FREMDLINGE IN VIGARANO CAI 477B: ASSEMBLAGES, COMPOSITIONS, AND POSSIBLE FORMATIONAL HISTORY.

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Vigarano 477B is a type B1 inclusion. Our PTS is a rectangular section of a potted but (4.1 x 2.4 mm) of the CAI. The CAI is coarse-grained with complex textural relationships. The CAI contains various types of melilites, few large fassaite crystals, spinels, hibonite, perovskite, and minor nepheline and sodalite. It is surrounded by a complex Wark & Lovering rimming sequence with olivine as the outermost layer. Spinels are inhomogeneously distributed through the inclusion. They are densely crowded in the core of the CAI. Near the rim, there are spinel-free areas consisting of polycrystalline aggregates of melilites with 120 triple junctions. These areas are surrounded by spinel belts similar to those found in Allende 5241 (1). Fremdlinge are confined to the core of the CAI specifically in the spinel-rich areas. Detailed description of this CAI will be given elsewhere [2].

PETROGRAPHY: Fremdlinge and Pt-rich phases occur in three distinct forms with a specific spatial distribution: (1) Numerous multiphase Fremdlinge usually consisting of two different FeNi-alloys. This type is mainly confined to the spinel rich part in the core of the CAI. The intergrowth texture between the two FeNi alloys is reminiscent of exsolution of kamacite and taenite by cooling of a homogeneous FeNi metal alloy (Fig.1). The kamacite phase has a quite narrow compositional variation with Ni-contents between 4.5 and 5.5 Wt.%. This phase is also rich in Co (0.9-2.4 Wt.%). The Ni-rich phase displays wider compositional variation with Ni-contents between 30 and 47 Wt.%. Highest Ni-contents are encountered at the kamacite-taenite interface. Several Fremdlinge display exsolution lamellae of Os-Ru or Mo-rich alloys both in kamacite and taenite (Fig.1). At the surface of the majority of Fremdlinge several complex oxide phases either as idiomorphic individual grains or as a thin continuous crust were encountered. They are distributed upon the surface of the Fremdlinge without any preference to kamacite or taenite. There are two types of Fremdlinge depending on the concentration of the refractory siderophile elements in the FeNi alloys. a) The major part of the metals contain minor concentrations of Os, Ir, Re, and Ru in solid solution both in kamacite and taenite. b) Several metals, however, do not contain any detectable concentrations of these elements, though their textural features are identical to those enriched in the rare Pt-metals. Some grains of the first group were found to display small crystals of sheelite (Fig.2) or powellite (Fig.1) along with other oxides on their surface. Ni concentration profiles across the oxide/metal interfaces revealed no variation in the Ni-contents. In addition to the indentations of Fremdlinge in the spinels, there is evidence of Fe diffusion from the oxide crust to the adjacent spinel. Few Fremdlinge were found to contain large individual crystals (10 μm) of a Mg-Fe oxide (Fig.3). Textural relations are indicative that this phase formed before crystallization of spinel (Fig.3). Electron microprobe analysis revealed that this oxide is a member of the periclase-wüstite solid solution series. This is the first report of a member of this series in meteorites. (2) Homogeneous Pt-rich metal nuggets. They are usually concentrated near the rimming layers and in some cases among them. The nuggets are usually depleted in the most refractory siderophiles Re, Os, Ir, and Ru and are highly enriched in Pt. No oxide phases were encountered surrounding the nuggets. (3) Pt-rich veins filling cleavages or cracks in melilite or fassaite. The veins are also highly enriched in Pt and depleted in the other refractory siderophiles. The compositions and mode of occurrence of these objects put important genetic constraints on their formational mechanisms. In the spinel-rich core very fine-grained aggregate of sphalerite was encountered as inclusions in few spinels. The grains were too small for a quantitative analysis.

