MinExTarget

Preliminary results of U-Pb dating and trace element analysis of cassiterites from the Western Sudetes, SW Poland.

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Introduction

Cassiterite has been found in many places in Western Sudetes in SW Poland, either in primary rocks or in placers. In the mica-quartz-chlorite schists of the Stara Kamienica Schist Belt, accumulations were significant enough to warrant extraction of tin in the past but despite interest and exploration efforts in the 20th century, mining has not been resumed and the resources are considered subeconomic. Origin of this deposit is not yet fully understood and it is assumed that the tin-polymetallic mineralisation most likely originated from complex interplay of hydrothermal, magmatic and metamorphic processes (Małek and Mikulski 2021), but the details are still a matter of discussion and several genetic models have been suggested (for detailed reference list see Michniewicz et al. 2006 and Mochnacka et al. 2015). The "usual suspect" is hydrothermal activity related to granitic intrusion, either to the Cambrian-Ordovician granitic protolith of the Izera Gneisses (pre-metamorphic, e.g. Michniewicz et al. 2006) while others to the Variscan Karkonosze Granite (post-metamorphic e.g. Mochnacka et al. 2015).

The main aim of this work was to conduct U-Pb dating of cassiterite and study trace elements in them in order to provide new data on geochronology and origin of the mineralisation. Additional cassiterites collected in two other locations in Sudetes (Czarnów and Piława Górna) were also analyzed for comparison.

