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SEQUENCE AND CONDITIONS OF THE SILICIFICATION EVENTS IN THE GARBY IZERSKIE DISLOCATION ZONE, SUDETES

Abstract: A multistage silicification process in the Garby Izerskie dislocation zone developed at the temperature range 455–110ºC under a pressure of 1.6 to 0.4 kbar. Metasomatizing fluids contained NaCl and variable amounts of Ca, K, F and Li. Silicification started before the maximum temperature (ca. 650ºC) in this area appeared and continued during later cooling.

Keywords: fluid inclusions, quartz, metasomatosis, Garby Izerskie, Karkonosze-Izera block, Sudetes

INTRODUCTION

The investigated area is a several-kilometres-long SW–NE dislocation zone in the Izera gneiss-schist metamorphic complex (Smulikowski 1972) of the age of ca. 500 Ma (Borkowska et al. 1980). The zone developed between Izera gneisses and hornfelsed schists (Fig. 1a) in the northern exocontact of the Variscan granitoid massif (Borkowska 1966). It is 100 to 400 m wide and dips steeply to SE. The zone is cut by transversal faults of various sizes and in its SW end it contacts with the Karkonosze massif. The zone is mineralised with quartz (Lewowicki 1965, Szałamacha 1965). The SE wall rocks are laminated biotite-quartz hornfelses with andalusite and pinite (Szałamacha, Szałamacha 1966), and with intercalations of skarns (Kozłowski 1978, Fila-Wójcicka 2000), whereas the NW wall rocks are augen gneisses, granite-gneisses and blastomylonitic gneisses (Fig. 1a, b).

SAMPLES AND METHODS

Samples. The formation of quartz in the dislocation zone took place by means of a metasomatic process, which developed due to the migration of hydrothermal solutions (Kozłowski 1978). The wall rocks, especially hornfelses, underwent the alterations which resulted in quartz crystallization and recrystallization in the quartz-rich laminae of hornfels, and in gradual removal of biotite with periodical formation of new minerals, and finally in disappearance of the laminar texture and

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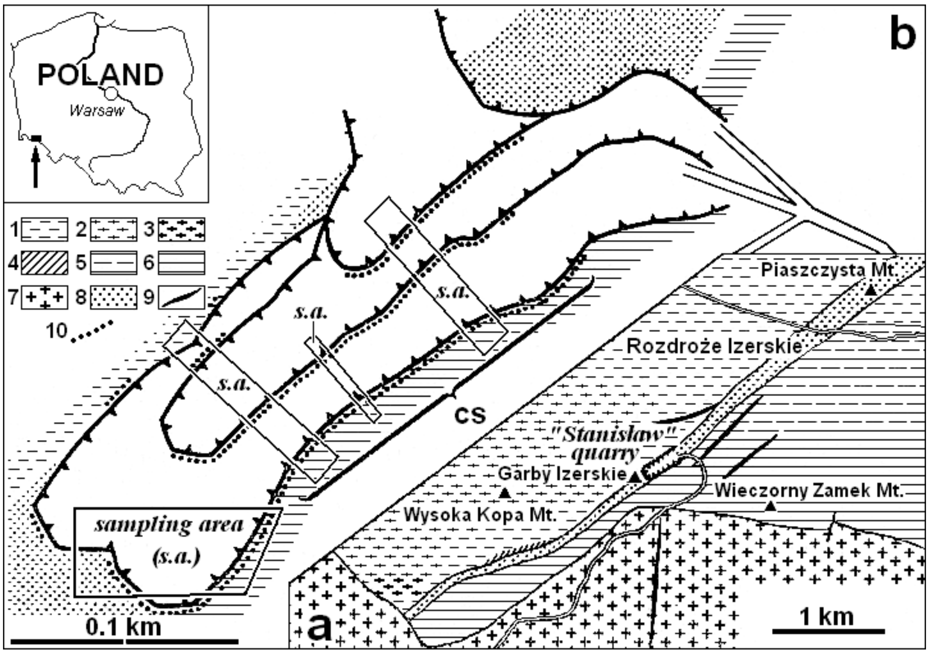

Fig. 1. Geological map of the Garby Izerskie zone (a), after Berg (1920) and the map of the "Stanisław" quarry (b) at Garby Izerskie (Kozłowski 1978); 1 – Izera gneiss, 2 – granite gneiss, 3 – porphyric granite-gneiss, 4 – blastomylonitic gneiss, 5 – cordierite (pinite)-bearing hornfels, 6 – biotite hornfels, 7 – Karkonosze granite, 8 – quartz zone, 9 – vein rocks, 10 – occurrence of the granite apophyses, cs – outcrop of calc-silicate (skarn) rocks.

origin of massive, almost monomineral quartz rock. The sequence of the quartz generations is as follows: **(1)** pale gray turbid metamorphic quartz in laminae within hornfels; **(2)** dark gray transparent quartz mostly in laminae, initiating silicification; **(3)** gray turbid quartz with dispersed chlorite occurring in laminae and in veinlets few millimetres thick; **(4)** light-gray quartz in all laminae with 0.5-2 mm white mica flakes; **(5)** light-gray quartz in all laminae with 10-50 μm white mica scales; **(6)** milky translucent quartz with clay minerals (at this stage the lamination disappeared); **(7)** milky massive quartz, locally with hematite; **(8)** milky drusy quartz with clay minerals and hematite; **(9)** massive transparent quartz, occurring also as thin veinlets; **(10)** transparent drusy quartz (rock crystal); **(11)** light gray, gray and amethyst quartz in thin veinlets and in bulges (Fig. 2).