MINERAL CHEMISTRY: Reconnaissance of the Ni distribution along concentration profiles across kamacite and taenite in Fremdlinge in Fig.2 revealed typical "M-Profiles" indicative of Ni-diffusion from kamacite to taenite due to cooling (Fig.4). The analyses and profiles indicate also that the concentrations of Os, Ir, and Ru are different in kamacite and taenite. Taenite contains usually higher concentrations of these elements (2-3% Os, 1.5-2.13% Ir, 0.52-0.67% Ru) than in kamacite (1.5-1.74% Os, 1.4-1.64% Ir, 0.18-0.29% Ru). From these values we calculated the following partition coefficients between taenite and kamacite: Os: 1.35-1.7, Ir: 1.0-1.5, and Ru: 2.6-2.8. These values indicate that the three elements behave similarly during exsolution of kamacite and taenite from a homogeneous FeNi alloy and that all three elements have a clear preference to taenite. This is also depicted in Figure 4 showing the increase of the concentrations of Os, Ir, and Ru at the kamacite-taenite interface to a higher value in taenite. Analysis of the Mo-rich phases present in both kamacite and taenite (Fig.1) revealed that they are complex alloys with similar Mo-concentrations (12.0 Wt% Mo). Analysis of one exsolution at the kamacite-taenite interface revealed 31.4% Ni, 51.7% Fe, 12.0% Mo, 0.71% W, 0.13% Rh, 0.26% Ru, 0.53% Re, 0.64% Os, 0.57% Ir, total 97.94). The high enrichment of Re in this phase compared to Os is striking. Exsolutions in kamacite contain even higher Re-concentrations (0.91% Re, 0.69% Os, 0.55% Ir). This is indicative of a much lower Os/Re ratio than cosmic resulting from the fractionation of Re to the Mo-rich alloy. Many of the Ni-rich alloys were found to contain Ca (0.21-0.6 Wt%) presumably present as submicroscopic inclusions of Ca-aluminate or Ca-vanadate. Some higher Ca-values are usually accompanied by higher V-contents thus supporting the presence of Ca-vanadates. Analysis of the Mg-Fe oxide revealed: 42.2% FeO, 0.52% CaO, 0.20% SiO_2, 0.09% Al_2O_3, 54.8% MgO. The mineral is a member of the periclase-wüstite solid solution series (Per69-Wü30).

DISCUSSION: The mode of occurrence and compositions of Fremdlinge and metals are indicative of distinct sequential events. Enrichment of the alloys in the core in Os, Ir and Ru and the low concentration in Pt indicate that they were formed before the Pt-rich nuggets. The lack of Ni-concentration gradients at the oxide/metal interface along with the even distribution of the oxides at the surfaces of kamacite and taenite is strongly suggestive of oxidation of the Fremdlinge before exsolution of kamacite and taenite from the original homogeneous alloy. The lack of oxide layer around the Pt-rich nuggets and veins is a strong argument for oxidation of the Fremdlinge before they were captured by the CAI. Cooling rates of the Fremdlinge in the CAI can be estimated from the band width and the Ni-concentration profiles and application of Ni-diffusion data. The presence of kamacite and taenite and the small amount of oxide concentrations also indicates that Fremdlinge in Vigarano were subjected to much less oxidation than those in Allende. The texture of the periclase-wüstite member with the coexisting alloys and spinel is suggestive of formation before capture of the Fremdlinge in the CAI. There is no evidence of reaction between metal and spinel and no Al-rich phase was found in this assemblage. Formation of the Mg-Fe oxide by condensation may have taken place under special conditions to explain why olivine did not condense instead (3). In any case formation of this phase requires low Si-concentrations to inhibit the condensation of olivine under oxidizing conditions. We interpret the Pt-rich metal veins as condensation products which have precipitated from the vapor phase after solidification of the CAI. The formation of these veins may mark the last condensation event before capture of the CAI in the Vigarano matrix. The occurrence of ZnS inclusions in the spinel may indicate the existence of volatile relict grains captured by the spinels.

