Primary cassiterite mineralization and its manifestation in the alluvial samples: Gierczyn-Przecznica case study in SW Poland

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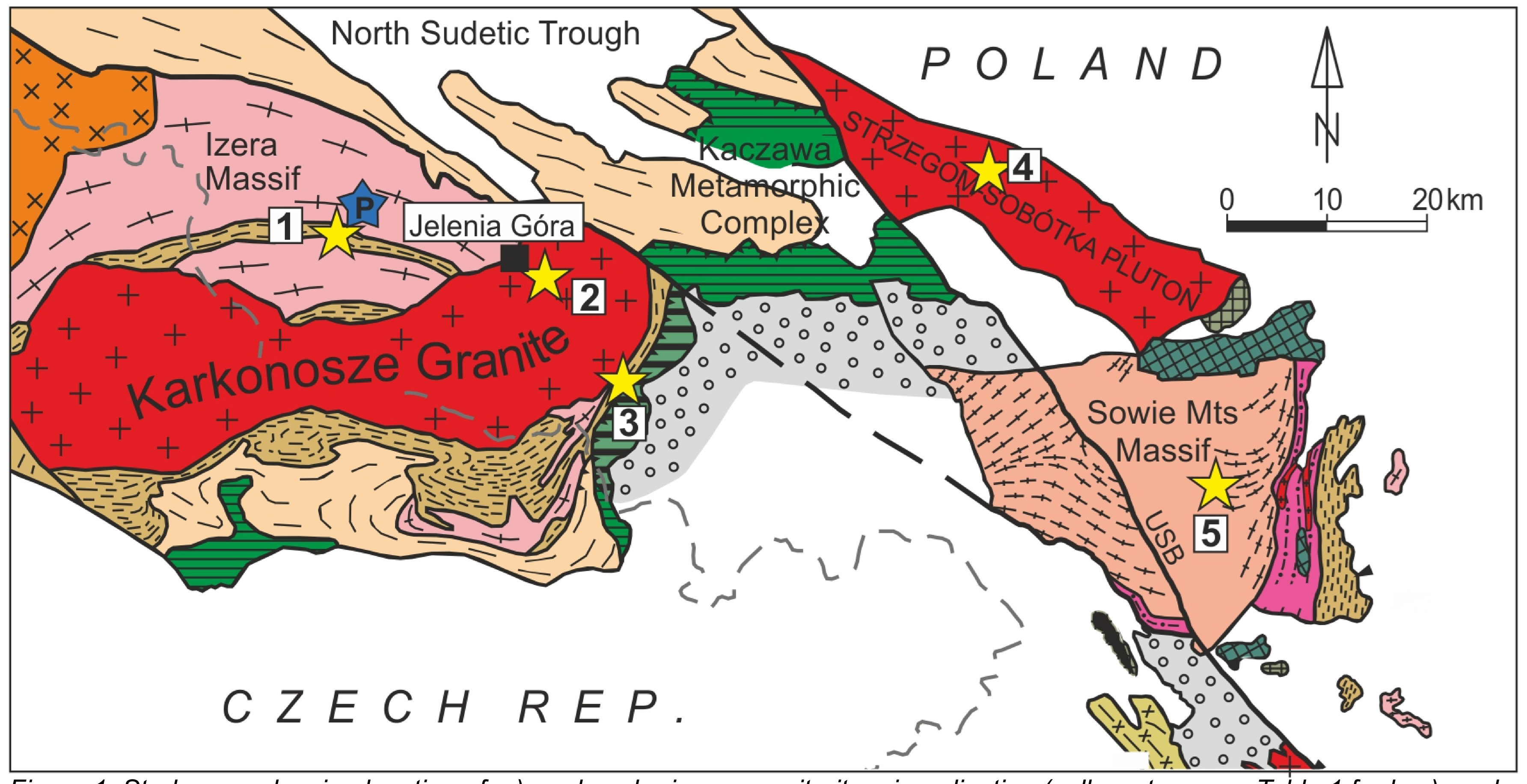
Introduction

Cassiterite has been found in the Sudety Mountains (SW Poland) in several geological units but its concentrations also occur in alluvial sediments both within the area and further from its primary source in the north. The panned concentrate (heavy mineral concentrate - HMC) preparation from alluvial material is an important technique used during geological prospecting. It's helpful in obtaining relevant geological information such as provenance, deposit type and proximity to primary mineralization. The Gierczyn-Przecznica region was selected as a test area to study how material from primary tin deposits manifest in alluvial samples and what information regarding mineralization type can be obtained from mineralogical and chemical analysis of heavy minerals. The goal of the study was to obtain HMC from the alluvial sediments in a standardized manner and then compare these with nearby tin mineralization presumed to be its main source as well as with other cassiterite occurrences in the West and Central Sudety Mts (Fig. 1)



