Giant Quartz-Hematite veins in the Oman Ophiolite: sub-seafloor or obduction origin? Part 1

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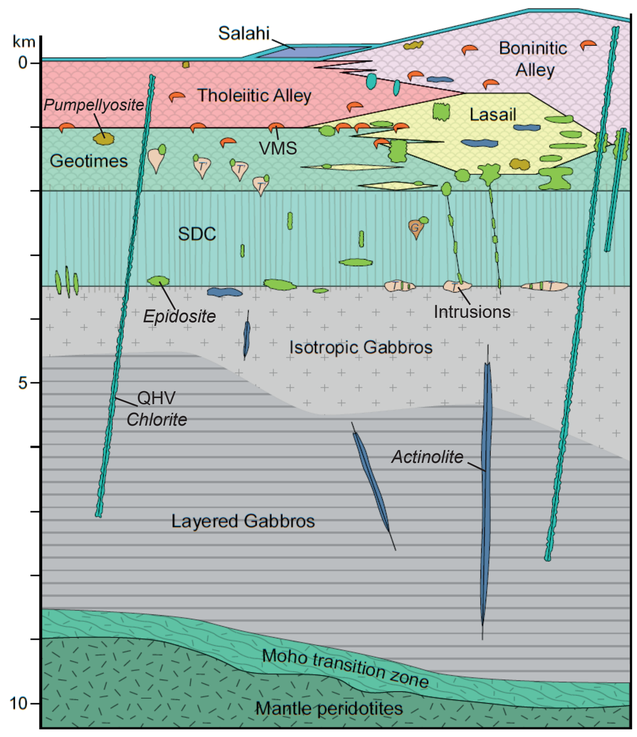
1. Introduction and Motivation

The Semail ophiolite in Oman is characterized by regional as well as local alterations. These are products of the genesis of this ophiolite sequence, which starts with the formation at the MOR and the associated hydrothermal convection cells and ends with the obduction onto the Arabian continental plate.

One of these local alterations are quartz-hematite veins that cause a chlorite halo in the host rock (QHC-veins). They are described in the literature as obduction-associated, but also as possible subseafloor pathways for VMS deposits. However, they have never been studied in detail. More in-depth investigations are needed to remedy this discrepancy. The first results on these investigations are presented on this poster.



Semail ophiolite stratigraphy with lithologies in roman and alterations in italics. Slightly modified after Belgrano et al. 2019

