The origin of hollow tubes in Alpine quartz crystals

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Abstract

Needle-like hollow tubes penetrating quartz crystals are a particular inclusion phenomenon of Alpine mineral parageneses. From several locations of the Eastern Alps samples of quartz crystals with hollow tubes were investigated to find the previous mineral forming the tubes. In four samples solid inclusions showing the same crystal morphology like the hollow tubes were identified by X-ray and microprobe as anhydrite, $CaSO_4$. The formation and dissolution of anhydrite in the hydrothermal system of Alpine clefts is discussed.

Keywords

Hollow tubes, quartz, Alpine clefts, anhydrite, Carinthia, Salzburg.

Projects: „Mineral documentation of the National Park Hohe Tauern":
Nr. 21303-68/112-2003; areas Rauris and Stubachtal, Salzburg: duration 2003-2008.
Nr. 3Ro-ALLG-231/2-2003 area Ankogelgruppe, Zirknitztäler, Carinthia: duration 2003-2008.
Project aims: Mineralogical investigations of Alpine mineral parageneses.

Introduction

The study of inclusions in minerals may reveal important informations about the history of mineral formation. Fluid inclusions are by far the most frequent in quartz and may contain liquids (H_2O, CO_2, heavy hydrocarbons), gas phases (H_2O, CO_2, CH_4 and N_2) and in saturated saline solutions also solids as for example NaCl and KCl. Their analyses point to the composition of the original liquid from which the quartz crystal was formed. Solid inclusions (minerals) in quartz are characterised as protogenetic (formed before the host quartz), syngenetic (formed at the same time) and epigenetic (formed after deposition of the host crystal).

A particular inclusion phenomenon of tubular voids in quartz is widely distributed in Alpine type mineral parageneses. The needle-like hollow tubes penetrating the Alpine quartz crystals are formed protogenetically relative to quartz and can only be observed in quartz and not in any other mineral of the same paragenesis. These hollow tubes with a rectangular shape in cross-section are usually designated "anhydrite tubes" in the literature. This assumption is due to a communication by KENNGOTT (1866), who described anhydrite as solid inclusion completely encapsulated by a quartz crystal from the Swiss Alps. Anhydrite has the same morphology like the hollow tubes penetrating the surface of the quartz crystal. In the Swiss Alps several locations of "anhydrite cavities" in quartz were described but only in a few cases, anhydrite has been verified by analytical methods (STALDER et al. 1998). In the Eastern Alps the characteristic tubular voids in quartz are found especially in Alpine clefts of the Tauern Window. From this area NIEDERMAYR (1997) and HYRSL & NIEDERMAYR (2003) reported several locations of hollow tubes in quartz, but anhydrite could not be detected in any specimen of the samples. To find the previous needle-like mineral which was transformed to hollow tubes was a main project aim of the mineralogical National Park projects during 2003 and 2004.

Samples and description

Selected mineral collectors which are named in the specific projects sampled quartz crystals from following locations:

A) Schleierfall, Seebachtal by Mallnitz, Ankogel group, Carinthia: quartz-cleft in migmatite.
B) Lassacherkees, Ankogel group, Carinthia: quartz-cleft in migmatite.
C) Romate by Mallnitz, Carinthia: smoky quartz-cleft in syenite gneiss.
D) Romate by Mallnitz, Carinthia: quartz-vein with beryl (aquamarine) in syenite gneiss.
E) Großer Stapnik, Reißeck group, Carinthia: quartz-cleft in banded gneiss.

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F) Hochkedl-Staffenhöhe, Reißeck group, Carinthia: quartz-cleft in amphibolite.
G) Nussing by Matrei, Eastern Tyrol: quartz-cleft in amphibolite.
H) Ritterkopf, Rauris, Salzburg: quartz-cleft in amphibolite.

All quartz samples include predominately needle-like hollow tubes up to 6 cm in length with rectangular cross-sections beyond 1 mm. Only a few hollow tubes are crossing the quartz crystals in the samples A, B, C, F and G; whereas in the samples D, E and H the tubes are very abundant (Fig. 1). Frequently the needle-like voids penetrate the quartz complete and are partly filled by clay minerals. Often one end of the hollow tube is encapsulated by quartz and the other end penetrates the quartz at the contact to the cleft wall. These tubes are filled only by air and show their morphology with contrast to quartz by total reflection (Fig. 2). From all samples polished sections were made for light microscope investigations. In the samples A, B, C and E also fully encapsulated needles in quartz could be found. The optical contrast is much lower than by the hollow tubes and cleavage planes indicate these inclusions to be solid (Fig. 1 and 3).