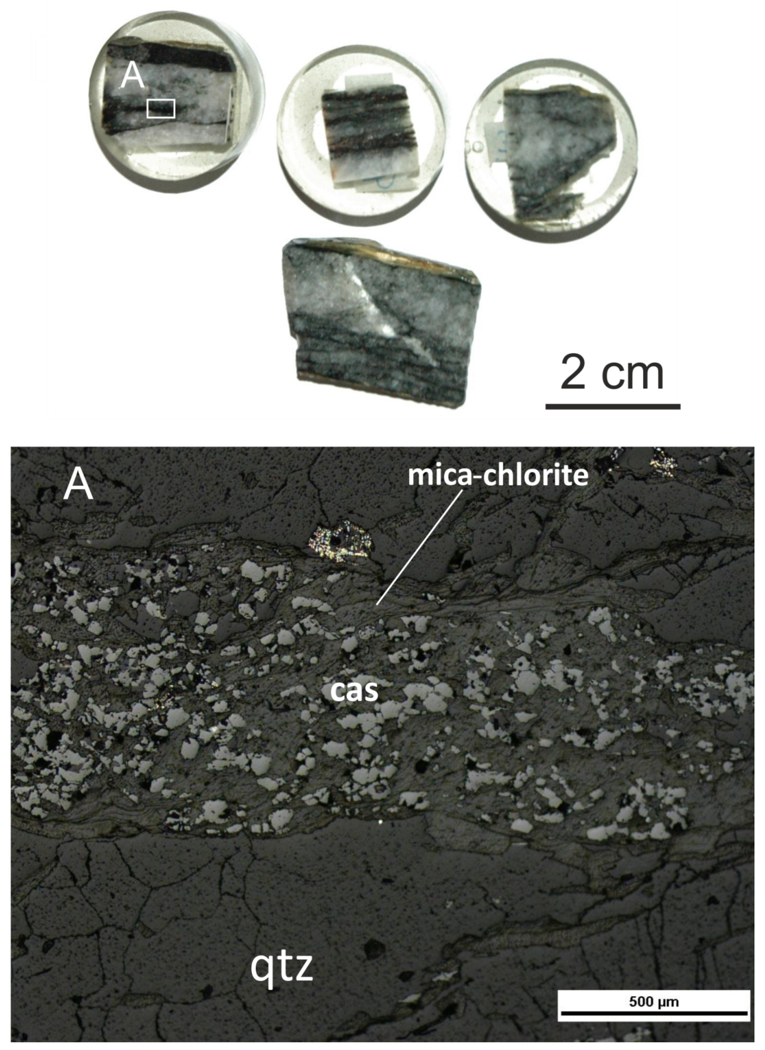


Figure 1. Study area showing location of: a) analysed primary cassiterite mineralization (yellow stars; see Table 1 for key), and b) the main area in which HMC were collected (blue star), modified from Mazur et al. (2010).

Figure 2. Example of primary cassiterite mineralization in the mica-quartz-chlorite schist from the Gierczyn area. Qtz – quartz, cas – cassiterite, reflected light.

Geological background

The most important occurrence of tin mineralization in the Sudety Mountains is located in the Stara Kamienica Schist Belt, part of the Karkonosze–Izera Massif (KIM). This unit is situated in the West Sudetes on the NE margin of the Bohemian Massif, located in Poland and Czech Republic. The KIM consist of the Karkonosze Granite pluton which crystallized 312-307 Ma (Mikulski et al. 2020) and its metamorphic envelope. Intrusion is considered to be post-collisional, transitional between I-, and S-type, mostly peraluminous, strongly evolved and fractionated (Mikulski 2007). The northern part of the unit constitutes the Izera Complex composed of texturally diversified Izera Gneisses and three main mica schists: the northern Złotniki Lubańskie, the central Stara Kamienica and the southern Szklarska Poręba. They are composed mostly of mica schists with minor interbeds of amphibolites, calc-silicate rocks, quartzites and quartz–feldspar schists and were metamorphosed under the conditions of upper greenschist and lower amphibolite facies.

Low-grade cassiterite mineralization occurs disseminated in chlorite–mica–quartz schist (Fig. 2) of the Stara Kamienica Schist Belt (SKSB). It forms a stratabound body (known in German literature as “zinnerzführendes Fahlband”, tin-bearing fahlband, Lehmann 1990) accompanied by a polymetallic sulphide/sulphosalt association with the dominance of chalcopyrite and pyrrhotite (e.g. Piestrzyński and Mochnacka 2003; Michniewicz et al. 2006).Cassiterite samples from different geological units in the Sudety mountains have been also obtained and measured for this study (Fig. 1, Table 1).

