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**POST-MAGMATIC VEIN MINERALS IN THE KARKONOSZE GRANITE
FROM THE "CIEPLICE 1" DRILLING CORE, SUDETES, POLAND:
PRELIMINARY RESULTS**

Core samples from the 2 km deep drilling "Cieplice 1" represent the so-called central type of the Karkonosze granite. Granite samples show post-solidus mineral transformation processes. Apart from the overall chloritization of biotites and sericitization of feldspars, which affected the bulk rock, calcite, laumontite and quartz occur as infillings of thin veins, which are probably of tectonic origin. Such veins are relatively rare in the studied profile. Their thickness usually ranges from 0.5 to 1 mm. (Fig. 1), and rarely approach 5 mm. Euhedral laumontite is the main mineral filling the veins. Calcite fills the central parts of the veins. Sometimes one observes two generations of veins, well distinguishable under cathodoluminescence (Fig. 2, view field 3×2 mm). Laumontite shows almost ideal composition $\text{Ca}[\text{AlSi}_2\text{O}_6]_2 \cdot 4\text{H}_2\text{O}$, according to EDS measurements (Link Analytical AN10/85S). Calcite usually is manganese-bearing, $\text{Ca}_{0.98}\text{Mn}_{0.02}\text{CO}_3$. Fig. 3 shows BSE images of the K-feldspar phenocryst cut by laumontite veins (upper) and laumontite-calcite vug (bottom).



Fig. 1. Laumontite-calcite-quartz vein.

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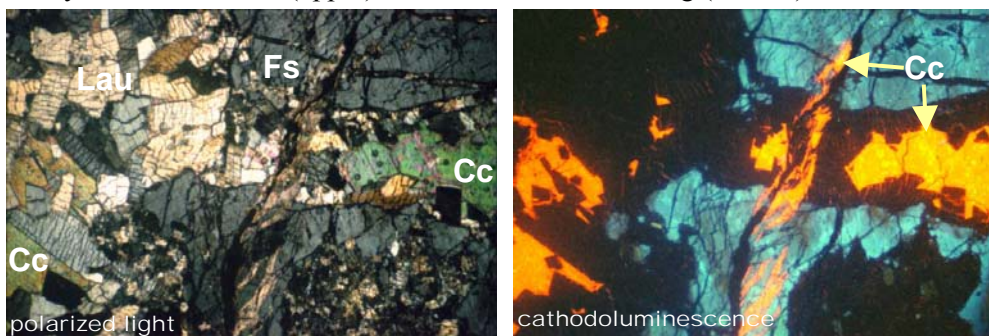


Fig. 2. Vein infillings in TLM (left) and cathodoluminescence (right).

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The occurrence of mineral association laumontite-calcite could be linked with decomposition of plagioclase coupled with releasing of calcium. The partial decomposition of plagioclases is evidenced by their intense sericitization. The present work shows preliminary results of studies on the conditions of crystallization of laumontite, calcite and quartz in veins. Oxygen and carbon isotope compositions were measured in 5 carefully hand-picked samples. The results are shown in Fig. 4. Only the sample 1285a shows a single calcite crystal, the remaining samples comprise bulk vein infillings. The analysis 1285 represents the crushed rock. In sample 1285d the CO₂ content was very low and the obtained value might be inaccurate. Two other samples showed only traces of CO₂ and were not measured. The most reliable result of the single calcite crystal measurement (1285a) is: $\delta^{18}\text{O}$ 11.78 ‰ (SMOW) and $\delta^{13}\text{C}$ -7.61 ‰ (PDB). The observed isotopic compositions of carbon are close to the average carbon composition in the Earth crust (Fuex, Baker 1973). Fluid inclusion preliminary studies were carried out on calcite crystals. In this mineral fluid inclusions occur frequently, but they are small, not exceeding 10 μm . Commonly fluid inclusions are round and oval, rarely isometric, resembling the shapes of negative crystals. These inclusions were recognized as primary (trapped during growth of crystal). There occur also groups of secondary fluid inclusions in the form of trails after sealed cracks. Apart from two-phase, there occur also one-phase liquid inclusions. However, we did not succeed in generating a gas bubble in these inclusions and, therefore, they were not suitable for interpretation. The biggest one of the studied inclusions, with a well visible gas bubble, is presented in Fig. 5. Seven primary, two-phase fluid inclusions were measured by microthermometry using a Linkam THMS 600 heating-freezing stage. When heating, fluid inclusions homogenized to liquid phase at temperatures 145–148°C, and in one case 173°C. They froze at about -70°C. We could not observe both the eutectic melting and

