

VIGARANO CAI 477B: PETROGRAPHY AND MG ISOTOPIC COMPOSITION OF THE CORE AND INDIVIDUAL RIM LAYERS; A. El Goresy, MPI Kernphysik, P. O. Box 103980, 6900 Heidelberg, FRG; C. Caillet, Laboratoire de Pétrologie Minéralogie, Université P. et M. Curie, Paris VI, 75252 CEDEX 05, France; E. Zinner, McDonnell Center for the Space Sciences and Physics Department, Washington University, St. Louis, Mo 63130, USA.

Vigarano 477 B is a texturally complex coarse-grained Type B Ca- Al- rich inclusion. The core consists of two distinct parts with melilite as the major constituent: (1) A rectangular part with densely crowded coarse-grained idiomorphic spinels that contains FeNi-metal blebs and periclase-bearing Fremdlinge. Melilite compositions vary between Ak₇₄ and Ak₃₄. Melilite contains typically minor but distinct concentrations of the Na-melilite molecule (0.18 - 1.78 mole % Na-mel). Few Ti-Al-rich fassaite (9.5-14.1 wt.% TiO₂; 15.8-20.2 wt. % Al₂O₃) are also encountered. (2) A portion barren of metals and Fremdlinge with relatively fine-grained spinels. Melilite in this portion is more gehlenitic in composition (Ak_{9,5}-Ak₃₉) and contains no Na-melilite [1]. Several rounded regions consisting of polycrystalline aggregates of melilite occur at the periphery of the core, adjacent to the innermost spinel layer of the rim sequence [2].

Previous ion microprobe analysis has revealed a difference of ≈ 10 ‰/amu in the Mg isotopic fractionation between periclase-wüstite in a metal-rich Fremdling (isotopically light) and adjacent spinel and melilite (isotopically heavy) and has been interpreted by Zinner *et al.* [3,4] as indicative for an extraneous origin of the Fremdling.

In order to clarify the evolutionary history of the CAI, its petrology, and the isotopic characteristics of the individual components, a systematic petrographic, electron microprobe and ion microprobe study was initiated. Special efforts were devoted to the individual layers of the rim sequence and their relationship to the core.

Petrography and Mineral Chemistry: The rim is ~ 220 μm wide and appears to consist of 6 distinct layers. These layers are (from outside inwards): (1) Aluminous diopside (17.7 CaO, 1.12 FeO, 16.7 MgO, 0.45 TiO₂, 0.05 V₂O₃, 2.59 Al₂O₃, 52.8 SiO₂) with increasing concentrations of FeO, Al₂O₃, and TiO₂ towards the second layer (0.39 -2.23 FeO, 0.71 -4.94 Al₂O₃, 0.14 -1.11 TiO₂). (2) A 15 μm thick layer of fine-grained nepheline+sodalite (presumably altered anorthite). (3) A 15 μm thick layer of Fe- and Zn-rich spinel (13.4 FeO, 0.34 ZnO) that is poor in V (0.21 V₂O₃). This layer also contains thin lamellae of hibonite. (4) A 75 μm porous and highly altered layer consisting of nepheline+sodalite+perovskite+gehlenitic melilite. (5) A 70 μm layer of large hibonite laths in compact, but heavily cracked, gehlenitic melilite (Ge₇₇Ak₂₃ - Ge₇₉Ak₂₁). Both Mg,Ti-poor (0.97 MgO, 0.54 TiO₂) and Mg,Ti-rich (2.77 MgO, 2.79 TiO₂) hibonites are present. (6) The innermost layer is made up of coarse Fe- and Zn-poor spinel (0.06 TiO₂, 0.73 V₂O₃, 0.29 CaO, 0.22 FeO, 0.01 ZnO, 0.12 Cr₂O₃, 70.3 Al₂O₃, 28.0 MgO) enclosed in melilite (Ge₇₇Ak₂₃).

Melilite in the core does not display any signs of alteration to nepheline or sodalite. In comparison, melilite in layer 4 is characterized by pervasive alterations. Less than 50% of the metal blebs and Fremdlinge have any Fe oxides on their surfaces and only very few metal blebs contain troilite, thus indicating a low degree of oxidation and sulfidization.

