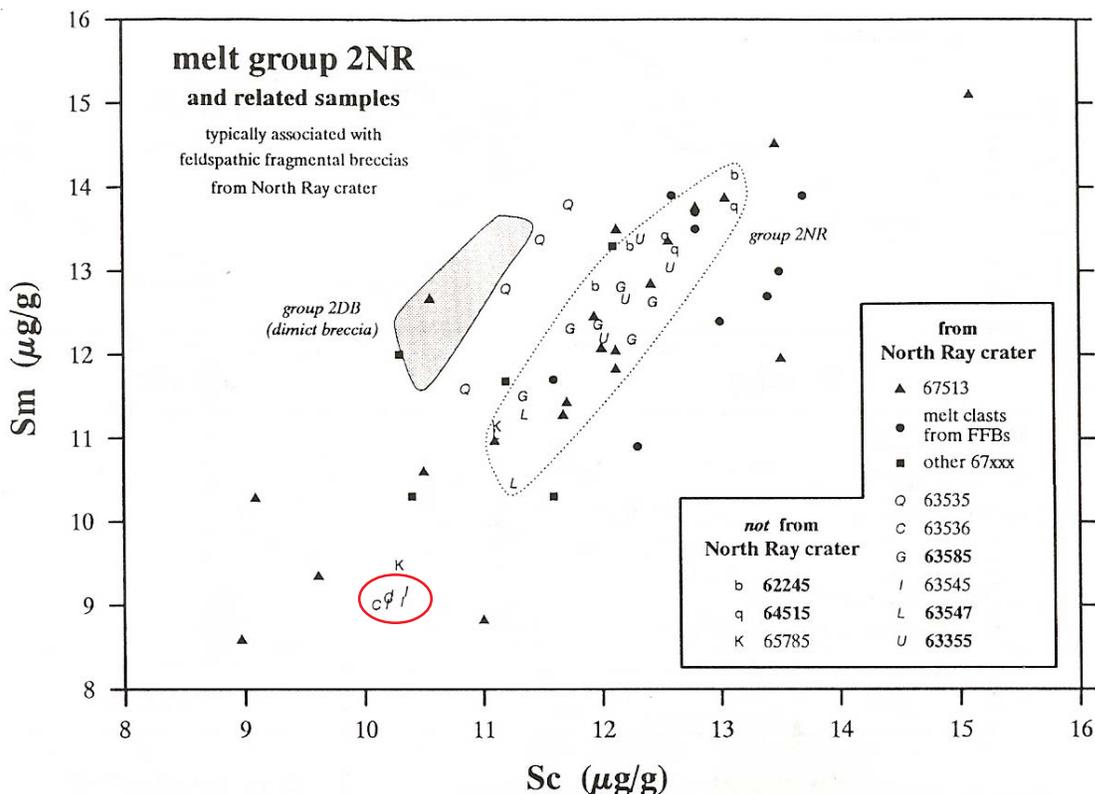


Figure 4: Composition of 63545 on Randy Korotev's main diagram for Apollo 16.

Table 1. Chemical composition of 63545.

