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SEM studies of ore minerals in skarns from Garby Izerskie, Karkonosze-Izera block, south-western Poland

KEY WORDS:
SEM, bismuth telluride, acanthite, native bismuth, native gold, native silver, skarns, Garby Izerskie.

ABSTRACT

In "Stanisław" quarry, that is located on Garby Izerskie, ore minerals-bearing calc-silicate skarns were found in 2009. The samples were studied using microscopical method of reflected light and scanning electron microscopy (SEM). Based on SEM study, the predominant ore minerals in investigated samples are chalcopyrite, pyrrhotite, bismuth telluride and native bismuth. Moreover, acanthite, native gold and native silver were also identified. Our studies are the first report of above mentioned minerals from the Garby Izerskie area.

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Introduction

The exocontact skarns from Garby Izerskie have been already studied in details from a petrogenetic point of view (Kozłowski 1978; Fila-Wójcicka 2000), but occurrence of ore minerals in this rock has not been sufficiently described so far. The skarns from Garby Izerskie, which occur as intercalations in hornfelsed schists, are the high-temperature calc-silicate varieties, with late silica and fluorine metasomatosis (Fila-Wójcicka 2000). During studies on pyrrhotite in calc-silicate skarns from Garby Izerskie (Rybicki 2011), more precisely unidentified bismuth telluride was found among opaque minerals presented in the skarns (Rybicki 2012). This paper focuses on ore minerals, which were found calc-silicate skarns from Garby Izerskie, and were investigated using scanning electron microscope (SEM).

Geological setting

The investigated area is the "Stanisław" quarry, located in the Garby Izerskie Zone within the boundary zone of the Karkonosze massif and the metamorphic Izera rock series (Fig. 1). The SE wall rocks are represented by 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 mostly augen gneisses, granite-gneisses and blastomylonitic gneisses (Kozłowski & Metz 2004). The Garby Izerskie Zone is mineralised with quartz (Kozłowski 1978), and a continous increase in quartz content can be observed in both the gneisses and hornfelsed schists toward the centre of this zone, to form an almost monomineralic quartz rock (Kozłowski 1978). The rocks of the Garby Izerskie Zone are cut by non-silicified granitoid apophyses. The skarns, fractured hornfelsed schists and granitoid apophyses were subjected to the activity of F-bearing solutions (Kozłowski 1978). Garby Izerskie fault zone is connected with a tectonic unit of the Sudetes Mountains, named Karkonosze – Izera block, consisted of the Karkonosze granite massif and its metamorphic envelope – Izera area (Mazur 2002). The Karkonosze massif is an intrusion of Variscan age (Kozłowski 1978).

