SLOVAK GEOLOGICAL MAGAZINE

A fluid inclusion analysis contribution to the study of tectono-metamorphic evolution of the Veporicum crystalline complex

VLADIMÍR BEZÁK , VRATISLAV HURAI & JÁN KRÁĽ

Geological Survey of Slovak Republic, Mlynská dolina 1, 817 04 Bratislava

Abstract. An analysis of the positon of quartz veins in Veporicum in space, and of their occurrence in the principal units (metamorphic rocks of the southern Veporicum, granitoids, metamorphic rocks of the northern Veporicum, Mesozoic cover) as well as the conditons of their formation, along with geochronological data, allowed to explain the formation of these veins in the context of the Hercynian and Alpine tectono-metamorpic development. On the basis of so far obtained data it may be stated that veins formed in granitoids in the Hercynian period (340-300 Ma), at temperatures of 450-500°C, and in the Alpine time (especially in the mylonite zones) at 300-380°C. These temperatures correspond to temperatures of Alpine vein formation in metamorphites of the northern and southern Veporicum and in the Mesozoic cover of Veporicum. Higher-temperature Alpine veins have not been found yet. The formation of Alpine veins is placed into the time of 140-80 Ma.

Key words: Western Carpathians, Veporicum, fluid inclusions,,geochronology, tectono-metamorphic events

The study of fluid inclusions in metamorphogenic quartz from crystalline complexes of Veporicum has been going on, with interruptions, for a longer time (e.g. HURAI 1983, HURAI et al. 1994). This method brought a number of interesting results, which must be considered when interpreting the tectonic and metamorphic evolution of the crystalline basement. In the first stage, data on metamorphic conditions were obtained, which, combined with geochronological data, characterised the metamorphic development and uplift of the complexes to higher levels. The results suggested two temperature ranges (HURAI 1983). The original interpretation, i.e. that both ranges belong to Alpine processes, met with a number of contradictions. Therefore, another solution was sought. This was contributed also by the progress the knowledge of tectonic development of Veporicum and by isotopic data. It has been proved that all veins contain also components coming from metasediments, even though they occur in granitoids, which was another point in favour of the nappe position of granitoids on metasediments (HURAI et al. 1994). A part of the Alpine-type veins, after analysing the tectonic position of their host complexes, had to be re-classified as Hercynian (HURAI et al. l.c.).

For the purpose of a confrontation of Hercynian and Alpine conditions, we analysed recently quartz samples from the cover Upper Paleozoic and Mesozoic from different parts of Veporicum-. The results indicated temperatures of the formation of Alpine veins ranging form 300 to 350°C. From other new data there are interesting the temperatures of quartz formation in schists of the Sinec complex - 370-380°C. These temperature are quite consistent with so far determined conditions of the crystallisation of Alpine veins in metamorphic rocks of the southern Veporicum and in Alpine mylonite zones of granitoids (HURAI et al. 1994).

This contribution is aimed at analysing the available data in direct relationships to the tectonic evolution.

The basic types of metamorphogenic quartz so far determined in Veporicum are the following:

1) veins of NE-SW direction parallel with the foliation of metamorphites, or in mylonite zones of granitoids with fluids indicating a temperature of 330°-380°C
2) filling of fissures in granitoids with crystallisation temperatures of 450°-500°C.

For the purpose of this analysis we distinguished the following basic types of host complexes:

a) metamorphites of the northern Veporicum (Krakľová Zone)
b) granitoids of the Kráľova hoľa Zone
c) metamorphites of the Kohút Zone
d) Upper Paleozoic and Mesozoic cover in all zones.

Tectonic relations of the se complexes are at present interpreted as an interaction of Hercynian and Alpine processes and their superposition is shown on Fig. 1. The granitoids are in thrust position, having originated already in the Hercynian tectonic stage. Age relationships (from published geochronological data) are shown as well as occurrences of the different quartz types.

