A showcase of analytical techniques: V metal in hibonite

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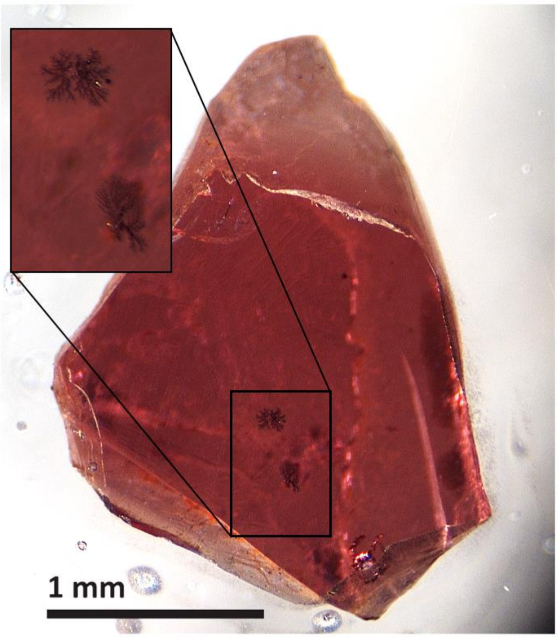

Hibonite ($CaAl_{12}O_{19}$) is one of the earliest phases to condense from the solar nebula. It also is found in high-temperature calc-silicate metamorphic rocks. We have found it intergrown with corundum, grossite ($CaAl_4O_7$), spinel and native vanadium in ejecta from Cretaceous volcanoes on Mt Carmel, Israel. The presence of V^0 (Figure 1) implies very low oxygen fugacity, similar to nebular conditions.

To understand the genesis of this unusual material, we have needed to use a wide range of techniques to study both major minerals and their inclusions. These techniques include stereo microscopy for general characterization (Figure 1); backscattered electron (BSE) imaging on a scanning electron microscope (SEM); energy dispersive X-ray spectroscopy (SEM-EDS) to determine mineral compositions; electron microprobe (EMP) to determine mineral chemistry; focused ion beam (FIB) for sample preparation; transmission electron microscopy (TEM) to observe submicron-scale structural features and crystallography; electron energy loss spectroscopy (EELS) to determine element valences; and Micro-Computed Tomography to image vanadium structures in 3D (Figure 2).

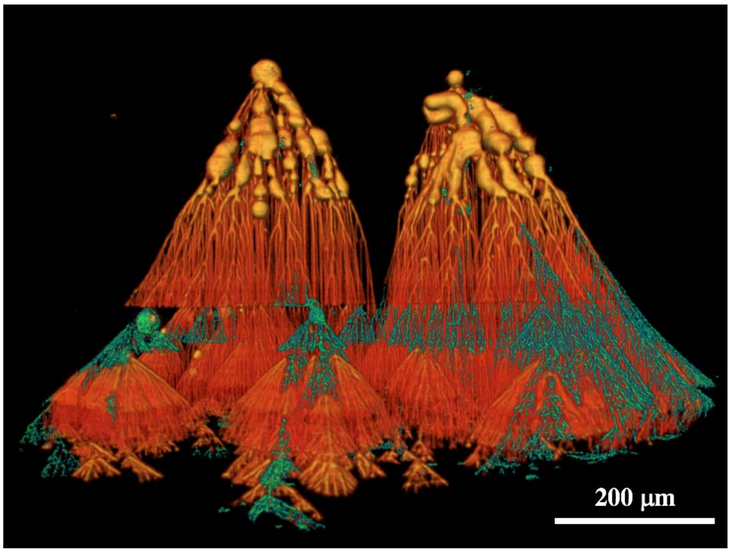

Figure 1. Stereo microscope image of hibonite with V_0 inclusions (dark aggregates, see inset).

The images reveal that the vanadium occurs both as rounded to drop-shaped inclusions, and as dendritic arrays of blobs and fibres that appear to have nucleated first on crystal faces, then continued to grow as the crystal face moved out into a surrounding melt/fluid. Pauses in crystallization appear as planes cutting off the dendrites, and new nucleation points appear on these planes, growing further with the next pulse of crystallisation. These images reveal much about the growth environment, and the detailed mechanisms and implications of dendritic crystallisation.

Figure 2. 3D-CT image of hibonite dendrites; crystal face is the lower surface.

Scan for 3D-CT video