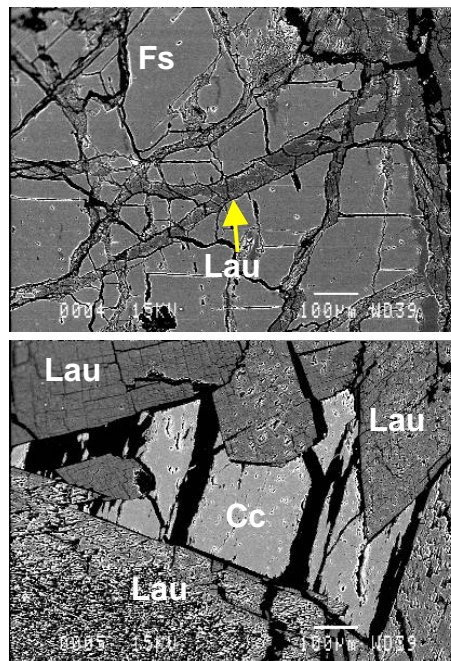


Fig. 3. Veins in BSE imaging.

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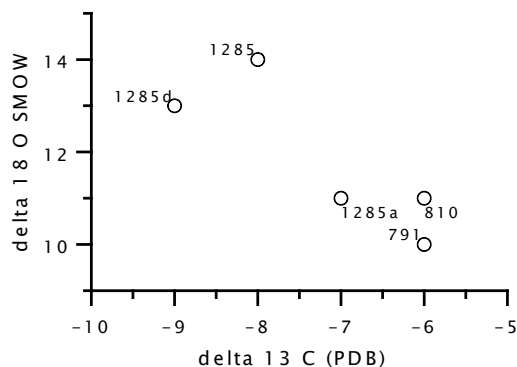


Fig. 4. Oxygen and carbon isotope compositions.

the final melting of ice, and therefore assess the chemical composition and salinity of fluids. During the freezing run crystallization of salt hydrates was not observed. In course of heating of the frozen inclusions, gas bubble appeared at the temperatures 5–20°C, likely due to a metastable state. These observations allow to assume that the salinity of solutions was low. The density of a fluid can be read out from the phase diagram (Shepherd et al. 1985) assuming the fluid salinity being equal to 0 and the most representative homogenization temperature $T_H = 145^\circ\text{C}$. It is equal to 0.92 g/cm^3 (Fig. 6). Temperature of trapping T_T of inclusions is higher than T_H because of the effect of pressure and salinity. Facing to the lack of pressure estimation we assumed that the forming pressure of the fluid inclusions was not lower than 0.4 kbar (the sample was taken from 1285 m depth) and not higher than 1 kbar, what corresponds to lithostatic pressure at about 3.5

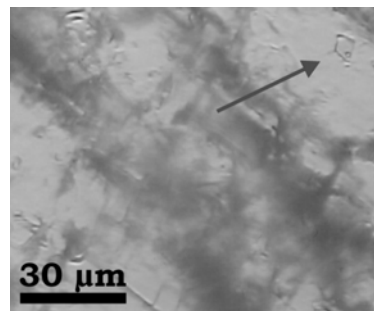


Fig. 5. A primary two-phase fluid inclusion in calcite.

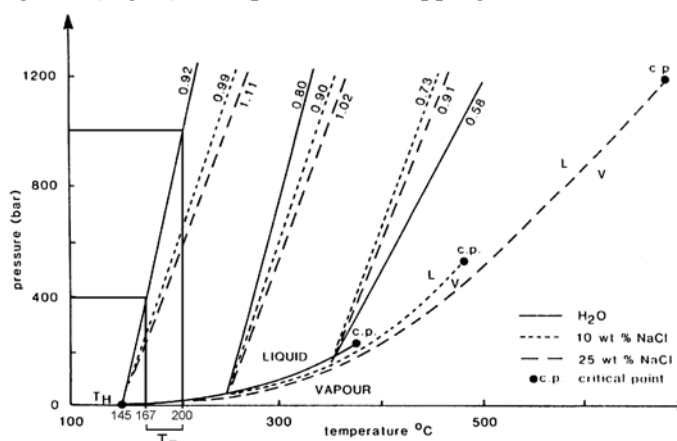


Fig. 6. Phase diagram showing the relationship between the T_T and pressure.

km depth. Correspondingly, trapping temperatures would be as high as 167–200°C (Fig. 6). Assuming oxygen isotope equilibrium exchange between solution and crystallizing calcite, and subsequent conservation of calcite isotopic composition, the isotopic composition of water was calculated for temperatures 167–200°C. $\Delta^{18}\text{O}_{\text{cc-H}_2\text{O}}$ for this temperature range is equal to 11.46–9.53 ‰, therefore the $\delta^{18}\text{O}$ (SMOW) of water equals approximately 0.3–2.2 ‰. Such high values of $\delta^{18}\text{O}$ of water suggest, that the water solutions from which calcite crystallized could not be solely meteoric, but likely have more complex origin, like a mixture of older evolved magmatic waters with the meteoric ones.

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