Pegmatite bodies are common in the Karkonosze pluton and mainly consist of K-feldspar, quartz and biotite (often chloritized). They generally fit the NYF (niobium-yttrium-fluorine) pegmatite signature, nonetheless the fluorine content is very low.

The eastern part of the Izera–Kowary Unit comprises the Czarnów Schist Formation, hosting the now abandoned Czarnów As-Au deposit some 200–300 m east of the Karkonosze granite. Mineralization occurs in a NW–SE-trending vein at the tectonic contact of schists with calc-silicate rocks.

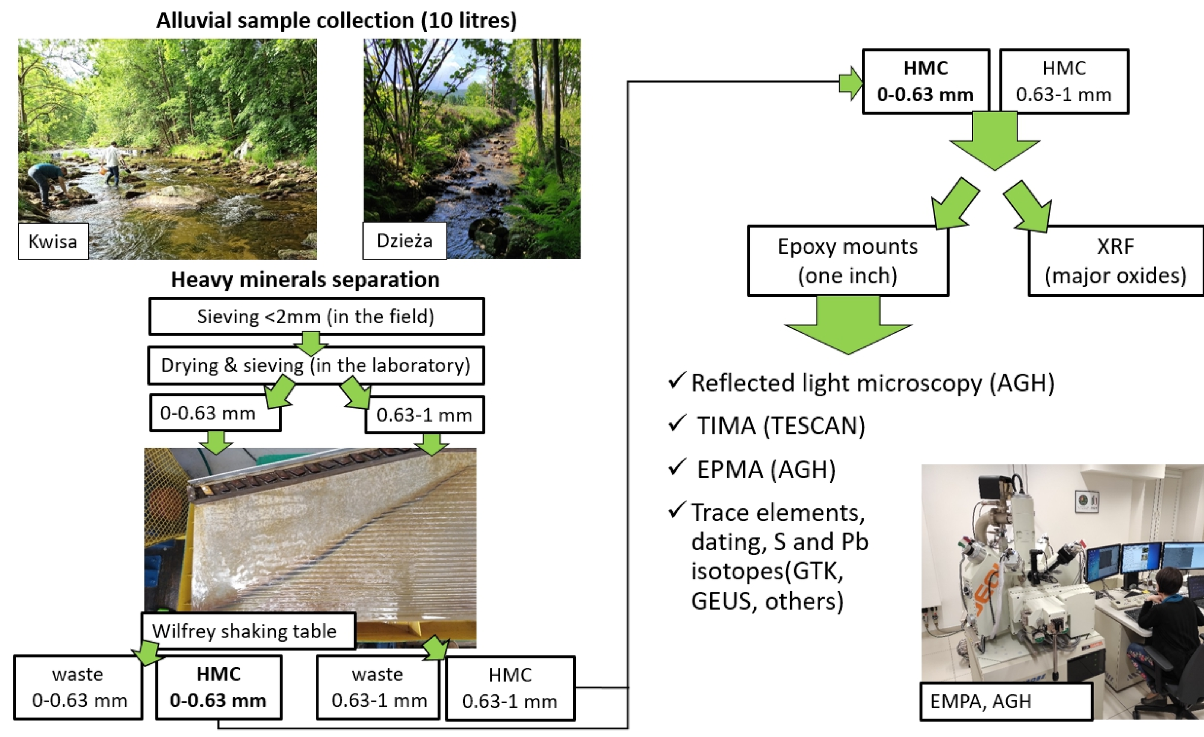
The Strzegom-Sobótka Massif is a post-collisional Variscan pluton (similarly to Karkonosze Granite), emplaced 304.8-294.4 Ma (Turniak et al. 2014). The pegmatites of the Strzegom-Sobótka massif have been known for many specimens of collector quality crystals (e.g. quartz, feldspar, fluorite, chabazite, stilbite, topaz, carbonates).

The Góry Sowie Massif is mainly composed of gneisses and migmatites, which are cut by granites, aplites, pegmatites, rhyolitic and lamprophyric dikes as well as by barite and quartz hydrothermal veins. A Late Proterozoic-Early Cambrian protolith has undergone polymetamorphic evolution and decompression that led to local partial melting and formation of anatectic granodiorites and pegmatites (Szuszkiewicz et al. 2013).