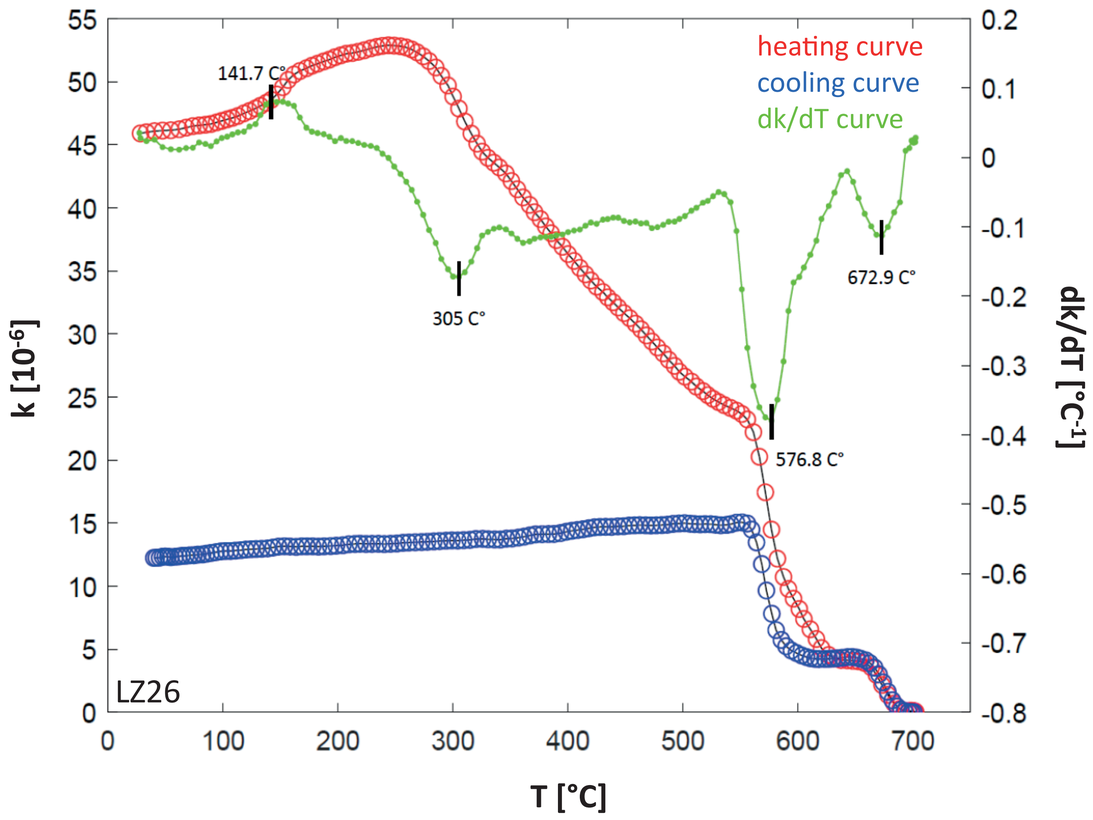
2. Aims and Methods

- Fluid characteristics and age differ in syn-VMS and syn-obduction stage.
- By determining the age and fluid characteristics, the QHC-veins can be assigned to a stage.
- Investigations of rock and paleomagnetism to determine a relative age.
- Investigations on fluid inclusions for more information on fluid characteristics and homogenization temperatures.

3.1. Results of rock and paleomagnetism

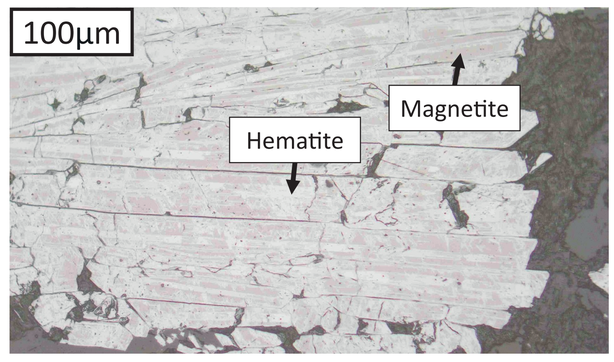
By heating the sample, naturally remanent magnetized Fe-oxides are demagnetized, by reaching their Curie temperature. These temperatures are characteristic for minerals. To find the different demagnetization temperatures, the heating curve is derived numerically.

Four minima and maxima were found. The minima at 672.9 °C corresponds with the Curie temperature of hematite (Bleil&Petersen 1982) and the one at 576.8 °C is caused by demagnetization of magnetite (Hunt et al. 1995). The increased susceptibility between 141.7 °C and 305 °C is a typical effect of maghemite. Due to the metastability of this mineral, only a kink in the heating curve is seen at its Curie temperature of 640 °C (Clark 1997). This is confirmed by the cooling curve, in which maghemite is no longer visible after its chemical alteration to hematite at elevated temperatures.



Identification of the magnetic minerals hematite, magnetite and maghemite, by high-temperature susceptibility measurements.

Petrographic studies give further insight into the relationship between the magnetic minerals. Thus, one recognizes in the hematite replacement with magnetite. Microscopically, maghemite could not be found as it is only slightly different from magnetite, which is further complicated by the small amount of maghemite in the sample.

