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REFILLING OF FLUID INCLUSIONS IN QUARTZ FROM METAPELITES, STARA KAMIENICA CHAIN, SW POLAND

Abstract: The recognition of the sequence of fluid inclusion formation is crucial for correct genetic interpretations of the inclusion data. The unambiguous criteria to establish this sequence may be obtained by means of the Kalyushnyi's method, applying the phenomenon of refilling of the inclusion vacuole. The paper presents the examples of the inclusion refilling found in quartz from metapelites of the Stara Kamienica chain in Sudetes Mts. This procedure allowed to establish the sequence of changes of the mineral-forming media of the studied quartz, recorded by seven generations of inclusions.

Keywords: fluid inclusion, refilling, inclusion generation, metapelite, Stara Kamienica, SW Poland

INTRODUCTION

Even thorough studies of fluid inclusions are of low value, when facing the lack of the criteria of establishing of well-founded sequence of the recognized changes of the mineral-forming medium. In euhedral or subhedral crystals the distribution of fluid inclusions in growth zones determines their relative age. However, if the attribution of the inclusions to growth zones is not distinct, or if we consider planes of secondary inclusions cross-cutting growth zones, the relative age of the planes with the inclusions usually is not obvious. The events which caused origin of the fractures in minerals subsequently healed with formation of the secondary inclusions may be very important for the minerals and the whole rock, thus their correct sequence is essential. The correctness of the good recognition of sequence of the fluid inclusion generations is especially desirable in minerals of the metamorphic rocks, in which some common minerals, suitable for fluid inclusion studies (*e. g.* quartz), may not display euhedral habits nor distinct zoning. This publication presents results of the fluid inclusion studies in quartz from metapelites; the rocks form an east-west striking belt in the northern part of the Izera Mountains in Sudetes, Lower Silesia (SW Poland). The belt is called Stara Kamienica chain and is built of chlorite-mica-quartz-garnet schists, metamorphosed under conditions of the albite-almandine-epidote subfacies, greenschist facies (Kozłowski 1974; Szałamacha, Szałamacha 1974; Makała 1994; Marcinowska 2002; *cf.* also Mazur 2002). Compositions of the metamorphic fluids in inclusions in quartz from these schists were characterized elsewhere (Marcinowska, Kozłowski 1997, 2003).

SAMPLES

The investigations were performed on 139 quartz samples collected in logs roughly perpendicular to the schist strike and completed by samples taken along the belt. A total of 307 double-side polished 0.3 mm thick slices of quartz samples was investigated,

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however, only a small portion of them, namely 29, contained inclusion systems, which yielded information on the sequences of the inclusion generations. The samples and preparations were the same as those studied to obtain the data on the fluid composition and temperatures and pressures of the metamorphic quartz formation (Marcinowska, Kozłowski 2003).

REFILLING OF FLUID INCLUSIONS

Fluid inclusion systems should be investigated very thoroughly to recognize the phenomenon of the inclusion refilling. The investigations include habits and typical dimensions of the inclusion vacuoles, temperature of homogenization (*Th*) of the inclusion fillings and composition of the salts dissolved in inclusion solutions, their concentrations and possible presence of other components (gases, daughter minerals). This characteristic is related to the position of a given inclusion system with respect to another system.

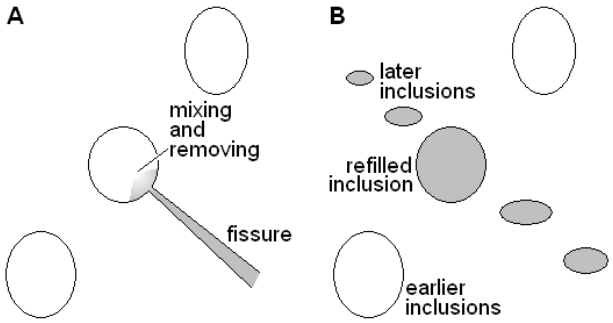

Fig. 1. Refilling of fluid inclusions: A – thin fissure opens an inclusion of the earlier generation and replaces the old fluid filling the vacuole by the new one, inflowing through the fissure; B – the fissure was healed and a new generation of inclusions along the healed crack was formed; the inclusion opened by the fissure, now closed again, preserves the old habit of its vacuole and contains new fluid typical of the inclusions formed from the healed fissure.

The refilling of fluid inclusions, first described by Kalyuzhnyi (1971, 1982) occurs when a vacuole of an existing inclusion is open by a fissure and then filled by the fluid from the fissure (Fig. 1). Next the crystal is healed and the fissure converts into a surface with secondary inclusions. The refilled inclusion has morphology of the inclusions of the earlier generation and contains fluid typical of the inclusions of the later generation. If the features of the generations were well recognized, sequence of the generations is easy to establish.

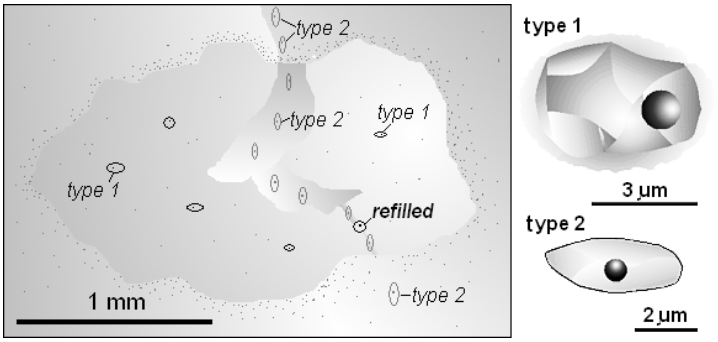

Fig. 2. Inclusions of the types 1 and 2, and refilling of the type 1 inclusion by the solution typical of the type 2 inclusions in quartz from the studied schists.

