67955 CATACLASIZED POIKILOBLASTIC NORITIC ANORTHOSITE 163 g

INTRODUCTION: 67955 is a gray, noritic anorthosite which has experienced extensive subsolidus annealing and equilibration, followed by mild brecciation. The sample breaks apart easily along the many fractures but individual pieces are coherent. Several glass veins cut the rock (Fig. 1).

67955 was collected to sample a large white clast in Outhouse Rock on the east rim of North Ray Crater (see 67915, Fig. 1). The lunar orientation is unknown. Many zap pits are present on original surfaces but are poorly preserved due to the friability of the rock.


FIGURE 1. S-72-37609.

PETROLOGY: 67955 is a coarse-grained, poikiloblastic rock that has been extensively annealed and subsequently brecciated. Warner et al. (1977) classify it as a "feldspathic granulitic impactite." Petrographic descriptions are given by Hollister (1973), Ashwal (1975) and Nord et a1. (1975). Texturally 67955 is dominated by coarse-grained clasts of noritic anorthosite (up to 1.5 cm) that grade to a matrix of finely comminuted mineral grains (Fig. 2). These lithic clasts typically show large (some >1 mm) pyroxene poikiloblasts surrounding subhedral to anhedral plagioclase and olivine. Brown glass veins penetrate the matrix but do not cut larger clasts. Roedder and Weiblen (1977a) discuss these glass veins in detail.

A mode given by Hollister (1973) is 78.5% plagioclase, 14.5% pyroxene (low-Ca > high-Ca), 6% olivine and 1% opaques. Minerals in both the lithic clasts and in the matrix are compositionally identical and very homogeneous (Fig. 3). Together with the seriate texture this suggests that the last brecciation event involved simple crushing of the precursor without the introduction of significant foreign material.