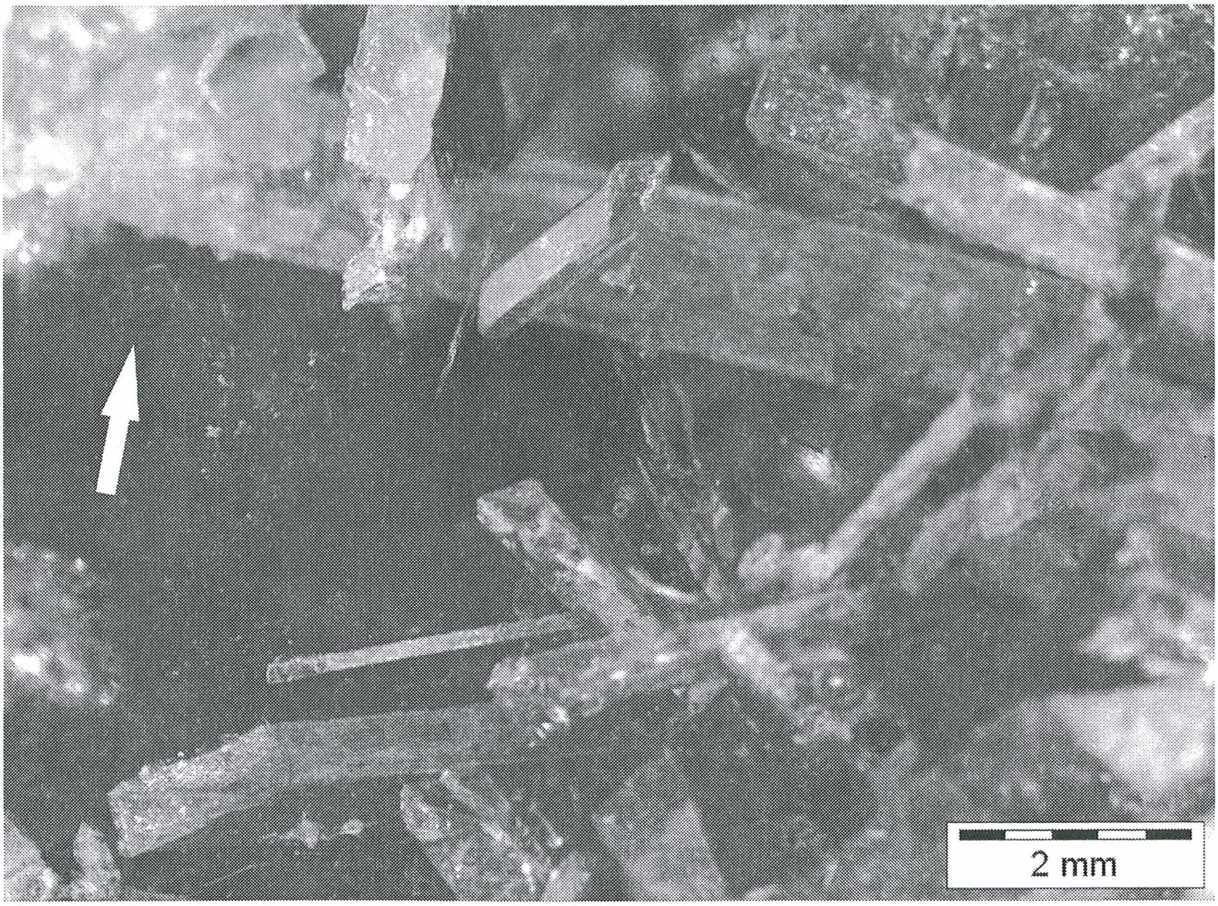

Fig. 1: Polished section of hollow tubes in quartz (dark grey) from Großer Stapnik, Reißeck group, Carinthia. The white arrow signs a nearly invisible solid inclusion (anhydrite) with the same shape like the hollow tubes (reflected light photo).