Methods and samples

Heavy mineral concentrates

Heavy mineral concentrates were collected from alluvial sediments with a semi-systematic sampling carried out along the Stara Kamienica Range, SW Poland. In total, 10 alluvial samples (12 kg each) were taken from the Kwisa river and its tributaries (Dzieża, Mrożynka, Czarnotka, Przecznicki Potok; low energy, some only seasonal) that flow through the SKSB perpendicular to its strike. After drying and sieving, grain fractions 0 – 0.63 mm and 0.63 – 1 mm were separated and then subjected to gravitational concentration using the Wilfley shaking table at the AGH University of Science and Technology. The heavy mineral concentrates (HMC) were then used to prepare representative samples mounted in 2.5 cm epoxy pots that were polished when set. Each grain mount contained one size



Automated minerals identification

A scanning electron microscope (SEM) with 4 EDS detectors was used to acquire high-resolution BSE images and a series of elemental maps on analyzed polished sections. The data was merged, segmented, and then classified based on a “classification scheme” mineral reference list to produce a classified image with false colors corresponding to identified phases. The method provided information on mineral composition and distribution, textural relations, and grain size distribution. The analyses were carried out on a TIMA system at TESCAN in Brno, Czech Republic. The SEM was equipped with a field emission source (FEG) and SDD-EDS X-ray spectrometer combined with Tescan Integrated Mineral Analyser (TIMA) software.

Mineral composition

Micro chemical analyses of cassiterite were carried out using a JEOL JXA-8230 Super Probe electron microprobe at the Laboratory of Critical Elements AGH-KGHM in Kraków.

Figure 3. Average (bold, only values above detection limits), and minimum-maximum content (in wt. %) of selected elements in primary cassiterites and HMC from the Stara Kamienica Schist Belt.

Results

Heavy mineral concentrates

Mineralogical composition of the heavy mineral separates from alluvial sediments is a good match with mineralogy of the SKSB and include mainly zoned almandine garnets, rutile, ilmenite, quartz-mica-chlorite clasts but also among other phases: cassiterite, gahnite, monazites and wolframite.

Cassiterite was much more abundant in the 0-0.63 mm fraction samples (0.02-3.72 wt.% SnO2) than in 0.63-1 mm fraction (0.01-0.17 wt.% SnO2). Some samples contained only a single grain of SnO2 while in the richest one it constituted one of the major components (e.g. sample Dzieża 1, Figs. 4 and 5).

Cassiterite chemistry

Primary cassiterites from the Gierczyn-Przecznica area are generally poor in Nb and Ta but in some cases contain elevated contents of In (up to 0.73 wt.% In2O3 in samples from the Przecznica area). Cassiterite from the eastern part (Przecznica area) seems to contain slightly more W, In and Ti in comparison with cassiterite from the western region (Gierczyn) (Table 1).

The composition of alluvial cassiterites is quite similar, exhibiting low concentrations of Nb, Ta and In but elevated concentrations of W.

The chemical composition of both primary and alluvial cassiterites from the Przecznica-Gierczyn area show similarities to those from the Czarnów deposit (to the extent allowed by the detection limits) but there are significant differences with those originated from pegmatites from Jelenia Góra, Strzegom and Piława. They are all characterized by low concentrations of In and significantly higher concentrations of Nb and Ta. The Strzegom sample stands out in terms of increased Mn content, whereas Jelenia Góra is highlighted by significant Zr and Hf admixtures.

Table 1. Average (bold, only values above detection limits), and minimum-maximum content (in wt. %) of selected elements in primary cassiterites and HMC from the Stara Kamienica Schist Belt.

	Detection limit	Strzegom (n=29)	Piława (n=25)	Czarnów (n=19)	Jelenia Góra pegmatite (n=22)	Gierczyn-Przecznica (n=236)	Heavy minerals concentrates (n=93)
WO_3	0.23	**0.31** *<0.23-0.5*	**0.30** *<0.23-0.47*	**0.38** *<0.23-0.66*	*<0.23-0.23*	**0.27** *<0.23-2.18*	*<0.23-2.07*
Nb_2O_5	0.15	**1.18** *<0.15-1.97*	**0.65** *0.17-1.05*	<0.15	**0.32** *<0.15-0.86*	<0.15	<0.15
Ta_2O_5	0.20	**5.5** *0.63-11.7*	**0.65** *0.22-1.43*	*<0.2-0.28*	**0.40** *<0.2-0.93*	*<0.2*	*<0.2*
SnO_2	0.045	**91.12** *83.77-97.61*	**98.38** *88.91-99.77*	**99.91** *98.67-101.5*	**95.59** *93.34-98.8*	**99.67** *91.25-101.37*	**100.01** *88.33-100.99*
In_2O_3	0.04	<0.04	<0.04	**0.2** *<0.04-0.23*	<0.04	**0.24** <0.04-0.73	<0.04
		MnO (0.08-1.77)			ZrO_2 (0.2-2.24) HfO_2 (0.16-0.24)		