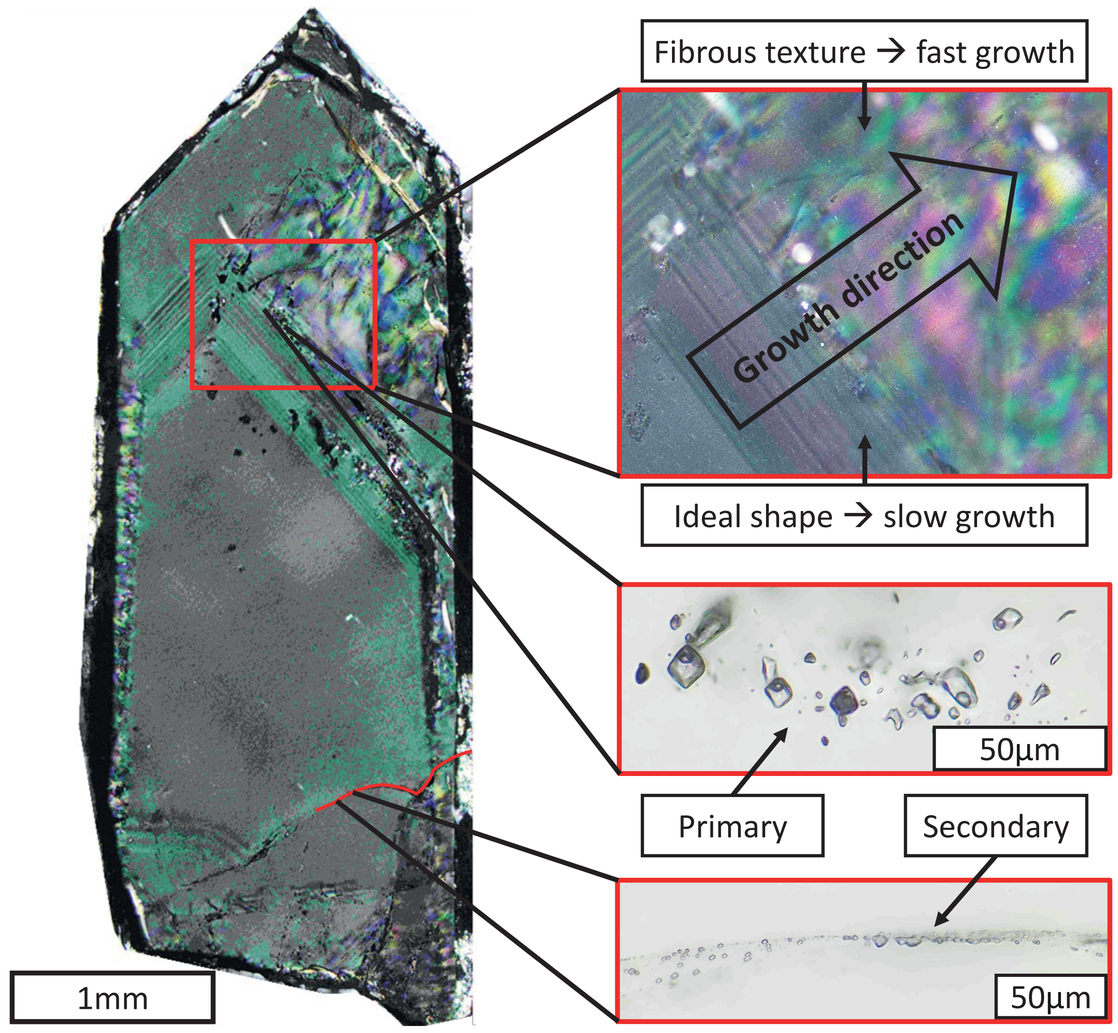


Reflected light microscopy

3.2. Results of fluid inclusions

The primary inclusions are located along the growth faces of the quartz which is the transition from slow to fast growth. The inclusions trapped during the formation of the crystal consist of aqueous liquid and vapor. No solid inclusions were found. The uniform vapor to liquid ratio tells us that a homogeneous assemblage was trapped.

Secondary fluid inclusions were found along healed fractures. The fracture formed these inclusions after the host crystal. Again, it is a homogeneous trapping, with the difference that only aqueous liquid was trapped and no vapor.



Fluid inclusions in a single crystal (cross polarized light) from a gabbro hosted quartz-hematite vein

4. Conclusions

- Magnetic and petrographic observations, show that vein hematite was transformed to maghemite and then magnetite, indicating influx of a reducing fluid after formation of the QHC veins.
- Formation of the veins below 150 °C is indicated by the small bubble size in the primary fluid inclusions.
- The low formation temperature is inconsistent with a fluid in deep oceanic crust gabbros.
- Either the QHC-veins are obduction-related or the single quartz crystals are from a late-stage filling.
- The preliminary results favour the syn-obduction genetic model.

5. Future work

Paleomagnetic orientations will be used to date the hematite to magnetite transition. Fluid inclusions microthermometry will be used constrain *P,T* and fluid salinity during vein formation. XRF analyses of wall rocks will be used to reveal element exchanges during formation of the chlorite halo.

References

Belgrano, T.M., Diamond, L.W., Novakovic, N., Hewson, R.D., Hecker, C.A., Gilgen, S.A., 2019. Controls on hydrothermal alteration in oceanic crust: insights from field mapping and remote sensing 1200 km^2 of crustal outcrop in the Oman–U.A.E. ophiolite. Unpublished manuscript

Bleil. U., Petersen, N., 1982. Curie temperature, in Landolt-Börnstein: Numerical Data and Functional Relationships in Science and Technology edited by G. Angenheister, Springer Materials: The Landolt-Börnstein database. DOI: 10.1007/10201909_76.

Clark D.A., 1997. Magnetic petrophysics and magnetic petrology: Aids to geological interpretation of magnetic surveys. AGSO journal of Australian geology & geophysics 1997, 17(2), p. 83-103

Hunt, C.P., Moskowitz, B.M., Banerjee, S.K., 1995. Magnetic properties of rocks and minerals, in Rock Physics and Phase Relations: A Handbook of Physical Constants, edited by T.J. Ahrens, pp. 189–204, AGU, Washington, D.C., DOI:10.1029/RF003p0189

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