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GREISENS FROM IZERA UPLAND, LOWER SILESIA, POLAND

The considered greisen rocks occur within the Izera metamorphic complex, which is the northern cover of the Variscan Karkonosze granitoid massif, forming together the unit called Karkonosze-Izera block. The greisen outcrops have been found in the area of the Mirsk Dale (Fig. 1).

In the area of the Izera metamorphic complex four schist zones have been distinguished within pre-Variscan gneisses. They comprise the hornfelses of the Szklarska Poręba zone, mica-chlorite schist zone of Stara Kamienica, and smaller, dismembered schist zones of Mirsk Dale and Złotniki Lubańskie (Oberc 1965; Pawłowska 1966, 1967; Smulikowski 1972). At the contacts of the schist zones the metasomatic processes developed, causing extensive albitisation. These phenomena occurred most widely along the Stara Kamienica zone, yielding metasomatic albite-rich rocks called leucogranites. These leucogranites formed from the protolith of the original granitic composition (Nowakowski 1976). Leucocratisation was connected with decomposition of biotite and complete albitisation of the oligoclase-andesine plagioclases (Nowakowski 1976) and partial albitisation of microcline (Smulikowski 1972; Kozłowski 1974), after which later, secondary microclinisation took place. The albitisation process developed in gneisses and pre-Variscan granitoids. Greisenisation, which always developed within the albitised rocks, would be a following stage of the metasomatic sequence.

The rocks of the greisen formation occur in the Izera Upland within gneisses, granite-gneisses, mica-chlorite and amphibole schists, and metadiabases. They are connected with the schist zone of the Mirsk Dale. The best known occurrence of the greisens id located at the Wyrwak Hill, called also in publications "Martwy Kamień". The first announcements of the vein recognised as the greisen-type rock are to be found in the explanations to the geological map issued by G. Berg (1926). Subsequently, Budkiewicz (1949) found topaz in this rock and suggested the name „topazite" for it, discussing its pneumatolytic-hydrothermal origin. Petrographically these rocks and the adjacent ones were elaborated by Kozłowska (1956), who introduced for them the name „greisen" and distinguished several rock varieties within the vein. She suggested also the separate stages for the boron- and fluorine-bearing emanations. Wieser (1956) performed petrostructural studies of the greisens and determined them as the B-tectonite. Heflik (1960) compared the

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chemical composition of the tourmalines from greisens with the composition of the tourmalines from leucogranites from Kotlina and on the basis of their similarities suggested their common origin. The described greisens were characterised more precisely by Pawłowska (1966), who recognised their zoned structure. She also gave the geochemical and mineralogical characteristics of muscovite from greisens and found cassiterite (wood-tin), pyrrhotite and ilmenorutile. in the rocks. She considered the greisens as formation of the same age as so-called fluorite quartzites from Krobica. She was doubtful about the Heflik's (1964) conclusion on the connection of the emanations with the Variscan Karkonosze massif.

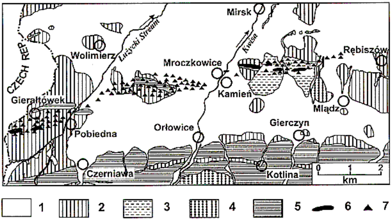

Fig. 1. Geological sketch map of southern part of the Izera Upland (after Berg, 1925 and Berg & Ahrens, 1925)
1. Cenozoic, 2 gneisses and granite-gneisses, 3 kaolinitized gneisses, 4 leucogranites, 5 amphibolites, amphibolite schists, mica-chlorite schists, 6 greisens, 7 detached block of greisen.

Studies of the present authors (Karwowski 1972, 1973, 1975, 1977; Kozłowski, Karwowski 1975) led to the finding of the more extensive occurrence of the greisen rocks and presence of the mineral association typical for greisens: ferberite, secondary scheelite, arsenopyrite, cassiterite, native bismuth, chalcopyrite and Nb-bearing rutile.