The 56 samples were collected in the open-pit quartz mine "Stanisław" at Garby Izerskie in the four sampling areas, marked in the Fig. 1b. The reference samples of a typical non-silicified hornfels were taken from Wysoka Kopa Mt. (Fig. 1a), ca. 1 km northwest from the dislocation zone.

Methods. The routine microscope methods were applied for the investigation of thin sections, prepared from all the observed rock and quartz varieties. Moreover, double-side-polished 0.5–1.5 mm thick slices of quartz were prepared for the fluid inclusion studies. The heating and freezing methods used for fluid inclusion microscope studies were described e.g. by Roedder (1984). For the determination of the homogenisation temperatures of the aqueous inclusions (±1ºC) and carbon dioxide inclusions (±0.1ºC), and for the measurement of the phase transition temperatures on freezing (±0.1ºC), the *Fluid Co.* microscope stage was applied. The cation compositions in bulk fluid inclusions were determined by the water leachate method and by spectrographic emission analysis; chlorine and fluorine contents in the leachates were determined by microchemical methods (Kozłowski 1978). For this study leachates of 22 samples (two of each quartz variety) were analysed and 493 fluid inclusions were investigated. Pressure during quartz crystallization was determined by the crossed isochores method.

FLUID INCLUSIONS

The investigated fluid inclusions were 10–50 µm long and contained aqueous solutions, aqueous solutions and liquid carbon dioxide or liquid carbon dioxide alone, all with contraction bubbles. In certain inclusions trapped chlorite, white mica, halloysite and hematite crystals were present. Inclusions in the earliest metasomatic dark-gray quartz were stretched or decrepitated and healed, thus indicating an episode of significant overheating. Temperatures obtained from these inclusions were consistent with the temperatures yielded by the non-altered inclusions in the subsequent quartz with chlorite (Fig. 2); thus the healing of the overheated inclusions started at 455ºC under the conditions of the next stage of silicification. Inclusions in later quartz generations gave temperatures gradually decreasing to 110ºC, though the temperature ranges were broad (Fig. 2).

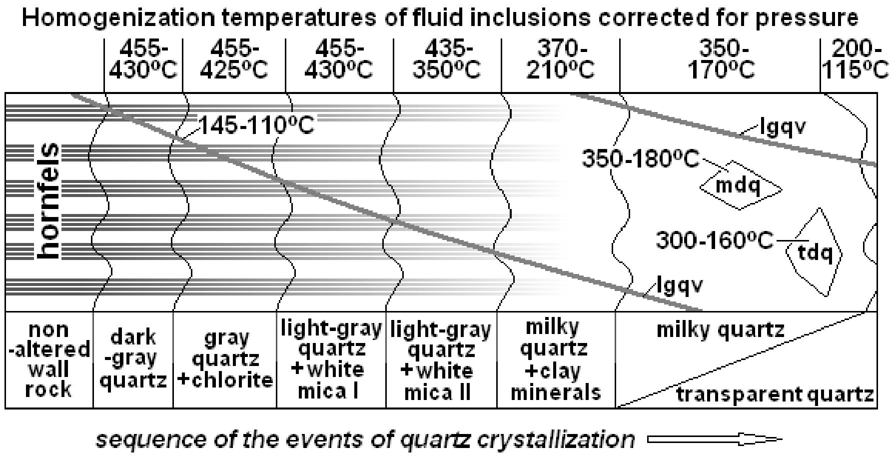

Fig. 2. Scheme of the sequence of quartz generations in the Garby Izerskie dislocation zone and homogenisation temperatures of inclusions in quartz, corrected for pressure. i.e. generally temperatures of quartz crystallization (except for early dark gray quartz, where all the found inclusions were decrepitated or stretched); mdq – milky drusy quartz; tdq – transparent drusy quartz, lgqv – light-gray and amethyst quartz in veinlets and bulges.

Fluids in inclusions in quartz from hornfelses and in the earliest metasomatic quartz yielded low concentrations of lithium (0.02 and 0.03 wt. %), whereas inclusions in the later metasomatic quartz had higher Li concentrations, from 0.10 to 0.31 wt. %. The parent solutions of the investigated quartz generations contained generally NaCl as the prevailing component, with two distinct maxima of the calcium contents in gray quartz with chlorite and in late veinlet gray quartz with amethyst. Light gray quartz with micas bore inclusions with fluid of elevated concentration of potassium. Fluorine concentrations were low at the early stages but increased distinctly in inclusions in late quartz, especially in the last quartz generation. Pressure varied from 1.6 kbar (early) to 0.4 kbar (late). The pressure-uncorrected temperature data given by Wołkowicz (2003) are difficult to discussion, though her homogenisation temperatures are similar to these of mine.

CONCLUSIONS

The multistage silicification in the Garby Izerskie dislocation zone started before this area reached the maximum temperatures of skarn formation (ca. 650ºC, Fila-Wójcicka 2000). This is evidenced by the decrepitated inclusions and Li-low solutions in the earliest metasomatic quartz. The Li- and F-rich solutions connected with the Karkonosze intrusion appeared after the temperature maximum, causing further, extensive silicification.

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