<i>reference weight</i>	Hubbard73	Stoffler85	2NR Korotev94 group		
SiO ₂ %	43.36	(a) 43.7	(d) 45.3	(c)	
TiO ₂	0.96	0.96	(a) 1.11	(d) 1	(c)
Al ₂ O ₃	22.4	22.04	(a) 24.4	(d) 21.2	(c)
FeO	7.21	6.32	(a) 4.9	(d) 7.7	(c)
MnO	0.07		(a) 0.06	(d) 0.09	(c)
MgO	12.31	12.3	(a) 11	(d) 11.1	(c)
CaO	12.8	13.3	(a) 14	(d) 12.9	(c)
Na ₂ O	0.38	0.38	(a) 0.43	(d) 0.5	(c)
K ₂ O	0.12	0.124	(a) 0.11	(d) 0.3	(c)
P ₂ O ₅	0.17		(a) 0.08	(d) 0.19	(c)
S %	0.08		(a)	0.11	(c)
<i>sum</i>					
Sc ppm				12.2	(c)
V					
Cr	750	(b)		1190	(c)
Co				44.1	(c)
Ni				650	(c)
Cu					
Zn					
Ga					
Ge ppb					
As					
Se					
Rb	3.16	(b)		6	(c)
Sr	170	(b)		166	(c)
Y					
Zr				400	(c)
Nb					
Mo					
Ru					
Rh					
Pd ppb					
Ag ppb					
Cd ppb					
In ppb					
Sn ppb					
Sb ppb					
Te ppb					
Cs ppm				0.22	(c)
Ba	204	(b)		277	(c)
La	19.7	(b)		27.6	(c)
Ce	47.9	(b)		72	(c)
Pr					
Nd	32.2	(b)		43	(c)
Sm	8.55	(b)		12.7	(c)
Eu	1.48	(b)		1.51	(c)
Gd	10.1	(b)			
Tb				2.52	(c)
Dy	11.2	(b)			
Ho					
Er	6.47	(b)			
Tm					
Yb	5.94	(b)		8.85	(c)
Lu	0.888	(b)		1.2	(c)
Hf				9.6	(c)
Ta				1.11	(c)
W ppb					
Re ppb					
Os ppb					
Ir ppb				15.9	(c)
Pt ppb					
Au ppb				13.4	(c)
Th ppm				4.4	(c)
U ppm	0.699	(b)		1.26	(c)

technique: (a) XRF, (b) IDMS, (c) NOT a real analysis

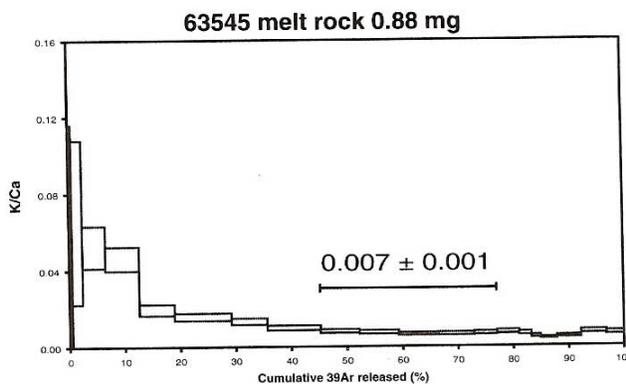
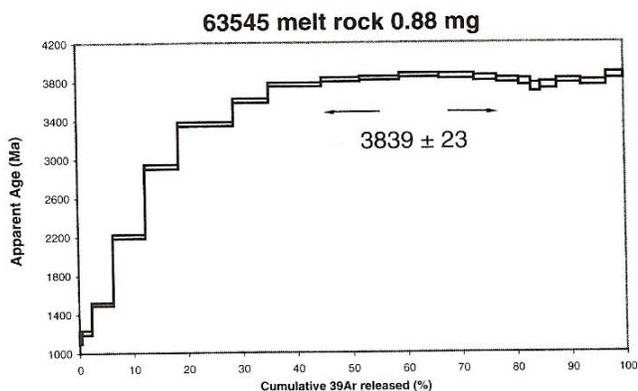


Figure 5a, b: Argon 39/40 age of 63545 (Norman et al. 2006).