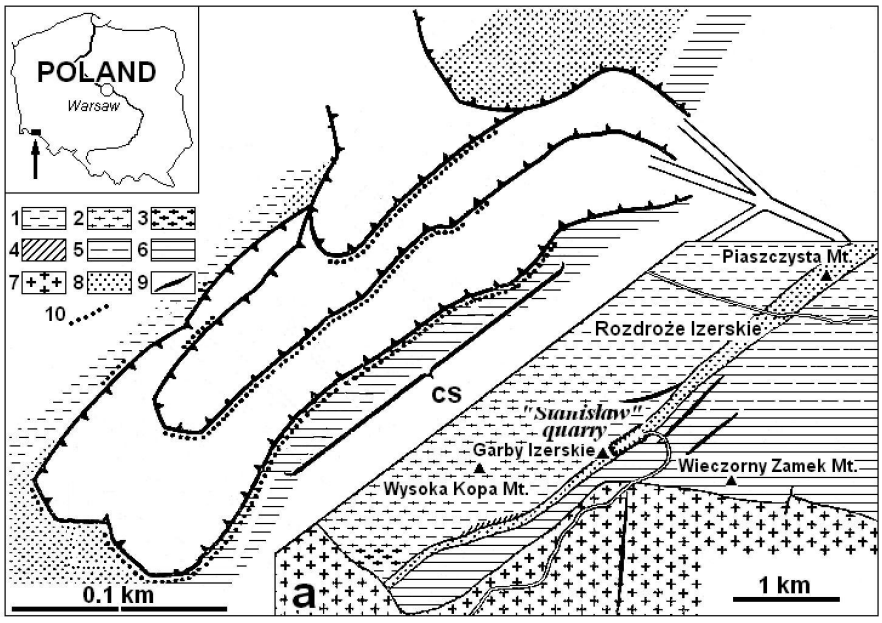

Fig. 1. Geological map of Izerskie Garby Zone (a) and "Stanisław"quarry map (after Kozłowski & Metz 2004).

1 – Izera gneiss,
2 – granite gneisses,
3 – porphyritic granite gneisses;
4 – blastomylonitic gneisses;
5 – hornfels with cordierite;
6 – biotite hornfels;
7 – Karkonosze granite;
8 – quarz vein;
9 – vein rocks;
10 – granite occurence; cs – outcrop of skarns.

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Material and methods

4 samples of calc-silicate skarns containing ore minerals were collected during the field works in "Stanisław" quarry in 2009. Mineralogical studies were multistage. Polished sections were studied by routine microscopical methods of reflected light and using scanning electron microscopy (SEM) in Laboratory of Scanning Microscopy at Faculty of Earth Sciences, University of Silesia with the use of environmental analytical microscope Philips ESEM XL30/TMP equipped with detector EDS (Energy Dispersive Spectrometer) / EDAX Sapphire type in low-voltage regime (low vacuum to 1 Torr).

In this study the following abbreviations are routinely used:
Ac – acanthite;
Ag – native silver;
Au – native gold;
Bi – native bismuth;
$Bi_{?}Te_{?}$ – unknown bismuth telluride;
Cal – calcite;
Ccp – chalcopyrite;
Fl – fluorite;
Po – pyrrhotite;
Qtz – quartz;
Wo – wollastonite.

Results

The microscopical study in reflected light was used as a preliminary method and on its basis, polished sections with the highest amount of ore minerals were selected for further analysis. SEM study shows that rock-forming minerals in tested samples are mainly fluorite (Fig. 3b, d, f), calcite (Fig. 3b, d, f), wollastonite (Fig. 3c, f) and quartz (Fig. 3e).

All ore minerals are accessory phases. They occur in irregular forms and fill the spaces between rock-forming phases. Among ore minerals, chalcopyrite is the predominant phase (Fig. 2d, Fig. 3a, b, d, e, f). Chalcopyrite crystals are up to 300 μm long and 150 μm width. The other ore mineral, common in studied samples, is bismuth telluride, which has been described previously by Rybicki (2012) (Fig. 2b, Fig. 3a, b, c, e, f). Bismuth telluride tends to form grains up to 200 μm long and 50 μm width. Native bismuth occurs as a grains up to 100 μm long and 80 μm width (Fig. 2c, Fig. 3a, d), while pyrrhotite forms monoclinic crystals up to 100 μm long and 100 μm width (see also Rybicki 2011) (Fig. 3b).

The other ore minerals found in studied samples are:
(1) acanthite, which tends to form very small grains in wollastonite-fluorite matrix (Fig. 2a, Fig. 3c),
(2) native gold, which occurs with acanthite (Fig. 3c),
(3) and native silver vein in fluorite (Fig. 3c).