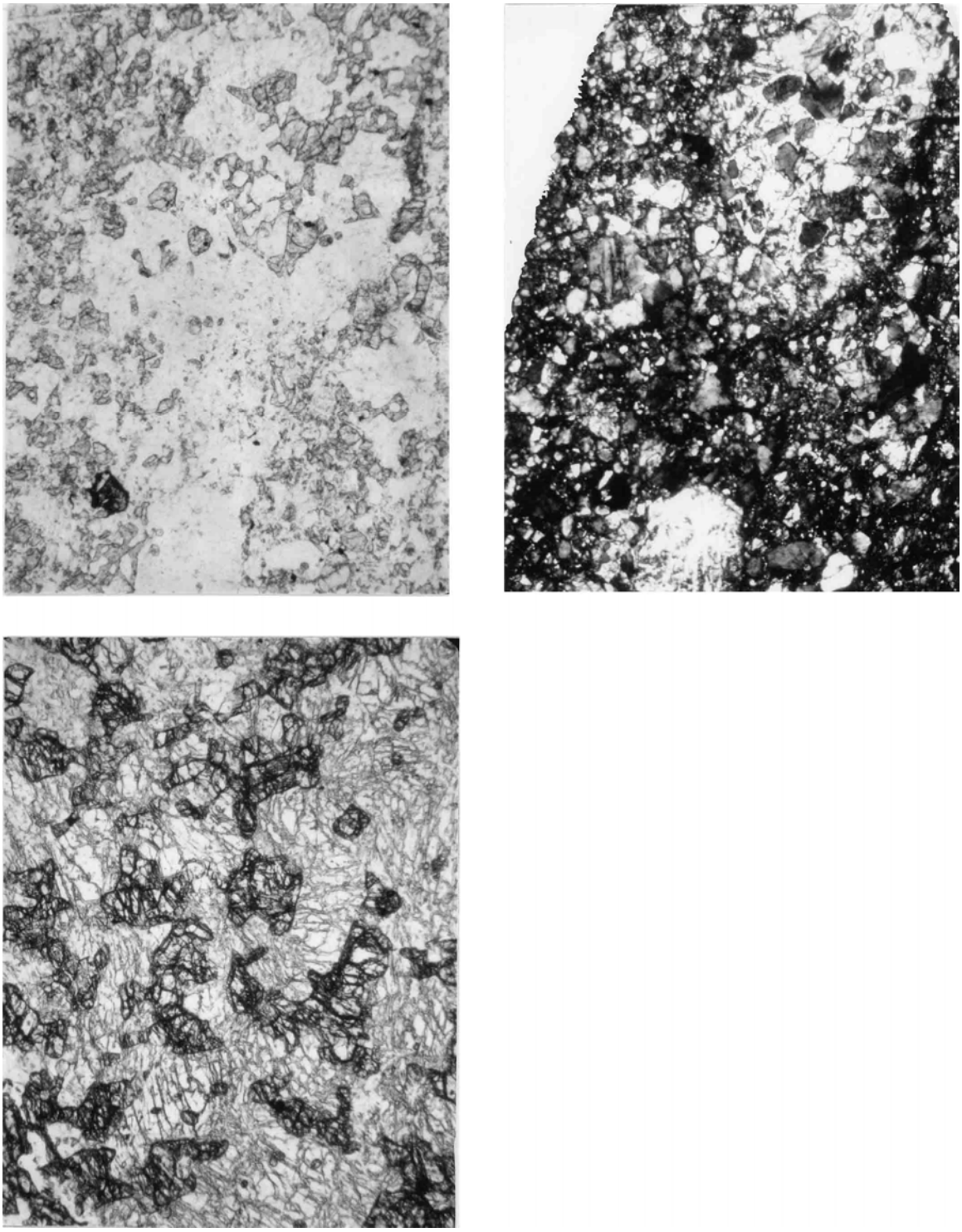


FIGURE 2.
a) 67955,6. Granoblastic clast in fragmental matrix, ppl. Width 2 mm.
b) Same view as a) but xpl.
c) 67955,47. Coarse-grained area, ppl. Width 2 mm.

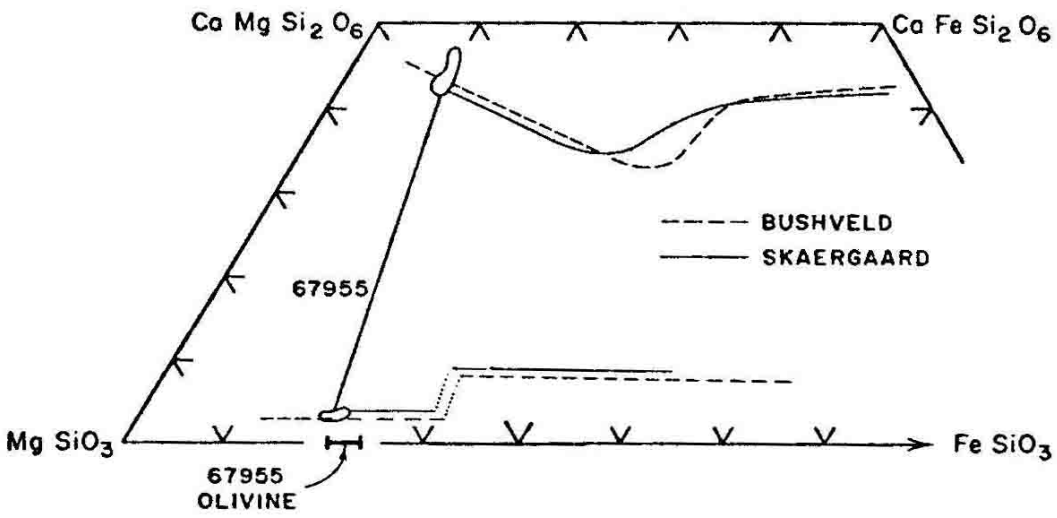



FIGURE 3. Pyroxene and olivine compositions from Ashwal (1975).