Analytical methods and results

The microprobe analyses (Jeol JSM-6310, with ED- and WD-spectrometer) of the solid needles included in quartz yielded oxygen, sulphur and calcium. The analytical sum indicated a water free calcium-sulphate mineral. This was also confirmed by the X-ray powder pattern (Siemens D5000, CuKα) that could identify this mineral as anhydrite, $CaSO_4$. To determine the crystal morphology of the needle-like anhydrite, a small part of the needle was broken from the polished cross-section. Oriented X-ray diffraction analyses (Bruker-axs, system GADDS) indicated the needle is an anhydrite single crystal with needle axis [100] (= a-axis). The crystallographic forms were measured by optical goniometry and resulted in {100}, {011}, {001} and {010} (Fig. 4).

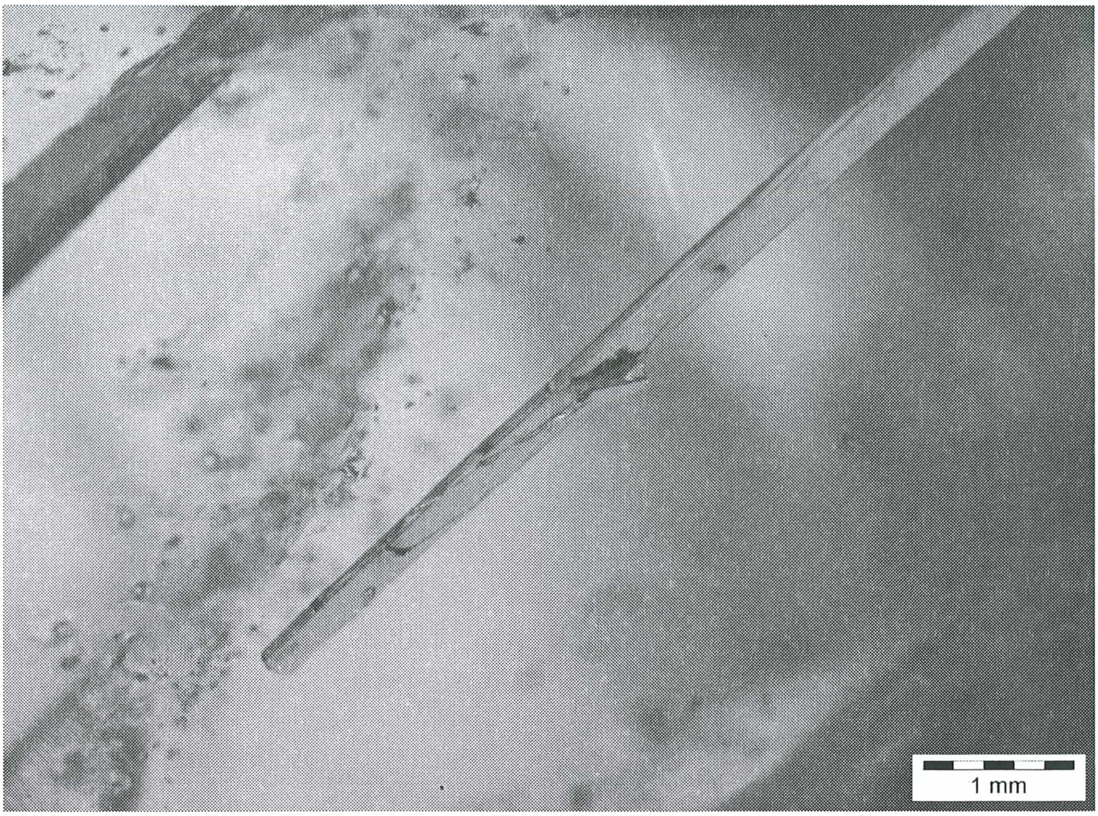

Fig. 2: Hollow tube in quartz in contrast to quartz by total reflection; from Schleierfall, Seebachtal by Mallnitz, Ankogel group, Carinthia (reflected light photo).

