PETROLOGY OF CLASTS IN BRECCIA 67915, Edwin Roedder, U.S. Geol. Survey, Washington, D.C. 20244, and P.W. Weiblen, Dept. Geol. & Geophys., Univ Minn., Minneapolos, Minn. 55455

Rock 67915 is a 2.6-kg feldspathic polymict B4 breccia (dark matrix, light clasts (1)) from Outhouse Rock at Sta. 11. It shows two large ill-defined whiter areas in a darker gray matrix; on the sawn surface the color contrast is greatly enhanced, but both these parts are themselves made of smaller clasts. No individual crystals are recognizable to the eye.

Forty-two probe mounts were made from various clasts in this complex polymict breccia. Although these clasts are quite variable in appearance, they are surprisingly similar in composition (2). The complex nature of the rock makes quantitative estimation of clast population hazardous at best, but ~95% of the rock consists of clasts ranging in composition from gabbroic to troctolitic anorthosite, set in a matrix of similar composition. Most clasts consist of crystal fragments of plagioclase and less abundant pyroxene and/or olivine embedded in a matrix of finer fragments of these same three minerals. Individual homogeneous clasts are generally only a millimeter or less in size. With a few exceptions, both opaque minerals and K-rich areas are either very scarce or completely absent in both clasts and matrix. One generalization is that the clasts made of fine crystal fragments tend to be either quartz- or olivine-normative gabbroic anorthosite, whereas those with coarser crystals are more commonly troctolitic anorthosite. Although the compositional range for the bulk of the clasts is rather small, the range of textural states is large, as is the range of shock metamorphic effects. These features will be described in greater detail in a later paper by another consortium member (B.N. Powell).

The gabbroic anorthosite clasts have been described previously (2). Most of the troctolitic anorthosite exists in three textural categories. The most common, presumably metamorphic in origin, consists of plagioclase and less abundant olivine fragments, $\geq$ 100 μm, set in a granoblastic matrix of finer grained plagioclase (An_{93}; anal. 1; Fig. 1). About 10% of the matrix consists of olivine (Fo_{70-80}; anal. 2) in 10-μm grains, mainly along plagioclase grain boundaries. A second type, much less common, consists of lathlike decussate plagioclase (~An_{94}) and interstitial olivine (~Fo_{72}); it resembles the basalts in texture (Fig. 2), and may have formed from rapid quenching of impact-generated troctolitic liquids. A third type occurs as a relatively large clast in 67915, 12, and consists of large, equant subhedral plagioclase crystals (An_{95}) set in a matrix of surprisingly iron-rich interstitial olivine (Fo_{56}). Although both minerals are badly fractured (Fig. 5) and in part sheared by impact shock, the original texture appears to be of cumulus origin.

The remaining 5% of the clasts in 67915 include a wide variety of rock types; several unique clasts may be of meteoritic origin (2). In addition to these individual, unique clasts, there are clasts of sodic ferrogabbro, mare basalt, and peridotite, judging from mineral analyses of the phases present. No additional clasts of the distinctive sodic ferrogabbro described earlier (2) have been found, but sheared concentrations of mineral fragments, (plagioclase ~Ab_{34}, ferropigeonite ~Fs_{65}, and cristobalite), presumably from this rock type, are present in several samples of the breccia. The total quantity

PETROLOGY OF CLASTS IN BRECCIA 67915

Roedder, E., & Weiblen, P.W.

of sodic ferrogabbro in 67915 cannot be large, however, as it is very high in K_2O, and the whole rock is extremely low in K_2O (3).

Basalt clasts are a relatively rare component. Although most apparent basalt clasts prove to be troctolites with decussate texture, at least one small one is a normal mare basalt in texture and mineralogy, complete with high-K plagioclase and late stage concentrations of K and Ba. If this is truly a fragment of mare basalt, it raises several problems, in particular as to its age of formation.

Several clasts of peridotite composition have been found. One of these (Figs. 3 and 4) consists mainly of augitic pyroxene ($En_{45}Wo_{35}Fs_{20}$; anal. 3) with a minor amount of exsolution resolvable (wt. % CaO varies from 15.4 to 18.2), olivine (Fo_{60-62}), plagioclase (An_{82-87}), and ilmenite (MgO-2.97 wt. %). Although badly shocked and polygonized, an original igneous texture is apparent. Another very unusual clast of peridotite consists mainly of orthopyroxene (opx) crystals (Fig. 6) containing perhaps 5% of oriented lamellae of clinopyroxene (cpx) as much as 10 μm thick (Fig. 7). The size and large difference in composition between the cpx lamellae ($En_{41.5}Wo_{42.3}Fs_{16.2}$; anal. 4) and the opx host ($En_{66.2}Wo_{3.9}Fs_{29.9}$; anal. 5; Fig. 8) suggest a relatively low equilibration temperature, perhaps 1000°C (4). Several coarse crystals of twinned but compositionally similar cpx occur in the same clast; these, however, are uniform, i.e., lack lamellae (Fig. 9, made at same scale factors as Fig. 8). Olivine (Fo_{65}; anal. 6) and plagioclase (An_{93}; anal. 7), plus minor amounts of ilmenite (MgO-3.71%), chromite, troilite, and 2.30% nickel iron make up the balance. Embedded in the opx crystals are clots of small crystals of plagioclase (An_{93}) and olivine (Fo_{73}). Fine intergrowths (Fig. 10) of opx (En_{62}) and troilite occur throughout the clast, mainly interstitial to or completely within olivine grains. One large, strongly curved olivine grain appears to have been partly replaced with this intergrowth. A possibly important feature of both peridotite clasts is the relatively high K_2O in the plagioclase (0.10-0.21%), in contrast with the bulk of the plagioclase in 67915, in which K_2O is below the detection limit (<0.05).

