SHOCK COMPRESSION OF A RECRYSTALLIZED BRECCIA FROM APOLLO 15*, T. J. Ahrens*, J. D. O'Keefe**, and R. V. Gibbons*,

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We have carried out 8 Hugoniot equation of state experiments on 15,418, a naturally shocked, nearly completely recrystallized rock of gabbroic anorthosite composition (1) (2). Petrographic analysis yields the following volumetric mineralogic composition: plagioclase, 74 ± 5%, pyroxenes plus small fraction olivine, 25 ± 5%, opaque minerals (iron-nickel, troilite) 0.1 ±0.05%, and vesicles 1.0 ± 0.5%. This analysis is in disagreement with the CIPW norm calculated from previously reported whole-rock compositions (3). Microprobe analysis yields for the plagioclase (An 95) composition: Na_2O, 0.39 ± .02; MgO, 0.06 ± .04; Al_2O_3, 35.5 ± 0.8; SiO_2, 44.7 ± 0.1; K_2O, 0.019 ± 0.01; CaO, 19.90 ± 0.08; FeO, 0.25 ± 0.08; and BaO, 0.01 ± 0.01, weight percent. Pyroxenes of two discrete chemistries are observed in this rock with compositions: (a) Na_2O, 0.08 ± .08; MgO, 21.4 ± 0.7; Al_2O_3, 1.5 ± 0.6; SiO_2, 52.3 ± 0.9; CaO, 1.6 ± 0.1; TiO_2, 0.54 ± .05; Cr_2O_3, 0.24 ± 0.01, MnO, 0.39 ± .01, and FeO, 22.3 ±0.2, and (b) Na_2O, 0.04; MgO, 14.2; Al_2O_3, 2.0; SiO_2, 51.7; CaO, 21.1; TiO_2, 1.1; Cr_2O_3, 0.85, MnO, 0.2; FeO, 10.2 (weight percent). The olivine present in the rock, which is difficult to optically differentiate from the pyroxene, has a composition: Na_2O, 0.003 ± 0.003; MgO, 24.9 ± 1.0; Al_2O_3, 0.4 ± 0.4; SiO_2, 36.4 ± 0.6; CaO, 0.7 ± 0.6; TiO_2, 0.07 ± 0.05; Cr_2O_3, 0.06 ± 0.01; MnO, 0.48 ± .01; FeO, 39.3 ± 0.8 (weight percent). Twelve individual specimens machined out of 15,418 (individual mass ~ 1.25 gm) had an average bulk density of 2.825 g/cm^3. Samples varied by at most, 0.015 g/cm^3 from average. The above densities include vesicles.

Using streak photography and projectile-impact techniques, a double-fronted shock wave was observed in all the shock experiments (Table 1). The amplitude of the elastic shock probably represents the Hugoniot elastic limit(4). We suggest that little or no shock damage should be induced by a stress wave of this or lower amplitude.

The observation (Figure 1) that 15,418 has density some 0.12 g/cm^3 greater than somewhat more pyroxene-rich terrestrial rocks is attributed to the greater iron content of the lunar pyroxene and the probability that the shock-induced high-pressure phase of plagioclase is slightly denser (hollandite structure, 3.84 g/cm) than the presumed shock-induced high pressure phase of pyroxene, majorite (3.78 g/cm^3).

We have constructed, using the theory of interacting continua (5), a theoretical Hugoniot for the present composition over a wider-than-experimental range of pressures by assuming each mineralogic constituent follows its individual equation of state with no exchange of heat between minerals, and that the shock pressure and particle velocity of all constituents are equal. For such a Hugoniot, appreciable shock melting should occur upon adiabatic release from 1.3 ± .3 Mbar, which is equivalent to the peak pressure produced upon impact of a 5 km/sec iron meteorite. We appreciate the help of A. Chodos in analyzing our sample and the experimental assistance of D. Johnson and H. Richeson. Work supported under NASA Grant NGL 05-002-105.