Spinel in the core and in layers 3 and 6 of the rim show distinct textural and chemical characteristics, reflecting specific events during the evolution of the CAI. The FeO-content of the core spinels is generally low (0.15-3.32 wt. %). The grains are usually zoned with the highest FeO-contents at their rims. This zoning is encountered regardless if the spinels are in contact with oxidized metal or completely isolated and enclosed in melilite or fassaite. The highest FeO-contents are usually found next to open cracks. The spinels are low in ZnO (0.01-

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0.16) and TiO_2 (0.12-0.23), but high in V_2O_3 (0.60-1.55). Spinels in layer 6 of the rim sequence show identical TiO_2 and V_2O_3 contents to those of the core spinels, but are systematically depleted in FeO (0.20-0.23) although they are - similarly to core spinels - adjacent to and intersected by cracks. Spinels in layer 3 of the rim sequence are low in TiO_2 (0.02-0.09) and V_2O_3 (0.16) but high in FeO (12.1-14.6) and ZnO (0.24-0.46).

Isotopic Composition: *In situ* ion probe measurements of Mg isotopes show that spinel and melilite in the core have a uniformly heavy isotopic composition of $F_{\text{Mg}} = + 4.7$ ‰/amu. Variations between different crystals are commensurate with measurement precision ($2\sigma \approx 1.5$ ‰) and much smaller than those previously measured on Au-mounted grains [3]. There is no difference in F_{Mg} between the spinel-rich portions and the spinel-free melilite regions. Spinel in layer 6 and hibonite in layer 5 exhibit the same Mg fractionation but parts of the melilite in layer 5 are closer to normal ($F_{\text{Mg}} = + 2.0 \pm 1.5$ ‰/amu), and spinel in layer 3 and diopside in layer 1 even more so ($F_{\text{Mg}} \approx + 1.0$ ‰/amu). Hibonite and melilite show ^{26}Mg excesses; the $^{26}\text{Mg}/^{24}\text{Mg}$ and $^{27}\text{Al}/^{24}\text{Mg}$ of spinel, diopside, melilite and hibonite lie on a line with $(^{26}\text{Al}/^{27}\text{Al})_0 = (4.7 \pm 0.7) \times 10^{-5}$.

Several important conclusions can be drawn from these findings:

(1) Spinels in the core and layer 6 of the rim sequence, that display the same chemical signatures for V and Ti and the same F_{Mg} , probably crystallized from the same liquid of the CAI.

(2) The most intriguing feature are the differences in the FeO- and ZnO-contents of the three spinel types. These differences are strongly suggestive of multiple oxidation events. The event which affected the core spinels led to oxidation of some of the metal blebs and diffusion of Fe into the core spinels, giving rise to zoning in spinels in contact with oxidized metals. The oxidation of the core did not lead to enrichments in the volatile elements (Na, K, Zn) as evidenced from the lack of alteration of the core melilites. Zoning in core spinels not in contact with metal blebs and adjacent to cracks suggests that a FeO-rich (but ZnO-poor) vapor phase was involved. However, it is unexplained why spinels in layer 6 remained unaffected, although they are spatially closer to the outer surface of the CAI from which oxidizing gases penetrated.

(3) Spinels in layer 3 originated from an entirely different chemical source depleted in V. The source medium which led to their oxidation (or formation at high $f\text{O}_2$) did not only raise their FeO-contents but also enriched them and layers 2 and 4 in Na, K and Zn. The fact that spinels both in layer 6 and in the core are depleted in Zn suggests that either: a) the gas which oxidized the spinels in layer 3 did not penetrate deep into the CAI (perhaps as far as layer 4), or b) spinels in layer 3 condensed at high $f\text{O}_2$ from a volatile-rich gas. In either case the gas reservoir had Mg close to normal.

(4) The event which led to the oxidation of spinels in layer 3 probably took place before incorporation of the CAI into the Vigarano matrix. Diopsides adjacent to the matrix are usually lower in FeO (0.39) than those close to FeO-rich spinels in layer 3 (.82-2.23). Since this event possibly also affected the F_{Mg} of melilite in layer 5, it must have occurred before the decay of ^{26}Al since the hibonite and melilite data points lie on the same $^{26}\text{Mg}/^{24}\text{Mg}$ vs $^{27}\text{Al}/^{24}\text{Mg}$ correlation line.

(5) Hibonites in layer 5 and spinels in layer 6 are most likely integrated parts of the CAI and are genetically unrelated to the formation of the rim.

In summary, these findings are suggestive of at least two oxidation events before incorporation of the CAI in the Vigarano matrix.

References: [1] C. Caillet, Ph. D. Thesis, Univ. P. & M. Curie, Paris (1990); [2] C. Caillet *et al.*, LPSC XIX, 156-157 (1988); [3] E. Zinner *et al.* LPSC XX 1245-1246 (1989); [4] E. Zinner *et al.* Nature (submitted) (1990).