# PRIMARY MAGNESIAN EUCRITE MAGMA COMPOSITIONS: ESTIMATES FROM THE COMPOSITIONS OF CUMULATE DIOGENITES

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If diogenites are cumulates generated by the fractional crystallization of the magnesian eucrite primary magmas at elevated pressures within the eucrite parent body (EPB), their compositions can be used to set limits on the chemical characteristics of the most primitive magma that crystallized pyroxene to generate these cumulates. This abstract represents a first attempt to use the results of our experiments on magnesian eucrites to interpret diogenite cumulates. Our elevated pressure experiments [1] determined the effect of pressure on crystallization boundaries relevant to the generation of diogenite cumulates. At a pressure of 1 kbar the olivine primary phase volume shrinks and the olivine(oliv) - low-Ca pyroxene - spinel - liquid boundary is no longer a reaction boundary. At 1 kbar experimentally produced liquids on the olivine(oliv) - low-Ca pyroxene - spinel - liquid boundary are plagioclase (plag) - hypersthene normative, indicating that the boundary is tangential to low-Ca pyroxene (lo-Ca pyx). Since the maximum pressure attained in a Vesta-sized EPB is about 1 kbar, our experimental result allows the generation of diogenite cumulates by polybaric fractional crystallization of an ascending partial melt produced at depth within the EPB.

Potential magnesian eucrite parental magmas have been identified as clasts in howardite meteorites. Yamato 7308 pigeonite-eucrite clast 1 and Kapoeta clast rho [2,3,4] have been proposed as the parental magmas for the incompatible-element-poor and incompatible-element-rich geochemical trends identified in eucrite basalts. We used these compositions as starting materials for our experimental study. One consequence of our experiments is that neither composition is precisely representative of what one would predict to be a high degree partial melt of the EPB parent body. When we calculate batch melts of the EPB at pressures of 1 kbar, and compare them to the compositions of Kapoeta and Yamato 7308, we find that these magmas represent 10 and 24 wt. % melts, respectively, of a model EPB composition. However, the projected positions of Kapoeta and Yamato on Olivine - Plagioclase - Quartz pseudoternary diagrams are not consistent with these predicted extents of partial melting. Kapoeta should plot at the oliv - loCa pyx - plag - spinel - metal - liquid boundary, but it projects instead to the oliv - loCa pyx - spinel - liquid boundary. Yamato should plot on the oliv - loCa pyx - spinel - liquid boundary, but it plots in the olivine primary phase volume. Jones [5] and Warren [6] have also discussed the issue of whether or not these two clasts are representative of liquid compositions.

The composition of the cumulates that would crystallize from a differentiating magnesian parental eucrite magma could provide information on magmatic evolution in the EPB. For example, the most magnesian cumulates could be used to place limits on the maximum extents of melting in the EPB. Unfortunately, diogenite cumulates appear to be complex materials. Hewins [7,8] and Harriot and Hewins [9] have distinguished several groups based on minor element compositions of pyroxenes. Mittlefehldt and Lindstrom [10] have obtained trace element data on diogenites. The results do not provide a simple picture that can be interpreted in terms of cumulates formed from a limited numbers of parent magmas. The major element compositional variation of diogenites also indicates complexity. When the bulk diogenite analyses presented by Fredriksson et al. [11] and Fredriksson [12] are plotted on pseudoternary diagrams, Manegaon and Garland are distinguished by a high feldspar component, and are therefore not simple cumulates. Roda has the highest proportion of olivine in its norm (pyx/[oliv + pyx] = 0.75. Our experiments indicate that a cumulate formed at 1 kbar should have pyx/[oliv + pyx] = 0.97. At lower pressures, fractionation of loCa pyx alone should occur. All the diogenites in [10 and 11] contain normative olivine. Ibbenbuhren, Johnstown, Shalka and Tatahouine have pyx/[oliv + pyx] > 0.95, and these samples may be easier to interpret.

*Estimates of eucrite primary magma composition* If we accept magnesian eucrite clasts Yamato 7308 and Kapoeta rho as approximate, but imperfect representatives of the primary magma produced at depth, we can use the results of our elevated pressure experiments to refine these compositions. The table shows a calculated batch melt using the EPB composition of Morgan [13] and 1 kbar saturation boundaries. This melt is saturated with oliv, loCa pyx and spinel and represents about 24 % melting of the EPB. Also shown are the compositions of silicate phases saturated with this liquid. These predicted compositions fall within the range of cumulus pyroxenes and olivines found in diogenites. The analyzed "average pyroxene compositions" [11] (presumably hand picked) are also shown in the table for comparison. The En and Fs contents of our predicted diogenites fall at the upper end of the range of diogenite pyroxene compositions in [7], and an obvious difference is the lower CaO contents and higher FeO of the diogenite pyroxenes. Presumably the lower CaO and $Al_2O_3$ are a result of subsolidus exsolution and the higher FeO indicates crystallization from a more evolved liquid.

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Cr_2O_3$ | FeO | MgO | CaO | $Na_2O$ |
|---|---|---|---|---|---|---|---|---|
| *Estimated liquid and coexisting loCa pyx and olivine* | | | | | | | | |
| Liquid | 49.96 | 0.66 | 9.79 | 0.41 | 17.96 | 11.33 | 9.41 | 0.49 |
| loCa pyx | 54.74 | 0.15 | 1.24 | 0.84 | 12.30 | 27.22 | 3.53 | - |
| LoCa pyx $Wo_{6.9}En_{74.3}Fs_{18.8}$ Olivine $Fo_{76}$ | | | | | | | | |
| *Average pyroxenes from diogenites [10]* | | | | | | | | |
| Johnstown | 52.5 | nd | 0.98 | 0.78 | 15.5 | 27.0 | 1.48 | nd |
| Ibbenbuhren | 53.7 | 0.14 | 0.64 | 0.33 | 16.5 | 26.7 | 1.00 | nd |
| Tatahouine | 54.9 | <0.1 | 0.51 | 0.70 | 15.6 | 27.9 | 0.77 | nd |

**References** [1] Bartels K.S. and Grove T.L. (1991) Proc. Lunar Planet. Sci. Conf. 21st (in press). [2] Delaney J.S. et al. (1981) Lunar and Planet. Sci XII, 211-213. [3] Delaney J.S. et al. (1984) Proc. Lunar Planet. Sci. Conf. 15th, C251-C288. [4] Ikeda Y. and Takeda H. (1985) Proc. Lunar Planet. Sci. Conf. 15th, C649-C663. [5] Jones J.H. (1987) Meteoritics 22, 95. [6] Warren P.H. et al. (1990) Proc. Lunar Planet. Sci. Conf. 20th, 281-297. [7] Hewins R.H. (1980) Lunar and Planet. Sci XI, 441-443 [8] Hewins R.H. (1981) Lunar and Planet. Sci XII, 445-447. [9] Harriot H.C. and Hewins R.H. (1984) Meteoritics 19, 15-23. [10] Mittlefehldt and Lindstrom (1989) Lunar and Planet. Sci XX, 697-698. [11] Fredriksson K. et al. (1976) Meteoritics 11, 278-280. [12] Fredriksson K. (1982) Meteoritics 17, 141-145. [13] Morgan J.W. et al. (1978) Geochim. Cosmochim. Acta 42, 27-38.