The question arises whether all the recognized rock types except the possible mare basalt could have been derived from a common parent by crystal fractionation, as has been suggested (5,6), or whether they belong to two magma series (see references in 7). This problem is treated in a companion paper by Weiblen and Powell in this volume.

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PETROLOGY OF CLASTS IN BRECCIA 67915

Roedder, E., & Weiblen, P.W.

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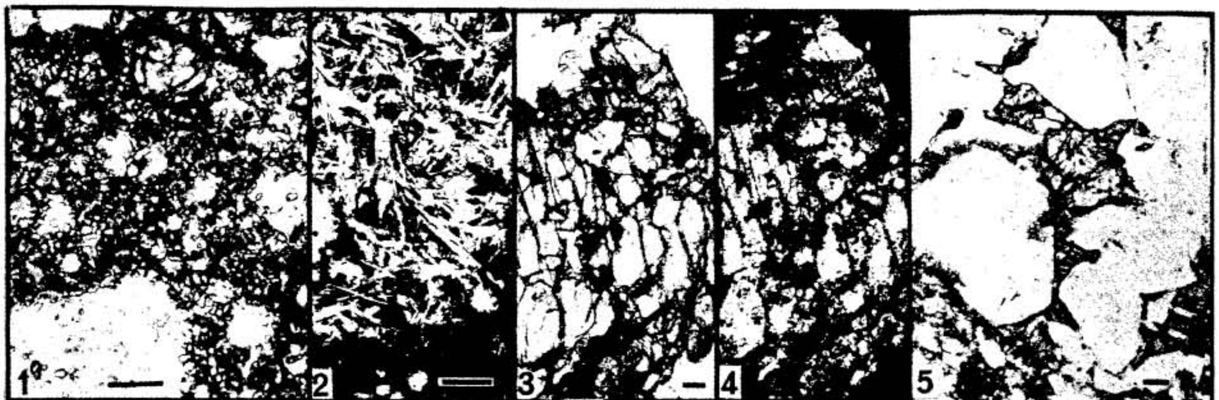
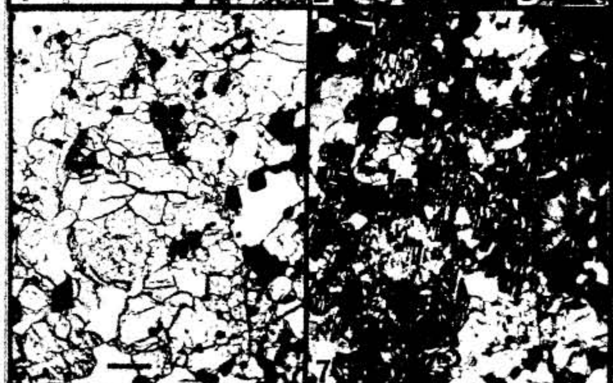
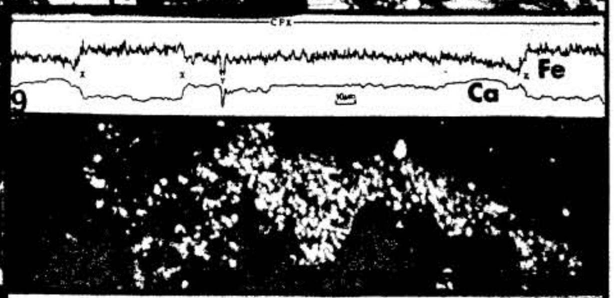
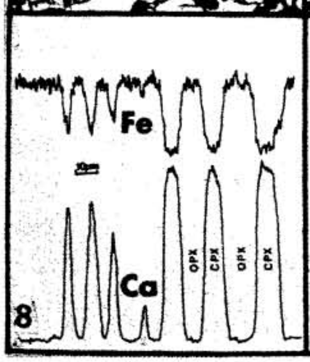






Typical mineral analyses from clasts in 67915 (see text for details)

Anal.	1.	2.	3.	4.	5.	6.	7.
SiO_2	44.5	39.9	49.4	52.6	51.7	36.3	44.7
Al_2O_3	34.2	0.17	1.48	1.57	0.67	<0.05	35.3
FeO	0.11	23.9	12.3	9.60	19.1	30.5	0.32
MgO	0.33	35.1	16.4	13.8	23.7	32.4	0.05
CaO	18.8	0.02	17.7	19.6	1.94	0.12	18.6
Na_2O	0.73	-	-	<0.05	<0.05	-	0.69
K_2O	<0.05	-	-	-	-	-	0.10
TiO_2	<0.05	-	1.09	0.83	0.51	0.06	0.05
MnO	<0.05	0.28	0.21	0.20	0.21	0.42	<0.05
Cr_2O_3	-	-	0.31	0.45	0.21	<0.05	-
NiO	-	-	<0.05	<0.05	<0.05	<0.05	-
Total	98.67	99.37	98.89	98.65	98.04	99.80	99.81



Figs. 1,2,3,5, and 6 - Photomicrographs taken in plain transmitted light; Figs. 4 and 7 - Same areas as Figs. 3 and 6, crossed polarizers; Figs. 8 and 9 - Electron microprobe traces (Opx - orthopyroxene, Cpx - clinopyroxene, X - grain boundary, Y - crack); Fig. 10 - Reflected plain light. Bars in photos are 100 µm. See text for details.