Plagioclase is $An_{92-97}$ (Fig. 4). Ashwal (1975) notes a weak but perceptible normal zoning (up to 2 mol % An). Shock effects in plagioclase range from fracturing and twinning through complete vitrification. The large oikocrysts are chiefly low-Ca pyroxene with high-Ca pyroxene restricted to interoikocryst regions. Neither of the pyroxenes in 67955 appear to be exsolved, but a small amount of optically invisible exsolution may account for some of the compositional variation in the high-Ca pyroxenes (Ashwal, 1975). Within the lithic clasts, olivine occurs either as rounded, interstitial grains or as inclusions within plagioclase and pyroxene. In some places, olivine inclusions are concentrated near the rims of larger plagioclase grains producing a "necklace" structure. Minor elements in olivine are very low (CaO 0.06%, $Cr_2O_3$ 0.04%, $TiO_2$ 0.04%) (Hollister, 1973). Trace phases in the lithic clasts include coexisting low-Ni and high-Ni metal (Fig. 5), ilmenite, troilite, phosphate, spinel and rare radiating oxide-anorthite complexes. Hollister (1973) reports a single large (0.5 mm) olivine clast, weakly zoned from $Fo_{78-81}$. This grain has no apparent counterpart in any of the lithic fragments.

Temperatures of equilibration of 1000-1100° C have been calculated from the composition of the mafic silicates in 67955 (Ridley and Adams, 1976; Hollister, 1973). Considering such high temperatures it is likely that some silicate melt was involved in the petrogenesis of this rock (Hollister,1973). In an electron petrographic study Nord et al. (1975) conclude that 67955 was not lithified by the North Ray Crater event.

CHEMISTRY: Major and trace element analyses of the bulk rock are reported by et al. (1974), Boynton et al. (1976), Wasson et al. (1977), Palme et al. (1978) and LSPET (1973). Meteoritic siderophile and volatile abundances are given by Ganapathy et al. (1974). Rancitelli et al. (1973a, b) provide natural and cosmogenic radionuclide abundances. Roedder and Weiblen (1977a) give electron microprobe analyses of the glass veins.

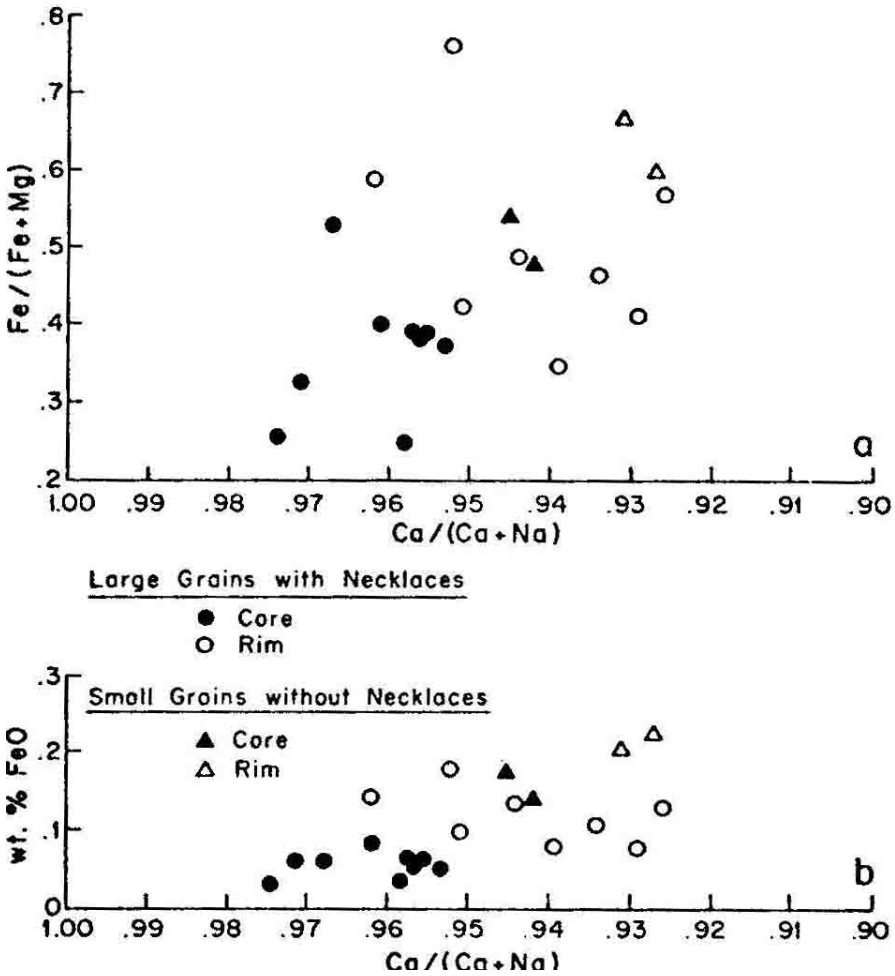
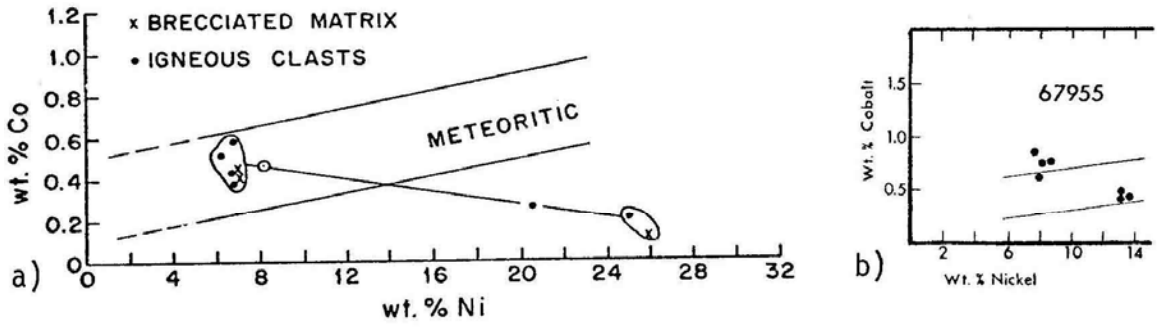



