

Spinel formation by sulphur-rich saline brines from Mansin (Mogok area, Myanmar)

During the last 2 decades, one of the authors has mapped the mineral occurrences in the Mogok valley and registered the mineral assemblages of approximately 100 spinel mines in a profile of 30 km length (first part published in Peretti et al., 2007 and Peretti & Tun 2016).

Abstract from 15th Swiss Geoscience Meeting 2017 (Davos, Switzerland)

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The map of the mineral occurrences shows the co-existence of spinel with ruby and sapphire in various types of marble rocks. Different colour varieties of spinel were found including fancy spinel, vivid red spinel and vibrant pinkish-red spinel. The variable colours of spinel may be due to the influence of trace elements from different types of metasedimentary or intrusive rocks in the environment of the marbles and changes in fluid compositions and formation conditions.

Detailed investigations with different methods (microthermometry, Raman spectroscopy, stable isotope and LA-ICP-MS geochemistry) are ongoing on spinel of one of the commercially most important mine, the Mansin mine. Its rock suite was investigated and sampled by detailed field work. The Mansin spinels formed in an impure layered dolomitic marble with layers of olivine, sulfides and spinel. There are indications for the influx of fluids that created halos in the marble forming Fe-rich dolomite.

To characterize the growth conditions of the Mansin spinels, fluid and solid inclusions were investigated in detail. At least two types of fluid inclusion assemblages are distinguished. Based on the actual knowledge, they were more or less simultaneously trapped as immiscible fluids (Giuliani et al. 2015) in the system Na? - K? - Ca - Mg - Al - Fe - Zn - SO₄ - Cl - H₂S - H₂O, with traces of some volatiles. These fluid inclusions may contain accidentally trapped minerals like phlogopite, calcite and retrograde precipitated daughter

mineral phases, i.e. native sulphur, different salts, diaspore, brucite, calcite, goethite, pyrite, marcasite, sphalerite, fluorapatite, etc. One fluid inclusion assemblage is characterized by an H₂S bubble of 10 to 35 vol.% and a series of daughter minerals. In contrast, the H₂S bubble of the second fluid inclusion assemblage is markedly smaller (3-5 vol.%), but nearly totally filled with daughter minerals. A striking feature of the first inclusion assemblage is the presence of two immiscible yellowish liquid phases (L1 and L2 at room temperature) and a vapour bubble (Fig. 1). The homogenization temperature of the L1 with the vapour phase lies at 101 ± 2 °C, close to the critical temperature of H₂S, which has been verified by Raman spectroscopy. An additional striking feature is the presence of large rounded, Raman inactive solids which are interpreted as salts.

Based on these preliminary results we conclude that the formation of spinel from Mansin was triggered by a very sulphur-rich, highly saline brine.

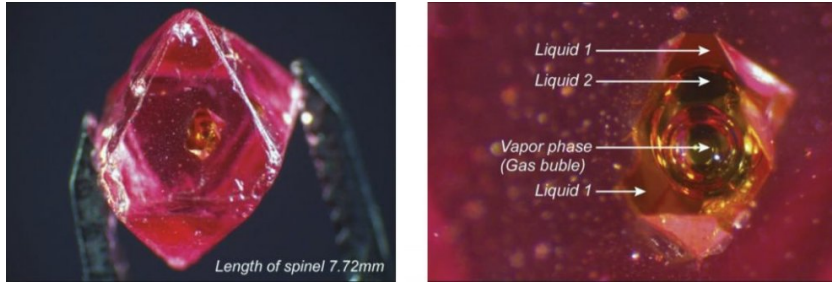


Figure 1. Multiphase fluid inclusion within a spinel from Mansin (East Mogok) at room temperature. There are two immiscible liquid phases and a vapor phase (gas bubble).

Spinel formation by sulphur-rich saline brines from Mansin (Mogok area, Myanmar)



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15th SWISS GEOSCIENCE MEETING 2017 DAVOS

Fig. 1: Geographic position and geology of the Mogok Stone Tract (map after Hughes 1997)

Aims/goals

The Paleogene Mogok metamorphic belt in central Myanmar (Fig. 1) is mainly made up of medium- to high-grade metamorphic rocks and younger intrusions (Metcalfe 1988; Thu et al., 2016). During the last 2 decades, mineral occurrences and assemblages of approximately 100 spinel mines from the Mogok valley (Myanmar) were mapped by Peretti et al. (2007) and Peretti & Tun (2016). Their investigations reveal the co-existence of spinel with ruby and in various types of marble rocks. This investigation presents preliminary results of melt and "fluid" inclusion studies aiming to decipher the chemical conditions under which spinel from Mansin grew at granulite facies conditions of 700-800°C and 7-8 kbar (Phyo et al. 2017).

Methods

Detailed investigations have been performed or are still ongoing by the following methods:

Polarization microscopy, microthermometry (LINKAM table), micro Raman spectroscopy (Bruker Senterra), electron microprobe analysis (JEOL JXA-8900), REM (REM Nova Nano-SEM 230, Acc. c. 20000 V), stable isotope and LA-ICP-MS geochemistry.

Fig. 2: Primary inclusion in spinel

Fig. 3: Secondary inclusions in spinel

Fig. 4: S-rich secondary inclusion

Fig. 5: White secondary inclusion

Fluid inclusion typology

Two types of inclusion assemblages are distinguished. Type 1 is a H₂S-rich yellowish inclusion characterized by two immiscible liquids and a vapour bubble (L1 and L2 - 10 to 30 vol. %), and a relatively small amount of daughter minerals (Figs. 2&4). Type 2 is represented by a white mineral bearing polycrystalline assemblage of daughter minerals and a small bubble of ~5 vol. % (Fig. 5). Both inclusion types are present as primary (Fig. 2) and synchronous trapped secondary fluid inclusions (Figs. 3-5). Nearly all daughter minerals have a rounded "corroded" shape.