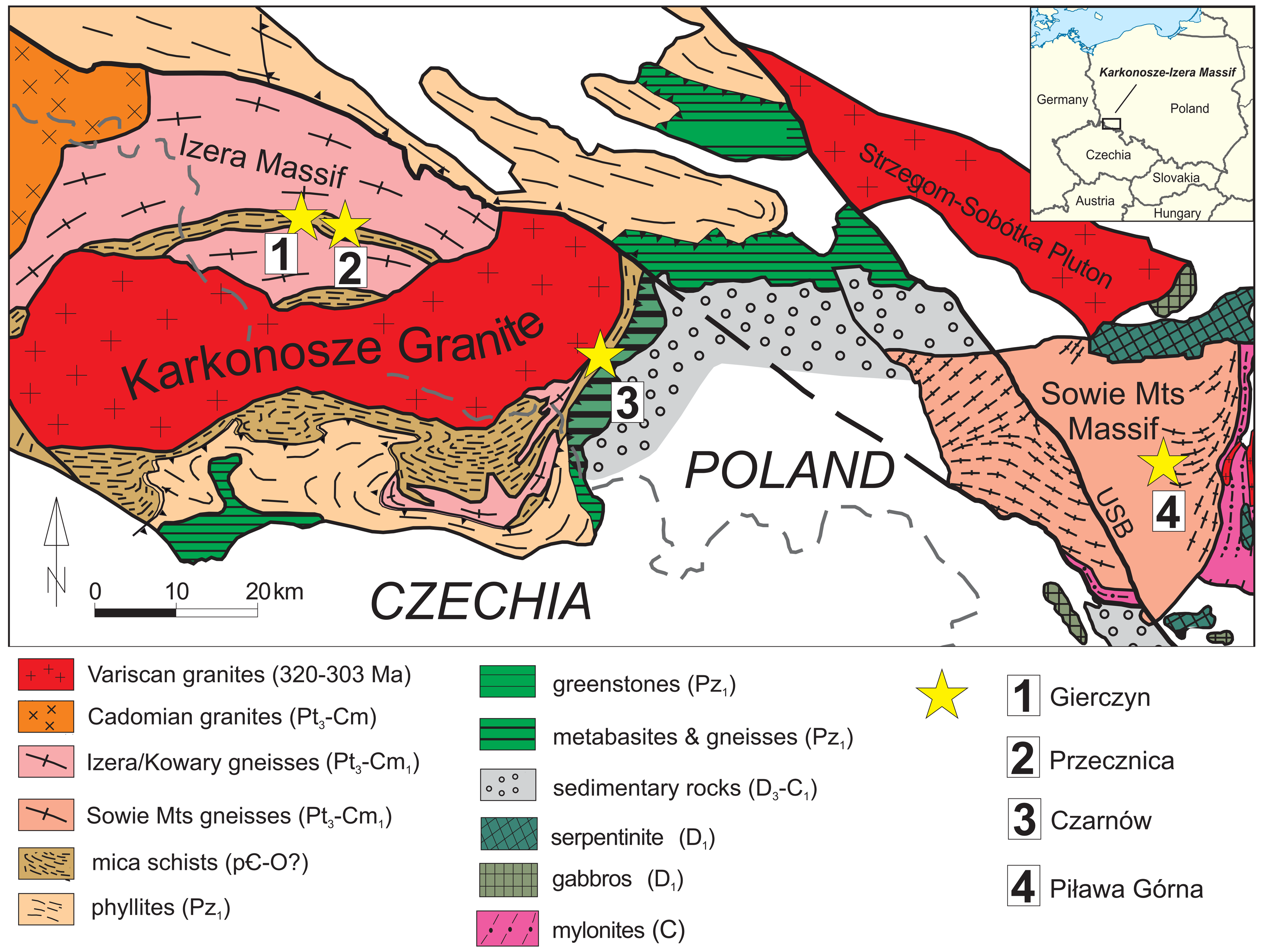

Figure 1. Geological map of Western Sudetes with the location of cassiterites collected for this study

Geological setting

Gierczyn-Przecznica area

The Stara Kamienica Schist Belt dipping toward the north at angles of 37.5-57.5°, hosts low-grade cassiterite mineralisation disseminated in the chlorite–mica–quartz schist (in some cases also rich in almandine garnet), locally accompanied by a polymetallic sulphide/sulphosalt association with the dominance of chalcopyrite and pyrrhotite (Mochnacka et al. 2015). The tin-bearing schists are 100-200 m thick and surrounded on both sides by barren schist, distinction between them is based on geochemical data (Sn content > 0.004%) rather than lithological boundaries (Michniewicz et al. 2006). Two types of cassiterite have been distinguished in the area, "brown" and "colourless" or "spongy".

Czarnów

Czarnów deposit consist of a steeply dipping (80° toward SE) SW-NE trending, 0.5–3 m thick quartz-ore vein, located at the tectonic contact of schists and calc-silicate rocks (Mochnacka et al. 2015). The ore mineralisation is composed mostly of massive or coarse-grained euhedral crystals of arsenopyrite and pyrrhotite that form lens-like bodies within the main quartz vein, or semi-massive impregnations in the country rocks (Mikulski et al. 2020). Minor quantities of pyrite, chalcopyrite, stibnite, cassiterite, magnetite or galena with sphalerite were also noted.

Piława Górna

One of the major geological units of the Central Sudetes is the Góry Sowie Block (Figure 1). It is composed predominantly of migmatitic para- and orthogneisses, amphibolites, and minor granulites, garnet meta-peridotites, pegmatites and calc-silicate rocks (Żelaźniewicz 1990). Pegmatites show geochemical variability and range from primitive and moderately fractionated pegmatites, enriched in Nb-REE-Be-B and belonging to the NYF pegmatitic family, to rare and much more strongly fractionated pods in the axial parts of the largest dykes that contain Li-Cs-Ta-Be-B mineralisation of the LCT type (Pieczka et al. 2018). In both types cassiterite crystals were observed.

Samples and methods

Cassiterite in samples from Gierczyn and Przecznica (Stara Kamienica Schist Belt) typically occurs as a small (20-200 µm) translucent grains with white/colorless internal reflections (Figure 2 A-B), disseminated in a quartz-mica-chlorite schist. "Spongy" cassiterite with brown internal reflections, sometimes intergrown with the more common translucent cassiterite, are more rare but was also targeted for LA-ICP-MS study (Figure 2 C-D). Due to small sizes, only coarser aggregates were selected for the U-Pb dating and trace elements analysis. Cassiterite in Czarnów occurs as aggregates of subhedral to euhedral crystals (500-1000 µm in size), often forming intergrowths with arsenopyrite (Figure 2 E). Internal reflections reveal zonation in some of the cassiterite crystals (Figure 2 F). Material from Piława Górna is represented by an approximately 7 mm large cassiterite crystal.

Chemical analyses of cassiterite in micro area were carried out using a JEOL JXA-8230 Super Probe electron microprobe at the Laboratory of Critical Elements AGH-KGHM in Kraków. U-Pb dating of cassiterite as well as trace elements were analysed at the LA-ICP-MS facility at GEUS in Copenhagen.