FIGURE 4. Plagioclase compositions, from Ashwal (1975).




Compositions of coexisting low- and high-Ni metallic phases from 67955 showing chemical similarity between grains in the anorthositic norite clasts and the granulated matrix. The circle indicates estimated pre-unmixing composition assuming 5 vol.% of high-Ni phase.

FIGURE 5. Metal compositions.
a) from Ashwal (1975). b) from Misra and Taylor (1975). See also Hollister (1973).

The analyses show that 67955 is a very homogeneous rock with ~27% $Al_2O_3$ and rare earths ~15 times chondrites (Table 1, Fig. 6). Siderophile element abundances indicate that there is significant meteoritic contamination. Hertogen et al. (1977) assign the meteoritic signature to Group 5H, common among North Ray Crater rocks. The glass veins are distinctly more aluminous and less magnesian than the bulk rock (Table 1), and therefore must represent injected foreign material rather than mobilized bulk rock.

RADIOGENIC ISOTOPES AND GEOCHRONOLOGY: Nyquist et al. (1974) give whole rock Rb-Sr isotopic data and calculate model ages of 4.70 ± 0.46 b.y. ($T_{BABI}$) and 5.01 ± 0.46 b.y. ($T_{LUNI}$) (Table 2).

U-Th-Pb isotopic data are reported by Oberli et al. (1979). 67955 contains excess U relative to its Pb content and plots slightly above the 3.9 - 4.45 b.y. "cataclysm" line.

RARE GASES/EXPOSURE AGES: Drozd et al. (1974) give Kr isotopic data and calculate $^{81}$Kr-Kr, $^{21}$Ne and $^{38}$Ar exposure ages of 50.1 ± 1.6, 17.9 ± 4.2 and 32.0 ± 12 m.y., respectively. Pepin et al. (1974) note that $^{21}$Ne and $^{38}$Ar ages tend to be systematically lower than $^{81}$Kr ages, and calculate a shielding depth of 4.8 g/cm$^2$ for which all ages are concordant at ~50 m.y. These data are consistent with the excavation of Outhouse Rock from a well-shielded area to its present location in. a single event.

$^{22}$Na and $^{26}$Al data are given by Rancitelli et al. (1973a). From these data Yokoyama et al. (1974) conclude that 67955 is probably saturated in $^{26}$Al activity.

