

FIG. 1. CaO/MgO (molar) in olivine vs. CaO/MgO (molar) in mesostasis for Semarkona chondrules.

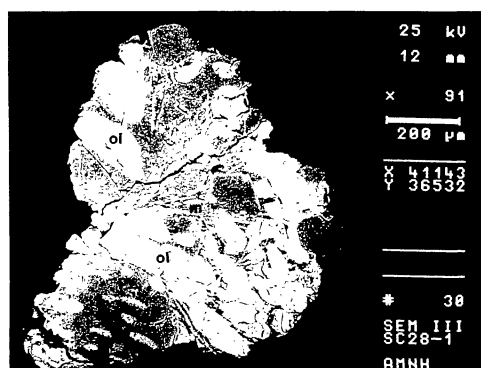


FIG. 2. A BSE image of a fragment of chondrule SC-28-1 chiselled from Semarkona. ol = olivine, py = pyroxene (gray), rpy = relic pyroxene (dark gray), m = mesostasis.

wt%). More importantly, a slightly MgO-rich relic pyroxene core ( $\text{Fs}_{3.8}\text{Wo}_{0.4}$ ) was found inside the FeO-rich pyroxene which also encloses some poikilitic olivines (Fig. 2). The olivines and pyroxenes are closely associated and have Fs/Fa ratios close to one. However, the pyroxenes are not at equilibrium with the coexisting mesostases.

Although the olivine compositions and textures are similar to the relic grains described by Nagahara (1983), the association of "incompatible" phenocrysts and melts in these unusual chondrules suggests that they were formed through cementation of unmelted mineral clusters by non co-genetic melts. Considering the high CaO contents of group A1 and A2 chondrules, the viscosity of the melts must be much lower than the  $\text{SiO}_2$ -rich melts of group B1 chondrules. It is therefore possible that some of these low viscosity melts may spin off from their host droplets and cement the FeO-rich mineral clusters in the vicinity. The presence of these unusual chondrules suggests that chondrule-forming processes were very dynamic and that while most chondrules were formed through *in situ* melting of pre-existing solid material, possibly accompanied by reduction and volatilization, some chondrules could have been formed through cementation of unmelted mineral clusters by feldspathic melts.

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**Evolution of a Vigarano forsterite-bearing CAI.** Glenn J. MacPherson<sup>1</sup> and Andrew M. Davis.<sup>2</sup> <sup>1</sup>Department of Mineral Sciences, NHB-119, Smithsonian Institution, Washington, DC 20560, USA. <sup>2</sup>Enrico Fer-

mi Institute, 5640 S. Ellis Ave., University of Chicago, Chicago, Illinois 60637, USA.

Forsterite-bearing inclusions (FIs) are a small subset of Ca-Al-rich inclusions (CAI), most notable for the fact that 5 out of the 9 reported examples have unusual isotopic properties (Davis *et al.*, 1991) relative to other CAI. The origin of their unusual Mg-rich bulk compositions and their relation to other CAI are not well understood (Wark *et al.*, 1987), and little is known about their  $^{26}\text{Al}$ - $^{26}\text{Mg}$  isotopic systematics because of a general absence of Al-rich phases. A new FI from Vigarano (CV3) contains anorthite, and unusual petrologic features suggest that it evolved from a bulk composition more refractory than the present one.

Vigarano 3137 is a ~5 mm diam., crudely round inclusion with some matrix embayments. It consists of fassaite (~45%;  $\leq 350\ \mu\text{m}$ ), melilite (~25%;  $\leq 950\ \mu\text{m}$ ), anorthite (~10%;  $\leq 225\ \mu\text{m}$ ), olivine (~10%;  $\leq 70\ \mu\text{m}$ ) and spinel (~10%; some up to  $20\ \mu\text{m}$ , most  $\leq 5\ \mu\text{m}$ , with some framboidal clusters up to  $\sim 40\ \mu\text{m}$ ). Olivine and spinel grains are poikilitically enclosed within melilite and fassaite, but the distribution of olivine is very heterogeneous. Most olivines are contained only within fassaite, and the rare grains enclosed within melilite are smaller and rounder. Melilite crystals are zoned from broad cores of  $\text{Åk}_{86-88}$  to rims of  $\text{Åk}_{44-54}$ . The primary anorthite in 3137 occurs mostly near the margin of the inclusion, some crystals being undeformed and others highly strained and deformed, and generally crosscut by thin lamellae of nepheline. Spinel grains within some of the anorthite crystals have thin rims of Al-rich melilite,  $\sim \text{Åk}_{11}$ .

Ion microprobe isotopic analysis of the anorthite shows no detectable excess  $^{26}\text{Mg}$  at  $^{27}\text{Al}/^{24}\text{Mg}$  ratios up to 1133, implying  $(^{26}\text{Al}/^{27}\text{Al})_0 < \sim 1 \times 10^{-6}$ .  $F_{\text{Mg}}$  in anorthite, melilite, olivine and fassaite is  $\sim 10\%$ /amu, slightly lower than the "F" inclusion TE (Clayton *et al.*, 1984) but heavier than most normal CV3 inclusions (Niederer and Papanastassiou, 1984).

Trace element enrichments in 3137 are (all relative to C1 chondrites): fassaite—La  $\sim 4.6\times$ , Sm  $\sim 20\times$ , Eu  $\sim 4.4\times$ , Yb  $\sim 22\times$ , Sc  $\sim 70\times$ , Sr  $\sim 3.1\times$ ; melilite—La  $\sim 3.9\times$ , Sm  $\sim 1.5\times$ , Eu  $\sim 33\times$ , Yb  $\sim 0.7\times$ , Sc  $< 0.4\times$ , Sr  $\sim 40\times$ ; anorthite—La  $\sim 11\times$ , Sm  $\sim 2.5\times$ , Eu  $\sim 8.7\times$ , Yb  $\sim 4.2\times$ , Sr  $\sim 0.4\times$ , Sr  $\sim 98\times$ . The REE patterns are smooth, indicating that the bulk trace element pattern of 3137 is not volatility-fractionated.

Many features of 3137 are puzzling, and point to a complex history. Relicts of aluminous melilite within some anorthite grains cannot have crystallized from the same Mg-rich melt as the olivine and Mg-rich melilite; they may represent an Al-rich precursor to the bulk composition that was eventually melted. Conversely, the concentration of anorthite on the outside of the inclusion is difficult to reconcile with its crystallization from a melt in which olivine is a near-liquidus phase and anorthite should be relatively late. The range of compositions in zoned melilite crystals crosses the minimum melt composition of the gehlenite-åkermanite binary and cannot be explained by fractional crystallization in a closed system. The overall Mg-isotopic mass fractionation in favor of heavier isotopes in 3137 suggests that some volatilization may have occurred prior to or during melting. In a general way the features of 3137 suggest multiple stages of melting coupled with two competing processes that tended to modify the bulk composition, namely addition of Mg-rich material before melting and minor volatilization of Mg during melting episodes.

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**Distribution of  $^{26}\text{Al}$  in the early solar system—A reappraisal.** Glenn J. MacPherson,<sup>1</sup> Andrew M. Davis<sup>2</sup> and Ernst K. Zinner.<sup>3</sup> <sup>1</sup>Department of Mineral Sciences, NHB-119, Smithsonian Institution, Washington, DC 20560, USA. <sup>2</sup>Enrico Fermi Institute, 5640 S. Ellis Ave., University of Chicago, Chicago, Illinois 60637, USA. <sup>3</sup>McDonnell Center