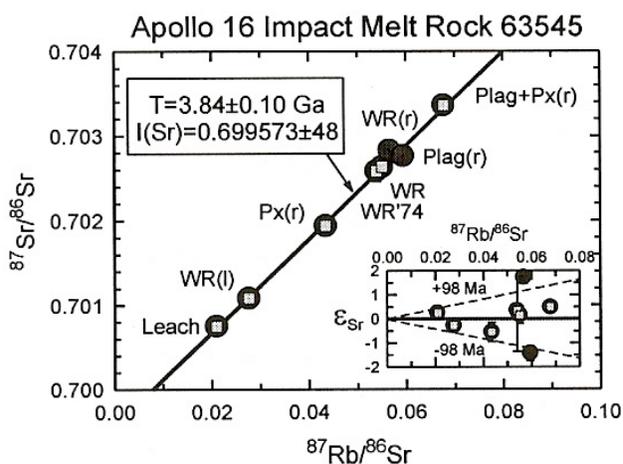
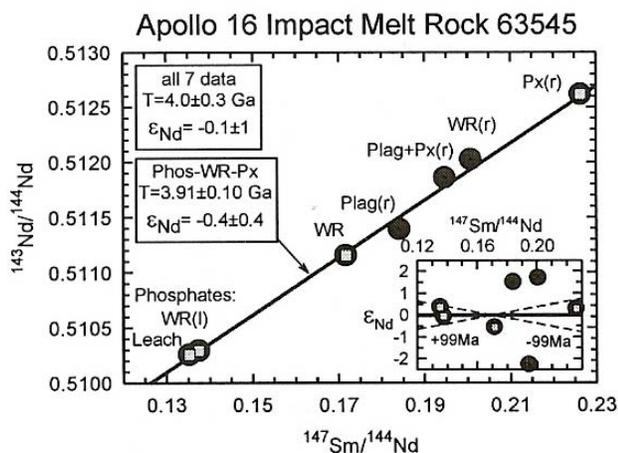


Figure 6 a,b: Internal mineral isochrons for 63545 (Nyquist et al. 2011).

Other Studies

Pearce and Simonds (1974) reported some magnetic measurements made on a potted butt.

Processing

63545 has been chipped, not sawn. There are 3 thin sections.

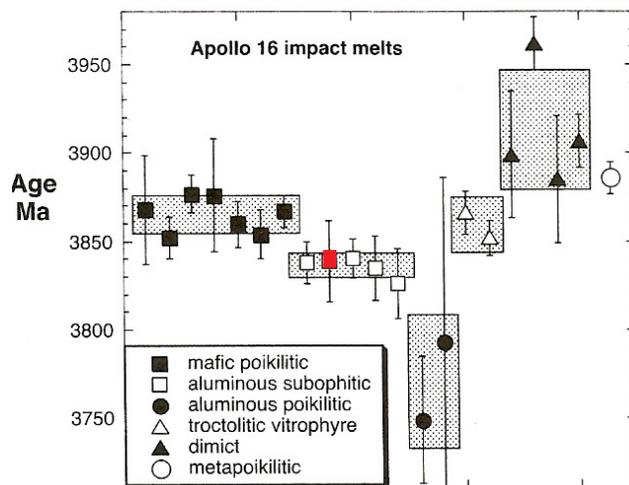
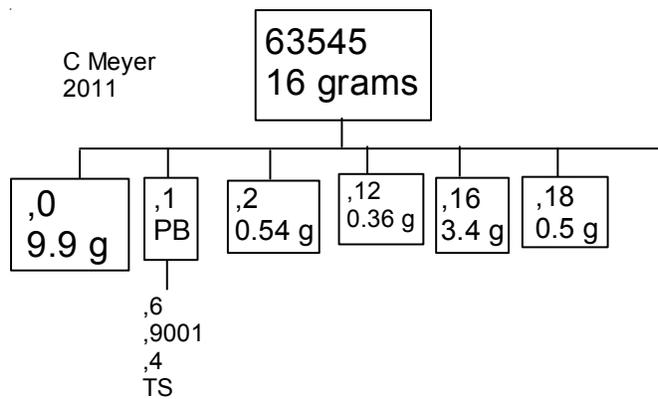


Figure 7: Summary age diagram by Norman et al. 2006, based on their Ar/Ar dating.

Summary of Age Data for 63545

	Ar/Ar	Rb/Sr	Sm/Nd
Norman et al. 2006	3.84 ± 0.02 b.y.		
Nyquist et al. 2011		3.84 ± 0.1 b.y.	3.91 ± 0.1 b.y.

Caution: Not corrected for various versions of decay constants.



References for 63545

Butler P. (1972a) Lunar Sample Information Catalog Apollo 16. Lunar Receiving Laboratory. MSC 03210 Curator's Catalog. pp. 370.

Delano J.W. (1977) Experimental melting relations of 63545, 76015 and 76055. *Proc. 8th Lunar Sci. Conf.* 2097-2123.

Hubbard N.J., Rhodes J.M. and Gast P.W. (1973a) Chemistry of lunar basalts with very high alumina contents. *Science* **181**, 339-342.