REFERENCES: [1] A. El Goresy et al. GCA(1985), 2433; [2] G.J. MacPherson (in preparation); [3] H. Palme, personal communication.

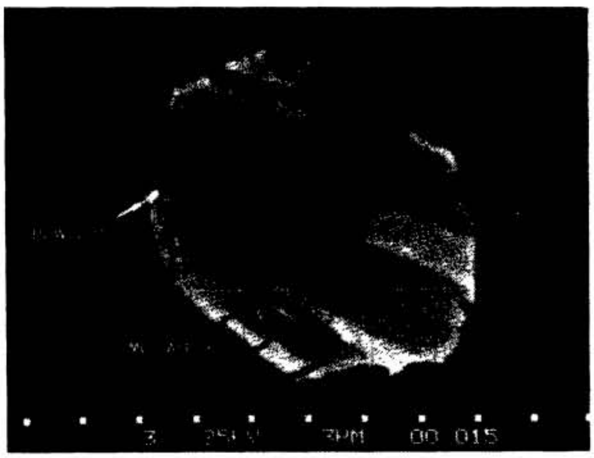

Fig.1

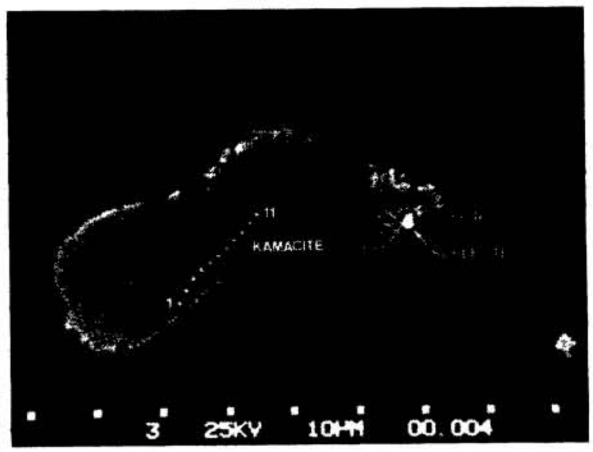

Fig.2

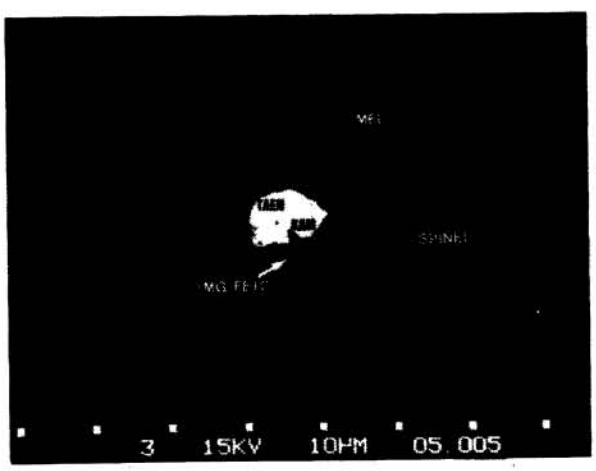

Fig.3

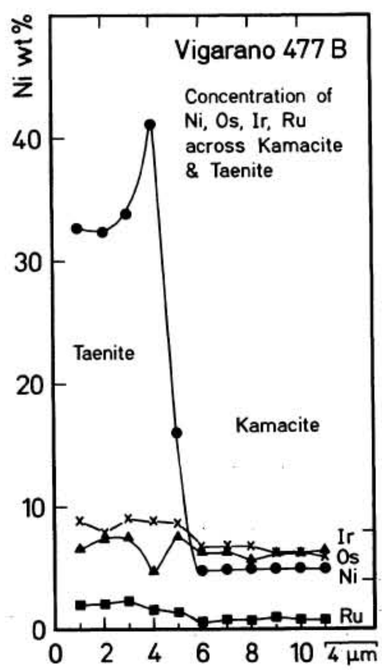

Fig.4