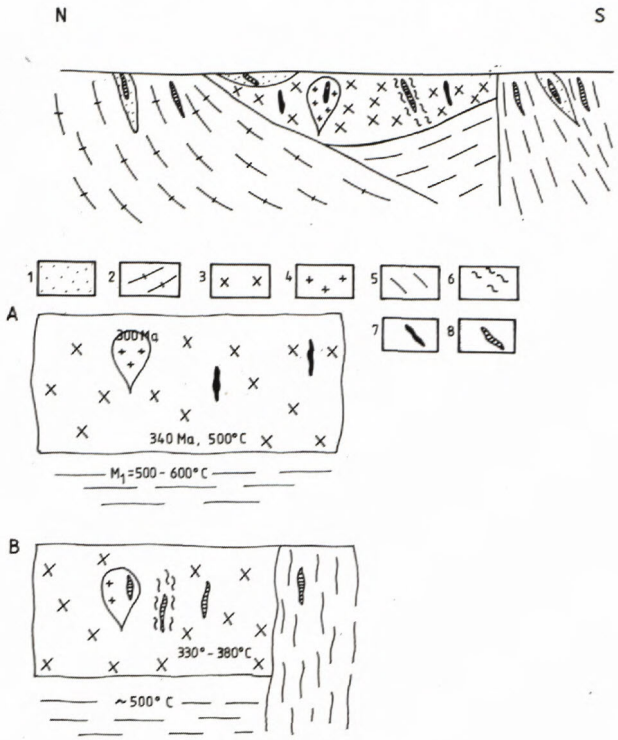

Fig.1 ***Top****: Present distribution of low and high temperature quartz veins in the Veporikum.*
Bottom: *Interpretation of the sequence in origin of the veins.*
A - Hercynian stage: *1. Metamorphism, 2. cooling below 500°C in granitoids (340 Ma), 3. creation of veins in the temperature range between 450° and 500°C, 4. intrusions of the Sihla type granitoids (300 Ma), 5. part of veins formed at 330 - 380°C (?)*
B - Alpine stage: *Metamorphism up to 500°C (in lower complexes), upper complexes 300 - 400°C (140 - 80 Ma), 2. creation of veins in the temperature range 330 - 380°C (in all complexes), 3. cooling below 300°C in all complexes (80 Ma)*
Explanations: *1-Mesozoic cover,2 - North-Veporic metamorphites, 3-granitoids, 4 - Sihla type granitoids, 5 - South-Veporic metamorphites, 6 - mylonite zones, 7 - high-temperature veins (450 - 500°C), 8 - low temperature veins (330 - 380°C)*

From metamorphic rocks of the Kohút Zone, 8 samples have been analysed so far (micaschists of the Ostrá Complex, the Klenovec gneiss complex, Sinec Complex) and all quartz samples belong to the first - lower temperature - vein type. In granitoids there are low-temperature veins of the first type (especially in mylonite zones) - 6 samples - and higher-temperature filling of veins of the second type (6 samples). One lower-temperature vein has been analysed from metamorphites of the northern Veporicum. From cover sequences of all zones, 4 samples have been analysed, belonging all to lower-temperature veins with parameters as in metamorphic rocks (Fig. 1).

Discussion

An analysis of the position of metamorphogenic quartz veins in space indicates that different-temperature quartz cannot have formed in the same period, but they are two tectono-metamorphic events. The fluid inclusions show also the temperature parameters of certain stages of their development and, together with geochronological data, they contribute to the reconstruction of the rate of uplift and of the cooling of the crystalline complexes.