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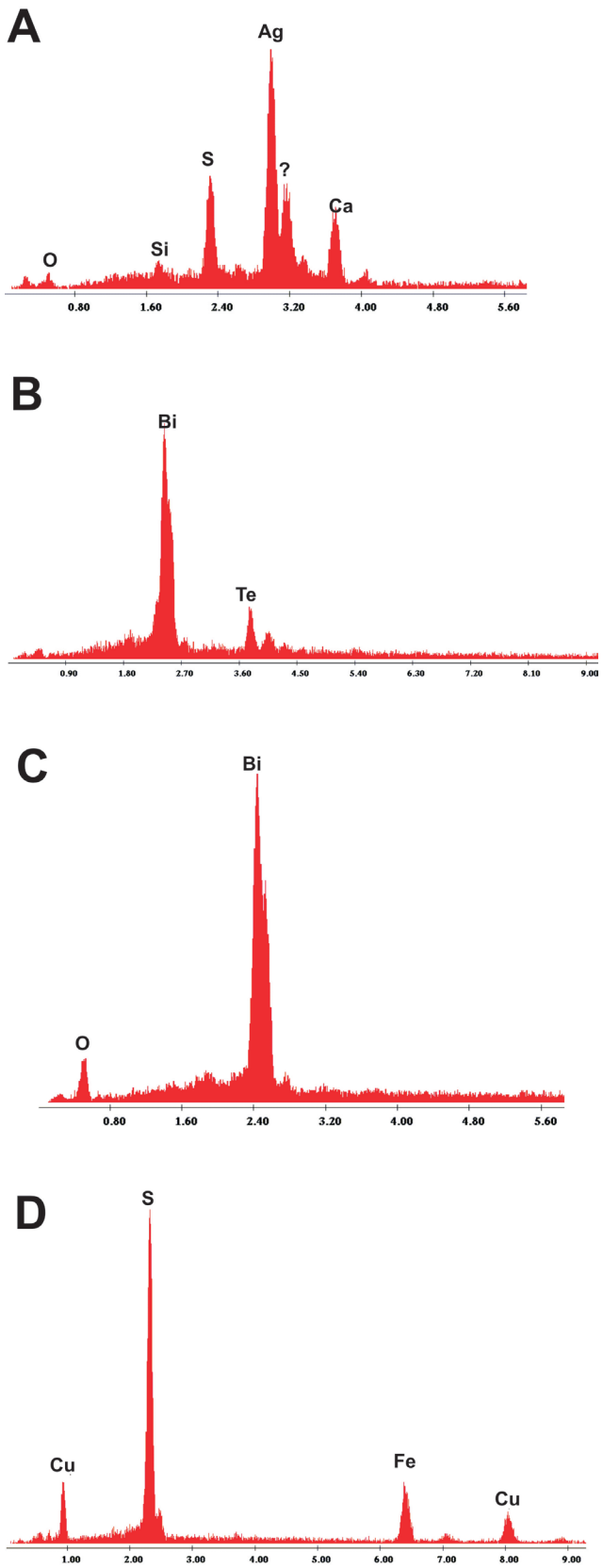
Fig. 2. EDS spectrum for:

A – acanthite and wollastonite;
B – bismuth telluride;
C – native bismuth;
D – chalcopyrite.