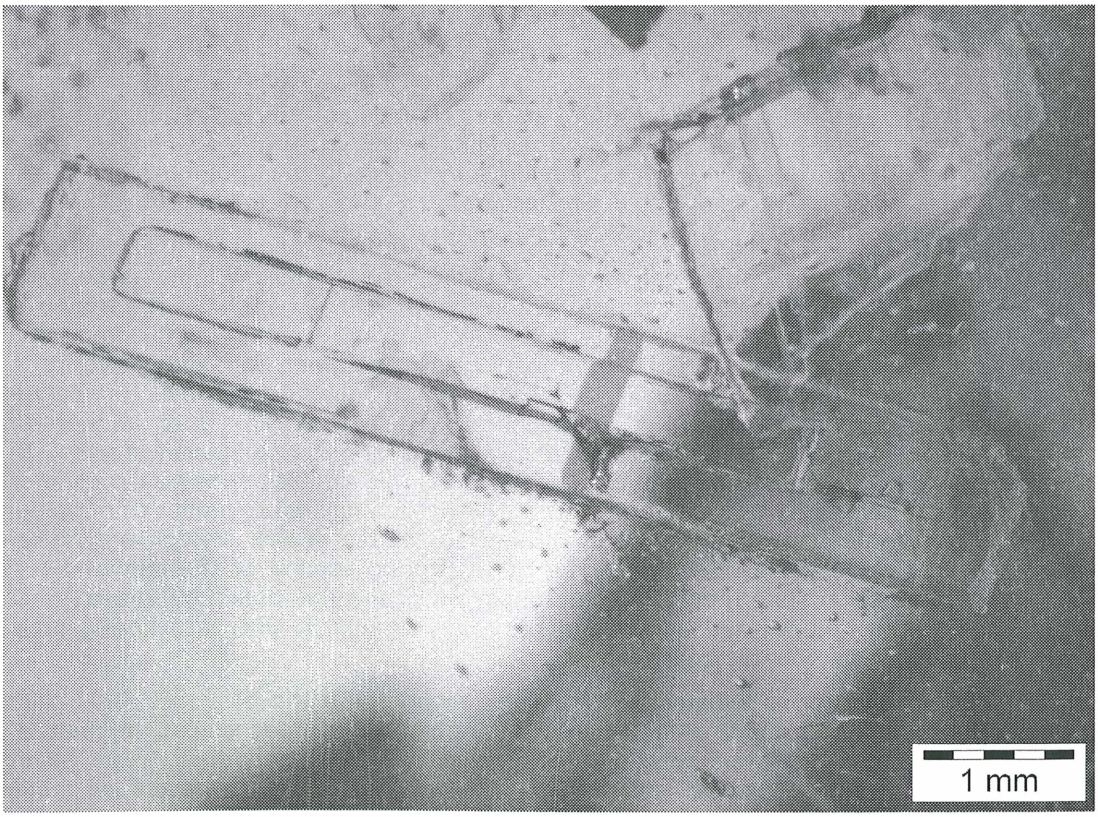

Fig. 3: Solid inclusion of anhydrite in quartz from Lassacherkees, Ankogel group, Carinthia. The cleavage plane of anhydrite is visible (dark grey) in the prismatic crystal (reflected light photo).