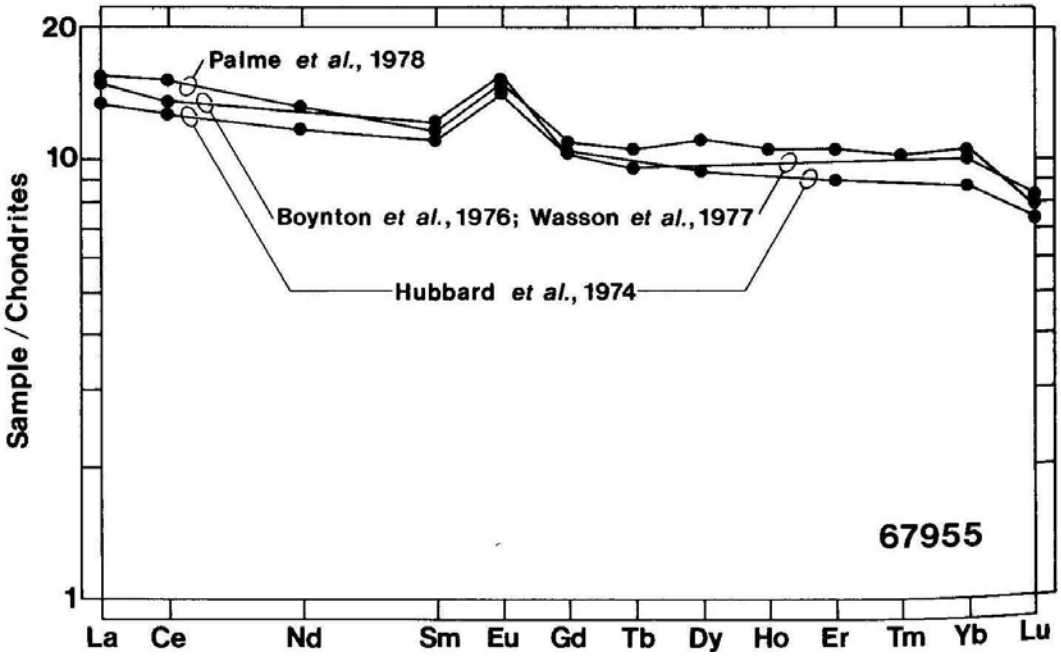



FIGURE 6. Rare earths.

PROCESSING AND SUBDIVISIONS: In 1972, 67955 was removed from its Documented Bag as four pieces, which were numbered ,1 - ,4 (Fig. 1). Allocations were filled mostly from chips from the largest piece (,1). The sample has never been sawn. ,1 is the largest single piece remaining (103.07 g).

TABLE 1. Summary chemistry of 67955 lithologies.

| | Bulk Rock | Glass Veins |
|---|---|---|
| $SiO_2$ | 45.2 | 46.3 |
| $TiO_2$ | 0.30 | 0.21 |
| $Al_2O_3$ | 27.3 | 29.8 |
| $Cr_2O_3$ | 0.12 | <0.05 |
| FeO | 4.2 | 3.0 |
| MnO | 0.06 | <0.05 |
| MgO | 7.7 | 4.9 |
| CaO | 15.3 | 15.5 |
| $Na_2O$ | 0.45 | 0.23 |
| $K_2O$ | 0.060 | 0.06 |
| $P_2O_5$ | 0.05 | <0.05 |
| Sr | 170 | |
| La | 4.9 | |
| Lu | 0.27 | |
| Rb | 0.9 | |
| Sc | 7.2 | |
| Ni | 173 | |
| Co | 17 | |
| Ir ppb | 6.9 | |
| Au ppb | 2.0 | |
| C | | |
| N | | |
| S | 100 | |
| Zn | 6.6 | |
| Cu | 1.28 | |

Oxides in wt%; others in ppm except as noted.

TABLE 2. Rb-Sr data for 67955,56 (Nyquist et al., 1974).

| $Rb_{ppm}$ | $Sr_{ppm}$ | $^{87}Rb/^{86}Sr$ | $^{87}Sr/^{86}Sr$ | $T_{BABI}$ (b.y.) | $T_{LUNI}$ (b.y.) |
|---|---|---|---|---|---|
| 0.885 | 169.1 | 0.0151±3 | 0.70012±8 | 4.70±.46 | 5.01±.46 |