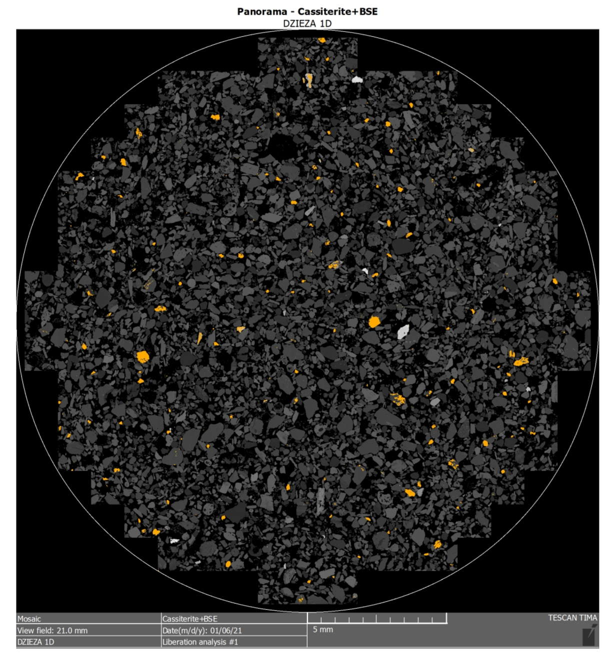


Figure 4. Cassiterite grains (orange) in HMC Dzieża 1 sample.

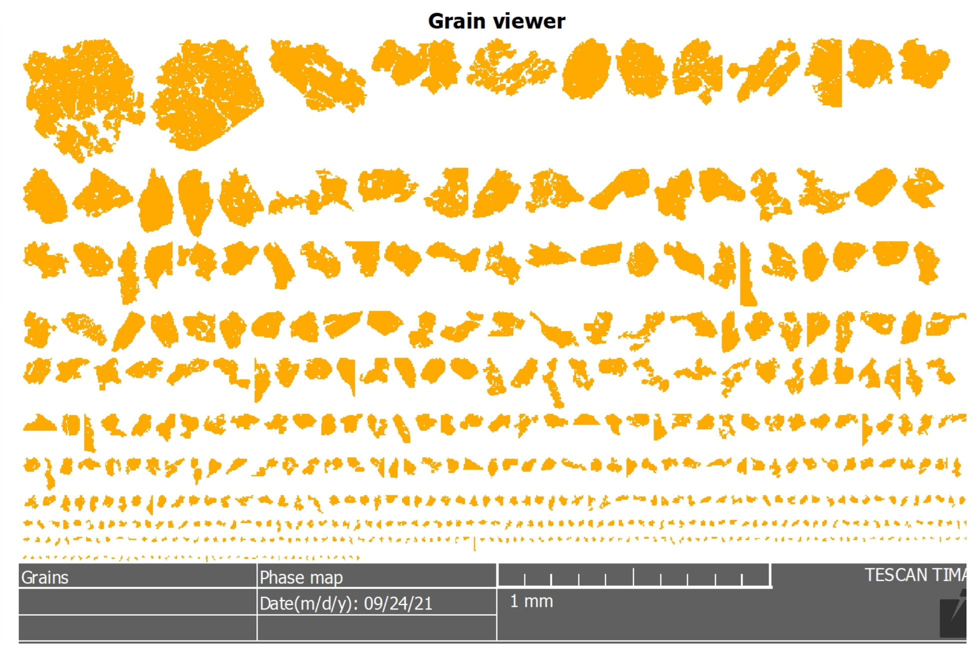


Figure 5. Cassiterite grain size distribution in HMC Dzieża 1 sample.

Conclusions

Comparison of the chemical composition of both cassiterite from the primary deposit area and alluvial deposits (HMC) showed their significant similarity. The chemical composition of cassiterites collected from pegmatites occurring in the granite massifs of the Sudetes and their adjacent areas enables the differentiation of these two populations. This suggests that the chemical composition of the alluvial mineral associations can be used to determine the primary source deposit genetic type. Such information will also enable the development of an appropriate exploration model at the initial stage of the prospecting. The cassiterites derived from the pegmatites are clearly distinguished by the presence of elevated concentrations of Nb and Ta (Table 1). The analysis of the obtained results indicates the genetic distinctiveness of the source of mineralizing solutions from which cassiterites crystallized in the pegmatite and schists of the Gierczyn-Przecznica area.

Acknowledgements

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