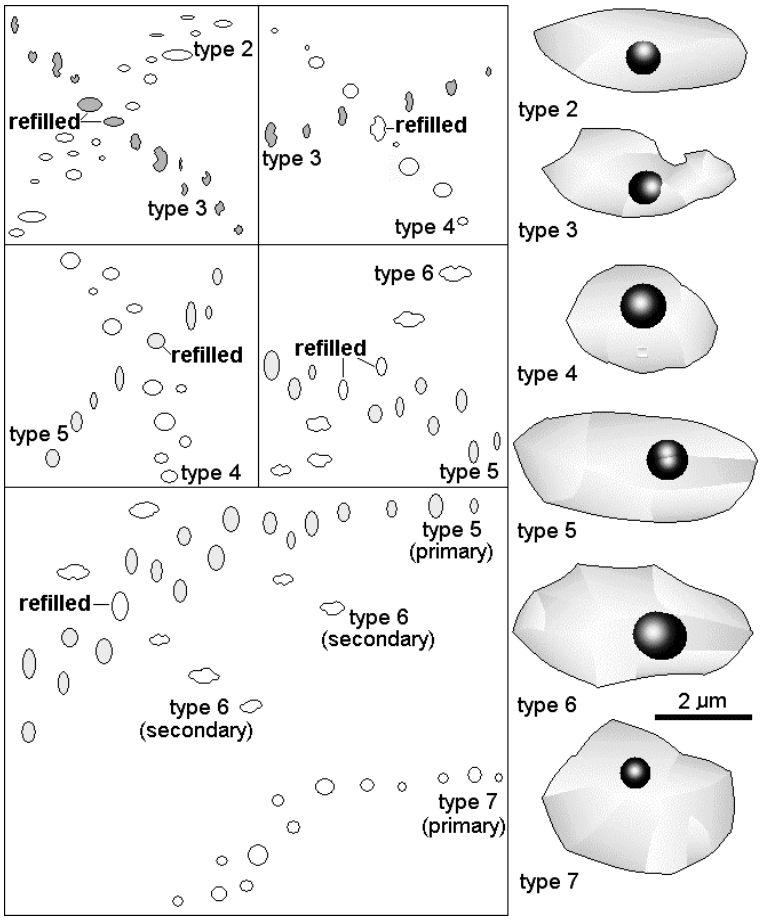

Fig 3. Types 2–7 of inclusions in quartz from the schists of the Stara Kamienica chain and examples of the refilling phenomena which allowed to ascertain the sequence of the inclusion formation.

Seven types of solution-filled inclusions were found in the studied quartz (Marcinowska, Kozłowski 2003).

Type 1. Inclusions frequently with evident leakage, filled by solution of the total salinity (*S*) of 16–27 wt. %, almost pure NaCl dissolved. The inclusions yielded temperatures (*Tcr*; here and later the temperatures of crystallization) from 480 to 540ºC and pressures (*P*) ca. 2.8 kbar.

Type 2. Inclusions with *S* 7–9 wt. %, NaCl dominates, KCl subordinate, *Tcr* 280–340ºC, *P* 2.4–2.6 kbar.

Type 3. Inclusions with *S* 16–20 wt. %, NaCl dominates, KCl and $CaCl_2$ subordinate, *Tcr* 350–420ºC, *P* 3.1–3.4 kbar.

Type 4. Inclusions with *S* 17–23 wt. %, NaCl dominates, KCl subordinate, *Tcr* 440–530ºC, *P* 4.3–4.9 kbar; few, not very reliable determinations yielded *Tcr* ca. 550ºC.

Type 5. Inclusions with *S* 13–14 wt. %, practically pure NaCl dissolved, *Tcr* 300–390ºC, *P* 3.3–3.4 kbar.

Type 6. Inclusions with *S* 16–20 wt. %, NaCl prevails but $CaCl_2$ occurs in significant amounts, traces of KCl, *Tcr* 380–440ºC, *P* 3.7–3.9 kbar.

Type 7. Inclusions with *S* 8–13 wt. %, NaCl prevails but $CaCl_2$ occur in similar amounts, *Tcr* 330–230ºC, *P* 1.8–2.6 kbar.

Temperatures, pressures, salt compositions and their concentrations, moreover to a certain degree the morphology of the inclusion vacuoles jointly characterise the generations of inclusions, thus the identification of the inclusion types is unambiguous. Hence, if the observations of the filled inclusions are correct, the established sequence of the inclusion generations yields the true scheme of the evolution of fluids in the metamorphic process of the schist formation.

CONCLUSIONS

The phenomena of refilling of fluid inclusions provide a unique opportunity to arrange the events of the evolution of the parent fluids of minerals in the correct sequence. It is especially important during studies of the metamorphic minerals formed under relatively low or moderate temperatures and pressures, in which the general regularities of the fluid evolution may be influenced by local processes or variable, progressive and retrogressive stages of metamorphism.

Studies of the inclusion refilling phenomena in the investigated quartz revealed that the inclusions of the *type 1* are most probably relics of pre-metamorphic fluids and that the post-peak retrogressive metamorphism had a progressive event recorded by the inclusions of the *type 6.*

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