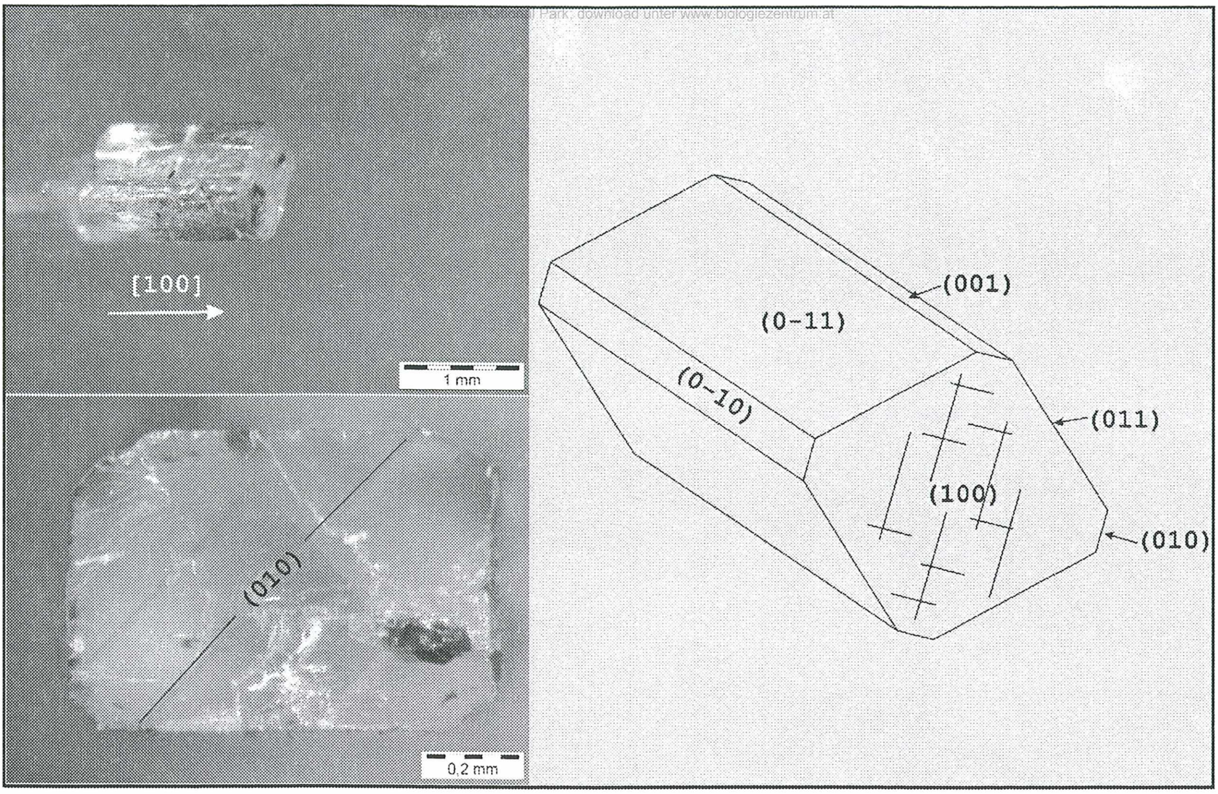

Fig. 4: Single crystal of anhydrite broken from the solid inclusion of the polished section (sample Schleierfall, Seebachtal by Mallnitz, Ankogel group, Carinthia). The needle axis is the crystallographic a-axis [100] (top-photo) and the cleavage planes are rectangular (down-photo). The faces of the anhydrite crystal are signed with Miller Indices in the idealized drawing.

Discussion

From eight localities (A-H) of the Tauern Window quartz crystals with included hollow tubes are described. In quartz crystals of the samples A, B, C and E fully encapsulated needles could be identified as anhydrite. From the Eastern Alps anhydrite inclusions in Alpine quartz crystals were reported for the first time by WALTER (2005). The assumption, that the hollow tubes are due to anhydrite, that was later dissolved, could base on following facts:

The anhydrite inclusions in quartz show the same morphology like the hollow tubes in all samples. Anhydrite is the stable calcium-sulphate mineral in the hydrothermal system of the Alpine clefts under oxidizing conditions. The solubility of anhydrite in the system $CaSO_4$ and H_2O at temperatures of 300° C and pressures of 1000 atmospheres is extremely low and anhydrite is the stable phase. At temperatures below 70° C the solubility of anhydrite reaches its maximum, anhydrite will be dissolved or transformed to gypsum, $CaSO_4 \cdot 2H_2O$. Anhydrite is therefore a protogenetic inclusion in quartz; it was formed before the quartz crystallization started. If the anhydrite needles were fully encapsulated in the later growing quartz, the permanent cooling of the hydrothermal system, caused by uplift and erosion of the overlaying rocks, could not dissolve this mineral. Are the anhydrite needles penetrating the surface of the quartz crystal, anhydrite has contact with the fluid and will be dissolved under 70° C during cooling of the alpine cleft. The anhydrite needles are now transformed to hollow tubes, which are not closed by quartz, because the quartz crystallization had finished before anhydrite was dissolved. Only weathering products (e.g. clay minerals) could fill now the hollow tubes.

The crystallization of anhydrite is independent from the chemistry of the host rock. This calcium-sulphate mineral was found in Alpine clefts located in amphibolite, banded gneiss, migmatite and syenite. The fluid composition was rich in sulphur and produced anhydrite under oxidizing conditions at an early stage of the cleft mineralization. Anhydrite is only protected by minerals, which are stable in the fluid of the hydrothermal system until weathering conditions, if it is fully encapsulated. Quartz is a very stable and frequent mineral of the Alpine clefts and often rich in solid inclusions of protogenetic and epigenetic crystallized minerals.

In Austria alpine mineral parageneses are predominately located in the Tauern Window, a protected area in great parts. For investigations earth scientists need samples of minerals and rocks which could not be found outside of this area. The scientific achievements are also presented for general public in meetings of societies for natural sciences.

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