The greisens outcrop best at the hill of Wyrwak, forming its summit part. Eastward they disappear under the Quaternary beds and the strike of the greisen zone is marked only by the accumulations of the detached blocks of this rock occurring in the east–west strip, extending to the area of Mlądz and Rębiszów. Westward the outcrops of the greisens occur in the bed of the Kwisa River, being shifted distinctly to the south with respect to the outcrops at the Wyrwak Hill Further to the west the accumulations of the greisen blocks form a continuation of the zone, but shifted even more to the south over a distance of several hundred metres. The southern border of the greisen occurrence is marked in this area by metadiabases. Close to the Czech Republic the extension of the greisen zone occurs again further to the south, in the region of Pobiedna and Gierałtówek, from where they approach the state border. Outside the area of the Wyrwak Hill, greisens *in situ* have been found in the abandoned open-pit kaolin mine and in the neighbourhood of Gierałtówek (Fig.1). The zone of the greisen occurrence extends in the east-west direction within a narrow belt (50 to 100 metres broad), parallel to the tectonically dismembered schist zone of the Mirsk Dale. The exact recognition of the geologic position of the greisen outcrops (outside the Wyrwak Hill) is difficult. Nevertheless the greisen blocka are always associated with the boulders of the intensely leucocratised rocks, moreover amphibolites, amphibole schists and mica-chlorite schists.

The most complete sequence of the greisens and their wall rocks could be observed at the Martwy Kamień (Wyrwak) Hill in the past. Presently, due to the area recultivation, most of the ditches and diggings disappeared. However, on the basis of the earlier performed studies, the following rock types in greisens and their wall rocks have been distinguished.

1. Leucogranites and leucogneisses
2. Partly greisenised leucogranites and leucogneisses
3. Quartz-feldspar-muscovite greisen
4. Quartz-muscovite greisen
5. Quartz-muscovite-topaz greisen
6. Quartz-topaz greisen
7. Irregular muscovite, topaz and tourmaline zones
8. Quartz-tourmaline-muscovite greisen (in places with topaz)
9. Mica-chlorite schists, amphibole schists, intercalations of metadiabases and amphibolites.

Distribution of the greisen zones is irregular and without distinct boundaries, rather continuous transitions are common. Only the southern contact with the schists is rather sharp and allowed to determine the dip of the whole greisen complex for ca. 45N.

The greisenised rocks should also comprise the bodies found in the leucogranites from Kopaniec (Pawłowska 1967, 1968), and those described as melanocratic veins from Kotlina, bearing fluorite, chlorite, quartz and topaz (Heflik 1964).

According to Kozłowska (1956), the leucogranites from Wyrwak differ from the leucogranites of the Stara Kamienica zone by less intense albitisation. In addition to albite, in the latter rocks partly albitised microcline is present, as well as completely fresh microcline. Muscovite, partly of the post-biotite origin and that formed in the greisenisation process, is abundant here. Similar minerals are observed in leucogneisses, in which only the texture is the relics of the parent rock. The transition of the leucogranites in the quartz-feldspar-muscovite greisens is continuous, accompanied with distinct increase of the greisen muscovite and fresh microcline.

The complete disappearance of feldspars resulted in origin of the quartz-muscovite rocks typical for the whole greisen zone. These greisens are coarse crystalline with random texture, though the varieties with parallel texture may be also seen. Quartz is the main mineral and it occurs as the post-gneiss relics and the greisen variety. The post-gneiss quartz may contains small inclusions of feldspars. The quartz content may reach 60–95% by vol. Muscovite is typical with the optical axes angle of ca. 45°. Fluorite is a subordinate component, occupying up to 5 % of the rock volume. Few percent may take apatite; zircon, mostly in post-gneiss quartz, is an accessory mineral.

Later formed topaz az the major component of the quartz-muscovite-topaz greisen. Topaz occurs as the cloudy (due to fluid inclusion presence) grains up to 1.5 cm in size. Other components are similar to that ones in the quartz muscovite greisen; fluorite is more abundant, in places becoming major rock-forming mineral.

The quartz-topaz greisen is a compact bi-mineral rock with topaz grains forming large clusters, in which the grains have the same optical orientation. The topaz content may reach 80 % by weight. A different variety of this greisen occurs to the north of Gierczyn – it has numerous tiny caverns and sandy appearance.

