ORIGIN OF OLIVINE IN THE NAKHLA ACHONDRITE, WITH IMPLICATIONS FOR DISTRIBUTION OF FE/MG BETWEEN OLIVINE AND AUGITE; **A. H. Treiman, Geology Dept., Boston University, Boston MA 02215 (TREIMAN@BUASTA)**

The igneous achondrite Nakhla, of the SNC group, is a cumulate consisting mostly of augite phenocrysts and olivine crystals. The origin of the olivine has been uncertain because its cores and the augites' cores appear to have been in Mg/Fe disequilibrium [1-3]. The olivines have been explained as xenocrysts [2], partially re-equilibrated phenocrysts [3], and as post-cumulus grains [1]. However, compositional zoning patterns in olivines and augites are nearly identical, suggesting that the olivine cores represent phenocrysts with original igneous compositions, and that available Mg/Fe partition data are inapplicable.

ZONING PATTERNS: Zoning was studied by EMP analysis traverses across selected crystals. Chosen augites had c axes $\perp$ to the thin-section plane; chosen olivines had a crystallographic axis $\parallel$ to the thin-section plane. AUGITE. Augites are strongly zoned in Mg/Fe (Fig. 1). Cores have weak reverse and oscillatory zoning from crystal centers at Mg*=0.63 to a maximum Mg*=0.64. Rim zones, outward from the cores, have rapidly decreasing Mg* at slopes consistent with fractional crystallization [4]. Rim zones on different crystals, and opposite sides of a single crystal, may have different Mg/Fe slopes, inflection points, and interruptions. Plateau zones, present beyond the rims of some crystals and as replacements, have constant low Mg*$\approx$0.46. OLIVINE. Olivines in Nakhla are also zoned with respect to Mg/Fe. All of the zones and zone characters present in the augites are also present in the olivines (Fig. 2).

PRISTINE OLIVINE PHENOCRYSTS: Because Nakhla's olivines and augites have closely related zoning patterns, the minerals probably had similar origins. The augites have been interpreted as phenocrysts [1-3]. Nakhla's rapid cooling [2] and the slow rates of chemical diffusion in augite [5] suggest that the augite zoning reflects primary igneous processes. So, the similarity of zoning patterns in augites and olivines implies that the olivines are (in part) phenocrysts, and that their chemical zoning reflects primary igneous processes. Olivine compositions apparently have not been modified by chemical diffusion [3].

MG/FE DISTRIBUTION: Prior studies [1-3] concluded that the olivines were not pristine phenocrysts because their cores were not in Mg/Fe equilibrium with the augites' cores. But if the olivine compositions are primary, then the Mg/Fe distribution coefficients are inappropriate. Most data give ${}^{Mg/Fe}D_{aug/ol} \approx 1.1$-1.5 (vis [6]). But for Nakhla's minerals, D$\approx$2.7, and some aug/ol pairs in the literature give higher D's. These data suggest that ${}^{Mg/Fe}D_{aug/melt}$ is poorly constrained, because it equals ${}^{Mg/Fe}D_{aug/ol} \cdot {}^{Mg/Fe}D_{ol/melt}$, and because ${}^{Mg/Fe}D_{ol/melt}$ is closely constrained [7]. It may be dangerous to use published ${}^{Mg/Fe}D_{aug/liq}$ in estimating Mg/Fe of the magma parental to Nakhla.

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REFERENCES: [1] Berkley et al., 1980, Proc. 11th L.P.S.C., 1089-1102, Pergamon. [2] Treiman, 1986, Geochim. Cosmochim. Acta 50, 1061-70. [3] Longhi & Pan, 1989, Proc. 19th L.P.S.C., in press. [4] Pearce, 1987, Contrib. Mineral. Petrol. 97, 451-9. [5] Brady & McCallister, 1983, Amer. Mineral. 68, 95-105. [6] Naslund, 1984, J. Petrol. 25, 185-212. [7] Roeder, 1974, E. P. S. L. 23, 397-410.

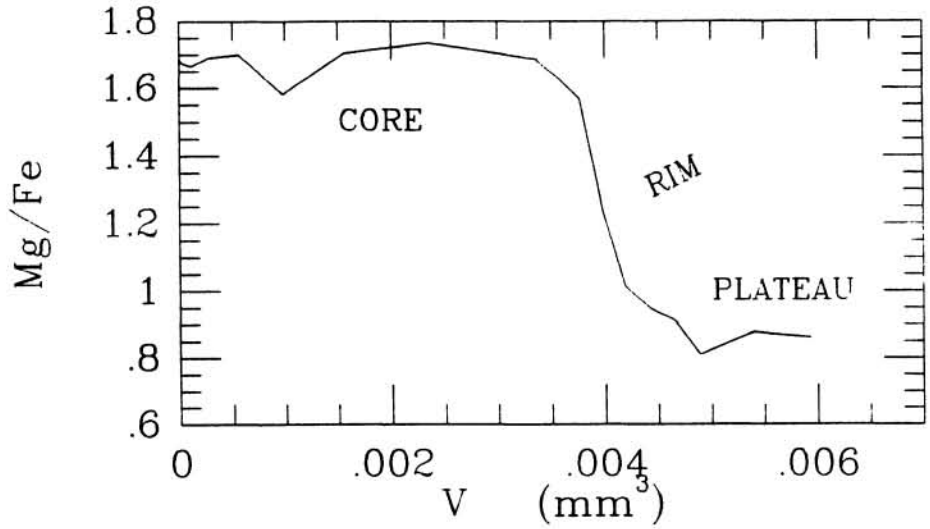

Fig. 1. Augite: Mg/Fe versus crystal volume ($2d^3_{center}$). Note the three zones: core, rim, and plateau.

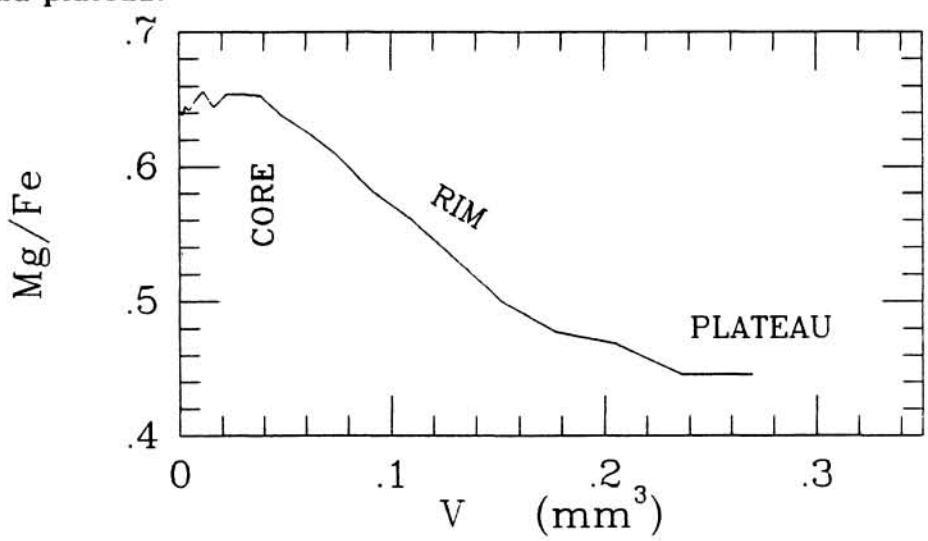

Fig. 2. Olivine: Mg/Fe versus crystal volume ($2d^3_{center}$). The same zones are present here as are in augite (Fig. 1). The linear negative slope of the rim zone suggests growth during fractional crystallization [4].