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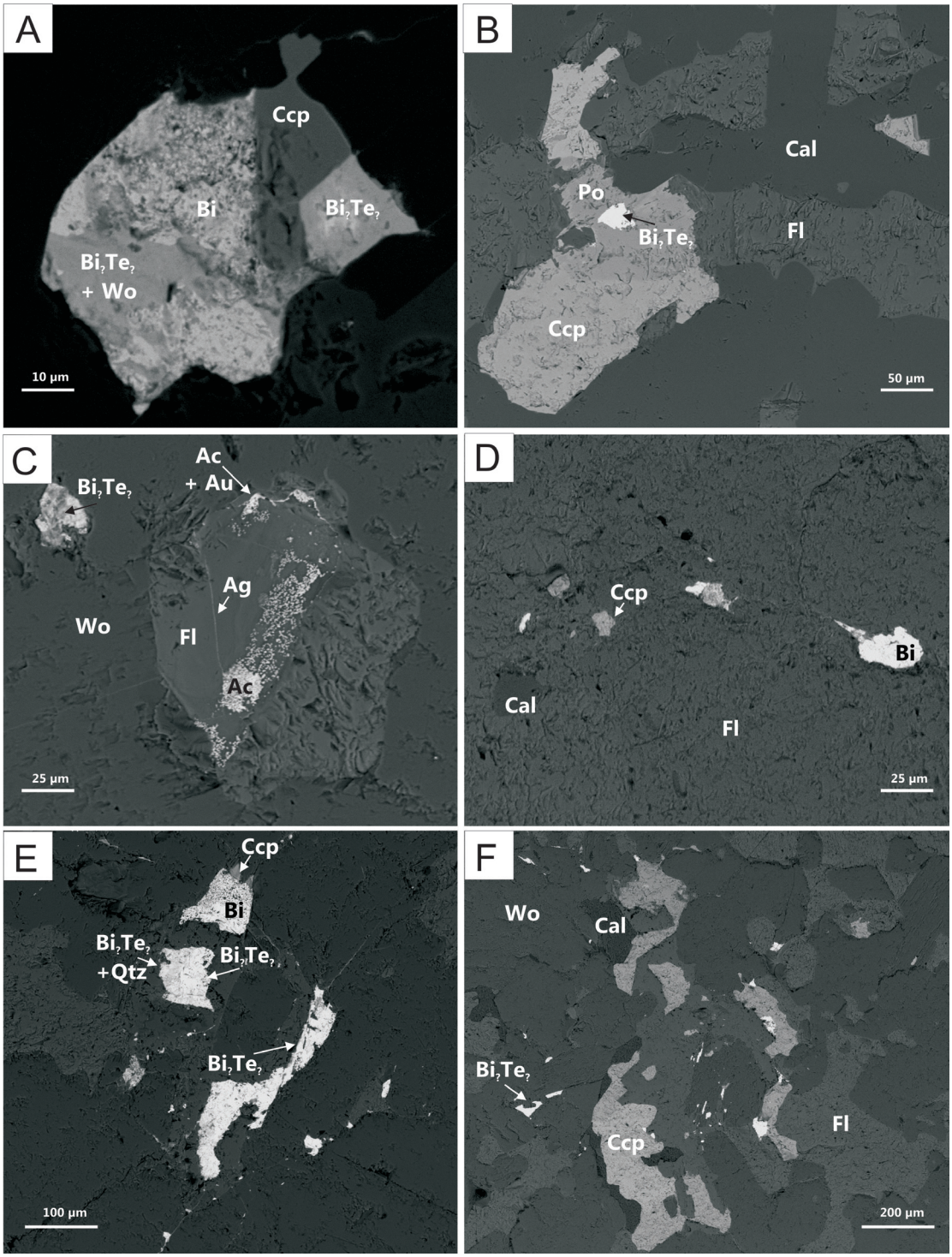

Fig. 3. SEM images of studied samples (BSE): A) Native bismuth among chalcopyrite and bismuth telluride grains and wollastonite; B) Bismuth telluride with chalcopyrite and pyrrhotite mineralization among calcite and fluorite; C) Acanthite with native gold and native silver vein in fluorite and wollastonite mineralization with bismuth telluride; D) Native bismuth, chalcopyrite and calcite in fluorite matrix; E) The aggregation of native bismuth and bismuth telluride with quartz; F) Chalcopyrite and bismuth telluride among wollastonite, fluorite and calcite mineralization.

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Conclusions

The main ore minerals in calc-silicate skarns from Garby Izerskie are chalcopyrite ($CuFeS_2$), monoclinic pyrrhotite (Fe_7S_8) (see also Rybicki 2011) and acanthite (Ag_2S). Other common phases are bismuth minerals (bismuth telluride and native bismuth). Moreover, small amounts of native silver and native gold have been noticed.

All phases described in this study have low-temperature, hydrothermal origin. They crystallized during the latest stage of the formation of skarns, which falls on fluorine metasomatosis (Fila-Wójcicka 2000).
The occurences of acanthite, native silver and native gold are the first reports of those minerals in studied area.

Acknowledgements

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