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Short Communication

Ultrahigh-Pressure and -Temperature Mineral Inclusions in More Crustal Mineralizations: The Role of Supercritical Fluids

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Abstract

Supercritical fluids or melts create an essential connection between the lower mantle and upper crust. Examples demonstrate these interactions.

Examples

Sensitized by the finding of stishovite and coesite as inclusions in the Waldheim granulite in Saxony, the author found, in cooperation with his coauthors [1,2] in evolved granites and related tin-mineralizations, a couple of ultrahigh-pressure and -temperature minerals, like diamond, moissanite, stishovite, coesite, and cristobalite-XI [3]. These minerals are mostly spherical crystals with a very smooth surface. They are, as a rule, minerals entirely out of place. That means these trapped crystals have no equilibrium faces. Thomas and coauthors have interpreted these in growing crystals trapped phases as transported via fast-rising supercritical melt or fluid from the Earth's mantle region into the crust, here granites and related mineralizations [1-3]. The crystallization velocity of the host must be very high to prevent equilibrium forms of the trapped spheres.

A careful study of the beryl-quartz veins related to the cassiterite mineralization revealed that the ordinarily tetragonal cassiterite contains a high portion of orthorhombic cassiterite [4,5]. There are isometric crystals of orthorhombic cassiterite in muscovite, water-pure topaz, or more significant remnants (cores) of orthorhombic cassiterite in the tetragonal cassiterite crystals. Also, this topaz, as well as the orthorhombic cassiterite, are of high-pressure and high-temperature origin. Supported is this statement by sub-spherical inclusion in the OH-rich topaz composed of carbonic material (graphite, moissanite, and nanodiamond), as well as spherical kumdykolite crystals [$NaAlSi_3O_8$] with carbonic material. Kumdykolite is the orthorhombic polymorph of albite formed at high temperatures followed by rapid cooling [6].

The next surprise was the finding of moissanite whiskers with nanodiamonds grown in beryl and quartz in a small hydrothermal beryl-quartz vein in the Sauberg mine of the Ehrenfriedersdorf tin district of the Erzgebirge, Germany [7]. Here the crystallization of the whiskers happens directly at the place of vein crystallization at about 720°C and pressures ≤2 kbar. Thomas [4,5] tried an explanation for this remarkable beryl-quartz-moissanite-nanodiamond paragenesis by a natural supercritical vapor-liquid-solid (VLS) mechanism and a low-pressure heteroepitaxial chemical vapor deposition process (CVD). In each case, the crystallization of moissanite at such low PT conditions is unusual and should be a challenge for further experimental studies. Supercritical phases like spherical beryl-II-moissanite intergrowing in these parageneses' quartz show the supercritical phases' participation in this crystallization process.

Another important point for further sophisticated studies in relationship to the unusual mineral inclusions is the chemical and physical character of the supercritical phases. Thomas [8] shows a new type of fluid inclusion that probably transported stishovite (and other mineral phases) from the lower mantle to the crust. Methane (CH_4) and water are miscible at ultrahigh pressure and temperature. The transport properties of such fluid and the solubility for different elements are of particular interest because, in the crustal region, we observe a lot of extreme element enrichments in relationship to the melt-water solvus [1,2,9,10]. If we look at the whole story, we see a continuous evolution of the system of thought. Conventional physicochemical processes cannot explain this Gaussian or Lorentzian element enrichment in melt inclusions related to such solvus curves. Further studies are necessary to illuminate these complex processes in more detail.

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