Within the quartz-topaz greisen, especially in the neighbourhood of the contact with the mica-chlorite schists, the small muscovite zones are abundant. They are almost monomineral, with minor contents of single garnet grains and fine-grained cassiterite, fluorite and scheelitised ferberite. Moreover, this greisen bears pure topaz zones of coarse-crystalline, sometimes euhedral topaz. Among the varieties of greisen, the tourmaline zones occur; they compose of prisms of black schörl, frequently fractures with shifted parts of the prisms. The fissures in tourmaline are filled by fine muscovite. Tourmaline occurs with quartz, fluorite, and in the outer parts of the tourmaline zones – large grains of topaz. The topaz zones are probably older then the surrounding greisens and formed in the preceding metasomatic processes.

The tourmaline-quartz-muscovite greisens (locally with topaz) are different . They bear anhedral tourmalines intergrown with quartz and muscovite and rarely with topaz. These rocks occur rarely, their largest occurrence was found in the eastern summit part of the Wyrwak Hill.

All the greisen rocks are cut by the quartz veins of various thickness, bearing locally prismatic euhedal topaz.

The southern boundary of the greisen outcrops at the Wyrwak Hill is marked by schists of the mica-chlorite and amphibole varieties, plus local amphibolites and metadiabases.

Within the greisen rocks minor occurrences of garnet, biotite and chloritoid have been found.

The geochemical and fluid inclusion studies, the latter based on the measurements of 3950 inclusions, (Karwowski 1977, Kozłowski et al. 1996) yielded the conditions of the greisenisation process. The metasomatising fluids were moderately concentrated solutions (4-5 wt. % during albitisation and with sharp variations from ca. to 21 wt. % during the greisenisation to 5-6 wt. % at the stage of the formation of the quartz veins. They had fluoride-chloride-carbonate composition with local abundant borate ions, with two maxima of the calcium concentrations (tourmaline and fluorite cluster formation), elevated concentrations of potassium during the tourmaline and muscovite crystallisation and generally sodium as the dominant cation; aluminium and lithium were present in appreciable concentrations. Magnesium contents were relatively high during the early stages of the metasomatic process. Generally the solutions were acid, but with varying pH values.

Phase of the liquid CO_2 is abundant in the fluid inclusions in the greisen minerals, with two distinct maxima during crystallisation of tourmaline and formation of the clusters of fluorite. Fine daughter crystals of NaCl in fluid inclusions are rare, but they confirm the episodes of very high concentrations of the solutions. The temperature and pressure conditions obtained from the inclusions of liquid carbon dioxide and aqueous solutions show large variations. The metasomatic process of albitisation started at ca. 500°C and 0.8 kbar, and the subsequent formation of tourmaline started at temperatures exceeding 500°C and at ca. 0.9 kbar. The typical greisen minerals (topaz, muscovite, quartz, fluorite and apatite) formed during gradual decrease of temperature from ca. 500°C to less than 200°C and pressures within the ranges from 0.9 to 0.5 kbar, with local and rapid decrease to 0.3 kbar due to opening of the fissures and subsequent formation of veins. Crushing and healing of the formed fissures in the greisen minerals occurred even at the temperatures of 200 to less than 100°C, as indicated by the secondary fluid inclusions.

CONCLUSIONS

The origin of the greisen rocks in the Izera Upland was characterised by a number of typical features:

1. The discussed greisens formed from the protolith of the older rocks of the granitoid-type composition that passed the metamorphic process.
2. The occurrence of the greisen rocks is connected with the zones of preference, occurring along the schist belts as the screening bodies.
3. One may consider the possibility of formation of the metasomatites, both leucogranites and greisens, in connection with the post-magmatic activity of the Karkonosze granitoid massif.
4. The greisens bear typical mineral association of the post-magmatic processes connected with the metasomatic conditions, especially the ore tin and tungsten minerals. It is noteworthy to mention, that the minerals of these elements have regional distribution, from the marginal parts of the Karkonosze massif through the schist rocks of the Stara Kamienica ridge to the placer occurrences in the Izera gneiss area, where coarse-crystalline cassiterite of apparently local origin was found (cf. e.g. Jęczmyk 1971).

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