Higher-temperature filling of fissures is associated exclusively with the granitoid complex. Accepting the nappe position of granitoids makes it impossible to interpret them as Alpine, as granitoids contain simultaneously also low-temperature veins and metamorphites, which were lower in position, only lower-temperature. Their formation is placed into the time after the thrusting of the migmatite-granite-gneiss complexes on low-metamorphosed sediments and after the intrusion of porphyric granites, which contain them, and, at the same time, after their cooling below 500°C (350-340 Ma, KRÁĽ et al.,1996), but before the intrusion of the Sihla granitoids (300 Ma, BIBIKOVA et al. 1990), which do not contain them, i.e. in the range of 340-300 Ma. The temperature conditions of the formation of Hercynian veins correspond to the Hercynian metamorphism of the metasediments (BEZÁK 1991).

The metamorphic rocks contain only low-temperature veins, formed at Alpine diaphtoritic processes connected with hydration, and not at progressive Hercynian metamorphism accompanied by dehydration. However, it cannot be excluded that higher-temperature veins have so far not been recorded by sampling. If they would exist, they would have formed also in the Hercynian stage, as the granites, or at the beginning of the Paleoalpine tectono-metamorphic development, as indicated by the analysis of latest Ar/Ar dating (KRÁĽ et al., 1996), and they would be associated only with the metamorphic complexes lowest in position. Paloealpine age of high-temperature veins in granites is out of question, as their immediate cover does not contain them.

The formation of Alpine metamorphogenic quartz took place in all complexes (veins in metamorphites, in mylonite zones of granitoids, in the Sihla granitoids, in Triassic metaquartzites) approximately at the same conditions (300-350°C). Slightly higher crystallisation temperatures (370-380°C) are indicated only by veins in the lower complexes of the Kohút Zone (Sinec).

The ages of the Alpine veins are limited by Ar/Ar, or K/Ar data, and the cooling of the crystalline complexes. According to newest data (KOVÁČIK et al. 1996, KRÁĽ et al., 1996), the age range of the assumed higher-temperature Alpine metamorphism (400-500°C), which affected the lower metamorphosed complexes (below the granitoids of the middle unit according to BEZÁK 1994) is so far not possible to prove, but we can say that it was not earlier than 140 Ma. The lower-temperature Alpine

metamorphic event (300-350°C), including also the formation of Alpine quartz veins, is supported by relatively reliable geochronological and geological evidence (in the cover). Its lower age boundary is dated at about 80 Ma (cooling below 300 °C in all Veporicum complexes).

References

BEZÁK, V. 1991: Metamorphic conditions of the veporic unit in the Western Carpathians. Geologica carp., 42, 4, 219-222.

BEZÁK, V. 1994: Návrh nového členenia kryštalinika Západných Karpát na základe rekonštrukcie hercýnskej tektonickej stavby. Mineralia slov., 26, 1-6 (In Slovak, Engl. res.).

BIBIKOVA, E. V. KORIKOVSKY, S. P. PUTIŠ M., BROSKA I., GOLTZMAN Y.V. & ARAKALIANTS M. M., 1990: U-Pb, Rb-Sr and K-Ar dating of Sihla tonalites of Vepor pluton (Western Carpathian Mts.). Geol. Zb.-Geol. carpath., 41, 4, 427-436.

HURAI V., 1983: Genetická interpretácia plynokvapalných uzavrenín v kremeni zo žíl alpského typu veporického kryštalinika. Mineralia slov., 15, 3, 243-260 (In Slovak, Engl. res.).

HURAI V., SIMON K. & BEZÁK V., 1994: Hercýnsky vek niektorých trhlín s alpskou paragenézou minerálov v kryštaliniku veporika. Mineralia slov., 26, 355-361 (In Slovak, Engl. res.).

KOVÁČIK M., KRÁĽ J. & MALUSKI H., 1996: Alpínsky metamorfný a termochronologický vývoj juhoveporických predalpínskych metamorfitov. Mineralia slov., 28, 185-202 (In Slovak, Engl. res.).

KRÁĽ J., FRANK W. & BEZÁK V., 1996: $^{40}Ar/^{39}Ar$ spektrá z amfibolov amfibolických hornín veporika. Mineralia slov., 28, 501-513 (In Slovak, Engl. res.)