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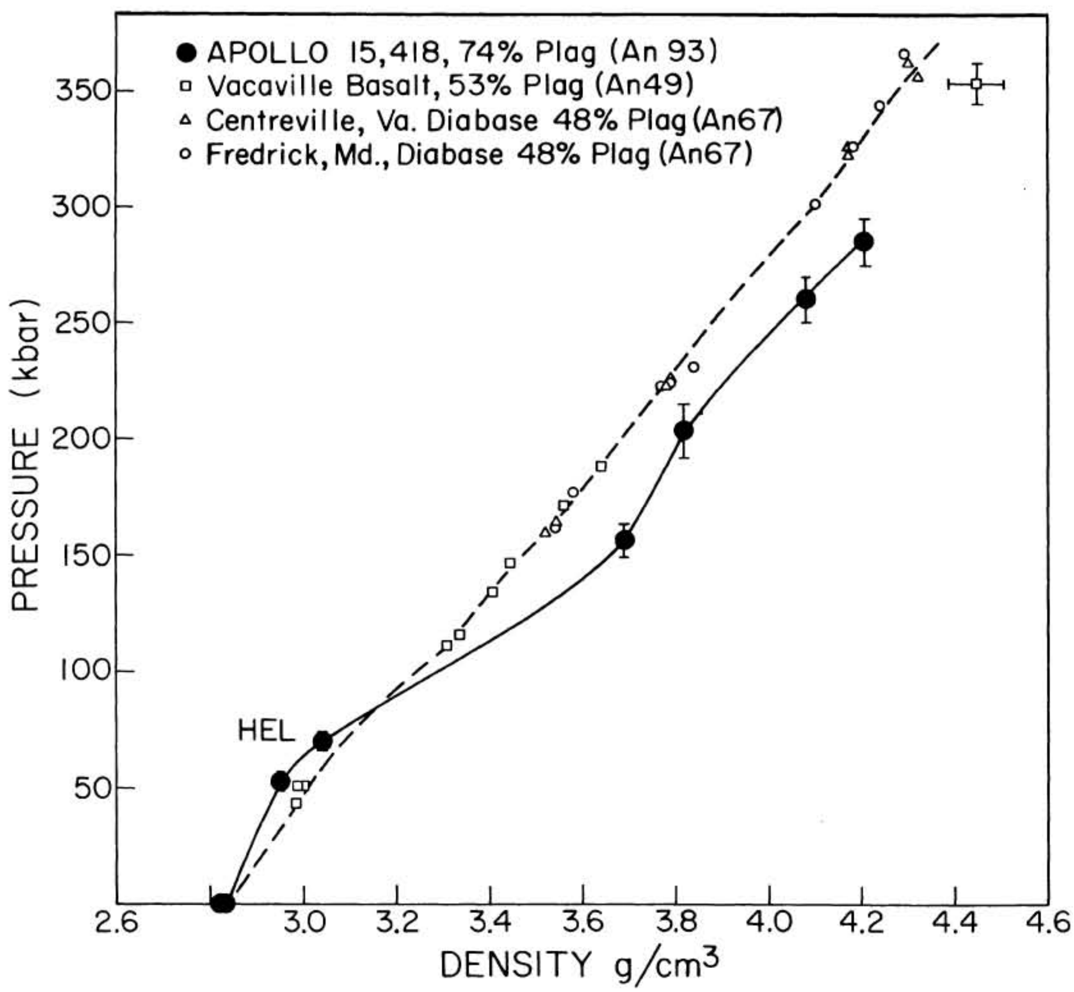

Table 1.

Hugoniot Data, Lunar Sample 15,418

(a)	(b)	(c)*	(d)	(e)	(f)	(g)	(g)
270	2.821	1.618 ±0.005	5.88 ±0.09	0.84	70 ± 4	204 ± 12	3.82
276	2.834	1.318 ±0.001	6.02 ±0.12	**	**	155 ± 8	3.69
268	2.813	2.166 ±0.005	6.30 ±0.01	0.60	53 ± 4	285 ± 10	4.21
269	2.822	1.992 ±0.005	6.10 ±.05	**	**	260	4.08

*polycrystalline W, 19.3 g/cm^3
**not measured

(a) Shot No.
(b) Initial Density (g/cm^3)
(c) Flyer Plate Velocity (km/sec)
(d) Elastic Shock Velocity (km/sec)
(e) Free-Surface Velocity (km/sec)
(f) Hugoniot Elastic Limit (kb)
(g) Final Shock Pressure (kb)
(h) Final Shock Density (g/cm^3)