Microthermometry

Several phase transitions were observed during heating by microthermometry, i.e., melting of H₂S at -86°C, dissociation of light coloured grains between 85 and 95 °C, or homogenization of H₂S with H₂S₂ at 102.5 ± 1 °C close to the critical temperature of H₂S (Fig. 5).

Daughter minerals in both inclusion assemblages

Native sulfur, anhydrite, apatite, pyrite, marcasite, sphalerite, chlorides, carbonates, diaspore, brucite, goethite, and very rarely anhydrite and rutile etc.

Fig. 7: Raman investigations with spectra of liquids L1 & L2, vapour (V) and solids of a primary inclusion

Fig. 6: Microthermometry of a sulfur-rich secondary inclusion

The striking difference between the two inclusion assemblages is the relative amount of daughter minerals with respect to the liquid volatile bubble. Type 1 and 2 contain two immiscible liquids:

- L1 = H₂O, HS, H₂S₂ and some CO₂ (Figs. 4&7)
- L2 = H₂S, H₂O (Figs. 4&7)

Type 1 additionally contains:

- native sulfur S₈ within the yellowish liquid H₂O phase, possibly in suspension,
- H₂S and some H₂O, NH₃, CH₄ and light higher hydrocarbons in the vapour bubble.

Fig. 8: Decrepitation of an inclusion in spinel (a) and its ejection (b) shows halite and sylvine in the external zone and sulfur in the inner zone (see REM spectra c and d with backscattered electron images).

REM

For gaining some chemical and mineralogical informations, a primary Type 1 fluid inclusion (Fig. 8a) has been heated, decrepitated and analysed by REM.

In the external zone of the ejaculate (Fig. 8b, point 1) halite or sylvine were detected, and in the inner zone (Fig. 8b, point 2), native sulfur were identified. Spectrum c (inner point 1) and spectrum d (external point 2) show the results of the REM analyses.

Fig. 9a-c: Microthermometry of fluid inclusions

Preliminary interpretation

The detected daughter minerals are native sulfur, sulfides, carbonates, chlorides, phosphates (apatite), Al-, Mg- and Fe-hydroxides (diaspore, brucite, goethite), and subordinately sulfates and oxides like anhydrite and rutile. The detected volatile species are dominantly H₂S, and traces of HS, NH₃, CH₄ and light hydrocarbons. Minute amounts of CO₂ dissolved in aqueous solution indicate that nearly all carbonate anions must have been used for carbonate precipitation. Daughter mineral and fluid phases refer to a sulfur-dominated melt, from which the two inclusion assemblages formed during retrograde conditions. Immiscibility is indicated, leading to the separation to the two inclusion assemblages, as mentioned by Giuliani et al. (2015) for rubies from the same deposits. In addition, most daughter minerals are rounded and changed their shape from one week to the other, even so during Raman measurements. These findings highlight that the Mansin spinel precipitated from a sulfur-dominated chloride carbonate melt in an extremely reduced acid growth environment, in the system Na-K-Ca-Mg-M-Ti-Al-Fe-Cu-Zn-V-C-N-P-S-Cl-F-H₂O.

References

Balashov, G., Sanyal, S., Sanyal, D.A., Ushakov, S. & Grossenbacher, D. (2013) Fluid inclusions in garnet from the Himalayas: genetic implications. *European Journal of Mineralogy*, 25, 101-116.

Hughes, R.W. (1997) Ruby and sapphire. *Ruby and Sapphire*, Bangkok, Thailand, 512 pp.

Matsuda, I. (1989) Origin and assembly of south-east Asian continental terranes. *Geodinamica Acta*, 2, 101-116.

Peretti, A., Peretti, F., Tun, N.L., Günther, D., Hammer, K., Beer, W., Schweizer, S., Pasteris, M. & Ammerstorfer, S. (2007) Giant quality gemstones: occurrence, chemical composition and crystal structure. *Contributions to Mineralogy*, 5, 1-103.

Peretti, A. & Tun, N.L. (2016) Mineralogical evidence, inclusion color analysis, collector gems, mining and market activities prior to 2008 in Mogok. *Contributions to Mineralogy*, 48(1-2).

Phyo, M.M., Franz, L., De Capitani, C., Balmer, W. & Kornemann, M. (2017) Petrology and P-T conditions of quartz and nepheline-bearing granites from Mogoke Stone Tract, Myanmar. 15th Swiss Geoscience Meeting Davos, Abstract Volume, 88-89.

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References

Giuliani, G., Dubessy, J., Banks, D.A., Lhomme, T. & Ohnenstetter, D. 2015: Fluid inclusions in ruby from Asian marble desposits: genetic implications. *European Journal of Mineralogy*, 27, 393-404.

Peretti, A., Peretti, F., Tun, N.L., Günther, D., Hametner, K., Bieri, W., Reusser, E., Kadiyski, M. & Armbruster, T. 2007: Gem quality johachidolite: occurrence, chemical composition and crystal structure. *Contributions to Gemology*, 5, 1-53.

Peretti, A. & Tun, N.L. 2016: Mapping of minerals, corundum color varieties, collector, gems, mining and market activities prior to 2008 in Mogok. *Contributions to Gemology*, Abstract volume.

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