Hubbard N.J., Rhodes J.M., Gast P.W., Bansal B.M., Shih C.-Y., Wiesmann H. and Nyquist L.E. (1973b) Lunar rock types: The role of plagioclase in non-mare and highland rock types. *Proc. 4th Lunar Sci. Conf.* 1297-1312.

Irving A.J. (1975) Chemical, mineralogical, and textural systematics of non-mare melt rocks: implications for lunar impact and volcanic processes. *Proc. 6th Lunar Sci. Conf.* 363-394.

Korotev R.L. (1994) Compositional variation in Apollo 16 impact melt breccias and inferences for the geology and bombardment history of the central highlands of the Moon. *Geochim. Cosmochim. Acta* **58**, 3931-3969.

LSPET (1973b) The Apollo 16 lunar samples: Petrographic and chemical description. *Science* **179**, 23-34.

LSPET (1972c) Preliminary examination of lunar samples. In Apollo 16 Preliminary Science Report. NASA SP-315, 7-1—7-58.

Norman M.D., Duncan R.A. and Huard J.J. (2006) Identifying impact events within the lunar catalysm from ⁴⁰Ar-³⁹Ar ages and compositions of Apollo 16 impact melt rocks. *Geochim. Cosmochim. Acta* **70**, 6032-6049.

Nyquist L.E., Hubbard N.J., Gast P.W., Bansal B.M., Wiesmann H. and Jahn B.-M. (1973) Rb-Sr systematics for

chemically defined Apollo 15 and 16 materials. *Proc. 4th Lunar Sci. Conf.* 1823-1846.

Nyquist L.E., Shih C.-Y. and Reese Y.D. (2011) Dating rock 63545 by Rb-Sr and Sm-Nd: Age of Imbrium; SPA dress rehearsal (abs#1868). *42nd Lunar Planet. Sci. Conf.* @ The Woodlands.

Pearce G.W. and Simonds C.H. (1974) Magnetic properties of Apollo 16 samples and implications for their mode of formation. *J. Geophys. Res.* **79**, 2953-2959.

Phinney W. and Lofgren G. (1973) Description, classification and inventory of Apollo 16 rake samples from stations 1, 4 and 13. Curators Office.

Reimold W.U., Nyquist L.E., Bansal B.M., Wooden J.L., Shih C.-Y., Wiesmann H. and Mackinnon I.D.R. (1985) Isotope analysis of crystalline impact-melt rocks from Apollo 16 stations 11 and 13. North Ray Crater. *Proc. 15th Lunar Planet. Sci. Conf.* in *J. Geophys. Res.* **90**, C431-C448.

Ryder G. and Norman M.D. (1980) Catalog of Apollo 16 rocks (3 vol.). Curator's Office pub. #52, JSC #16904

Stöffler D., Ostertag R., Reimold W.U., Borchardt R., Malley J. and Rehfeldt A. (1981) Distribution and provenance of lunar highland rock types at North Ray Crater, Apollo 16. *Proc. 12th Lunar Planet. Sci. Conf.* 185-207.

Stöffler D., Bischoff A., Borchardt R., Burghele A., Deutsch A., Jessberger E.K., Ostertag R., Palme H., Spettel B., Reimold W.U., Wacker K. and Wanke H. (1985) Composition and evolution of the lunar crust in the Descartes highlands. *Proc. 15th Lunar Planet. Sci. Conf.* in *J. Geophys. Res.* **90**, C449-C506.

Sutton R.L. (1981) Documentation of Apollo 16 samples. In *Geology of the Apollo 16 area, central lunar highlands.* (Ulrich et al.) U.S.G.S. Prof. Paper 1048.

Warner J.L., Simonds C.H. and Phinney W.C. (1973b) Apollo 16 rocks: Classification and petrogenetic model. *Proc. 4th Lunar Sci. Conf.* 481-504.

Wiesmann H. and Hubbard N.J. (1975) A compilation of the Lunar Sample Data Generated by the Gast, Nyquist and Hubbard Lunar Sample PI-Ships. Unpublished. JSC