

## Experimental study of the Na-in-cordierite thermometer at different fluid compositions (NaOH-H<sub>2</sub>O; NaCl-H<sub>2</sub>O)

M. SCOLA, P.W. MIRWALD AND P. TROPPER

Institute of Mineralogy and Petrography, Univ. Innsbruck, Austria (peter.mirwald@uibk.ac.at)

Orthorhombic cordierite, (Mg,Fe)<sub>2</sub>Al<sub>4</sub>Si<sub>5</sub>O<sub>10</sub>\*n(Na, H<sub>2</sub>O, CO<sub>2</sub> etc.), a characteristic mineral phase of medium to high grade metapelites, has thermometric properties. A previous study in the model system Mg-cordierite – 1n Na(OH) (Mirwald, 1986) showed that the Na-content is inversely related to temperature, is largely pressure independent, and stabilises cordierite by about 75MPa relatively to the upper stability boundary according to the reaction (1) Crd + H<sub>2</sub>O = Tc + Q + Ky (Mirwald, 1984).

In this study we investigated the Na-incorporation in Mg-cordierite using different NaCl solutions (X<sub>H<sub>2</sub>O</sub>= H<sub>2</sub>O/H<sub>2</sub>O+NaCl; X<sub>H<sub>2</sub>O</sub>: 1, 0.8, 0.6, 0.4 and 0.2) which implies, in addition, different H<sub>2</sub>O activities covering the P-T range 0.2 – 1.1GPa and 650 to 750°C. Thus, the present experiments were conducted in a slightly acidic fluid milieu. The experiments were carried out in a piston cylinder and a hydrothermal apparatus. Microprobe and X-ray diffraction were used for sample characterisation.

The preliminary data confirm the inverse temperature relation without a significant pressure dependence. Previous Na-T relation: Na(apfu) = 0.406+/-0.003 – 0.000471\*T(°C); this study: Na(apfu) = 0.398+/-0.015 – 0.000466\*T(°C). Again, the Na incorporation stabilises cordierite by about 75MPa, varying H<sub>2</sub>O activities have no significant influence on the position of reaction (1).

Further experiments performed on quartzphyllite samples and application of the Na-in-cordierite thermometer to high-grade rocks are presented by Wyhlidal *et al.* (2007) at the same meeting.

### References

- Mirwald, P.W. (1984): *Fortschr. Mineral.*, **62**, Beih. 1: 156-157.  
 Mirwald, P.W. (1986), *Fortsch. Mineral.* **64**, 119  
 Wyhlidal, S., Thöni, W.F., and Tropper, P. (2007), this volume.

## Water-rock interactions at the new Gotthard rail base tunnel, Switzerland

ULRIKE SEELIG<sup>1</sup> INGRID STOBER<sup>2</sup> AND KURT BUCHER<sup>1</sup>

<sup>1</sup>University of Freiburg, Germany;

(ulrike.seelig@minpet.uni-freiburg.de)

<sup>2</sup>Geological Survey of BW; (ingrid.stober@rpf.bwl.de)

In Switzerland the new 57 km long rail base tunnel traversing the Central Alps is currently under construction. From the 11.35 km long Amsteg-Sedrun section in the northern part of the tunnel 110 water samples from fractures and open fissures have been collected and analyzed. Geologically this section lies completely in the steeply dipping crystalline basement of the Aar massif.

Depending on the lithology the tunnel water samples show different compositions and the total of dissolved solids is varying from 171 to 4014 mg/l. The most prominent cation is sodium. Magnesium is in most samples close to or below the detection limit of 0.02 mg/l. The majority of the waters has also a very low calcium content. Only a few samples have elevated Ca-concentration, which can be related to the dissolution of fracture anhydrite. The major anions represent a mixture of bicarbonate, chloride and sulphate with varying concentrations. Chloride together with an equivalent amount of sodium is contributed to the waters from leaching of crushed fluid inclusions and grain boundaries. Sulphate originates mainly from the oxidation of sulphide minerals and to a minor extend from the dissolution of anhydrite locally present in fissures.

One striking feature of the tunnel waters is their surprisingly high fluoride content of up to 29 mg/l. In low-TDS waters the fluoride concentration can even exceed the chloride concentration. Fluoride is contributed by fluorite dissolution, which can be found both as secondary fracture mineral and in the granite matrix. The low calcium content of the fluorite-buffered waters leads to the observed extremely high fluoride concentration.

The other remarkable feature of the tunnel waters is their very high pH throughout all lithologies with values up to 10.4. It results from dissolution of calcite under closed system conditions, which leads to a strong decrease of the partial pressure of CO<sub>2</sub>. Calcite was found frequently in the granitoid host rocks. Calcite dissolution is also the source of bicarbonate in the waters. The dissolved calcium is then removed via a combination of plagioclase alteration and formation of zeolites. The hydrolysis of albite (anorthite content of the plagioclase is below 5 mole%) releases sodium as major cation into the water. Zeolites, especially laumontite, are present as thick mats on fracture surfaces in the tunnel. Zeolite formation is then responsible for the removal of calcium from the water.