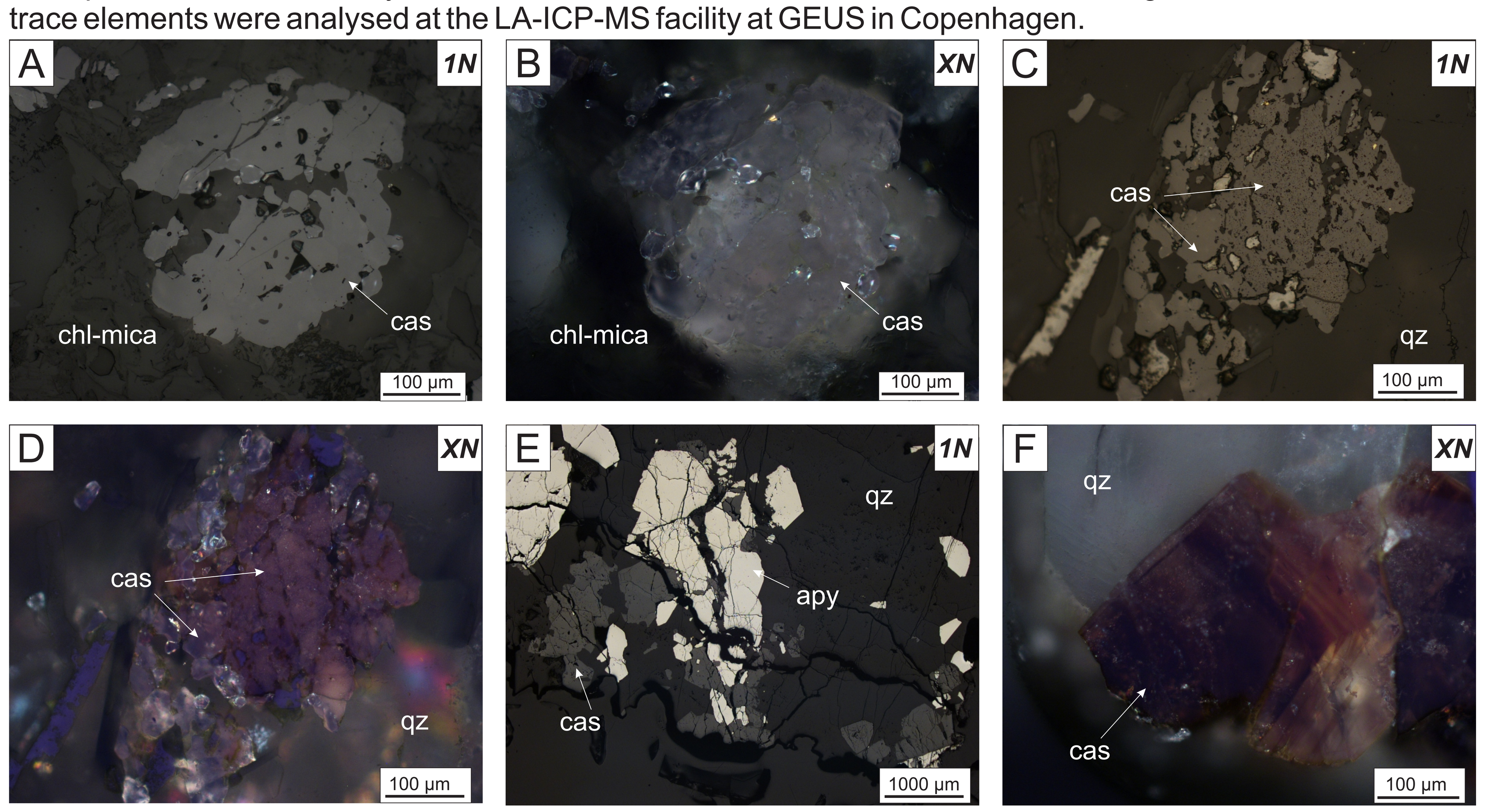

*Figure 2. Photomicrographs of cassiterite from Gierczyn-Przecznica and Czarnów. **A-B** Quartz-chlorite mica schist hosted cassiterite with white/colorless internal reflections, Gierczyn. **C-D** Przecznica, example of two intergrown types of cassiterite: one with white/colorless internal reflections and second "spongy" one with brownish internal reflections. **E** Cassiterite-arsenopyrite association from Czarnów. **F** Oscillatory zoned cassiterite from Czarnów; cas - cassiterite, apy - arsenopyrite, qz - quartz, chl-mica - chlorite-mica*

Results

Trace elements

Investigation of trace elements composition in cassiterites can help to distinguish different tin mineralisation types (Wang et al. 2022 and references therein). Although Wang et al. (2022) study only a few selected types of Sn mineralisation, pegmatite, greisen, skarn and quartz-vein types clearly cluster in different fields (Figure 4). The LA-ICP-MS analyses of cassiterites from Gierczyn-Przecznica, Czarnów and Piława Górna reveal significant differences between them (Figure 3). The cassiterites from Piława Górna are enriched in Ta and Nb, in Czarnów the same trend is observed for W and V. In the Gierczyn-Przecznica area, Hf and Mn are depleted, while these elements are enriched in the other types. The trace elements composition of cassiterite from Czarnów show significant variations this can be explained by presence of crystal zonation (Figure 2F).

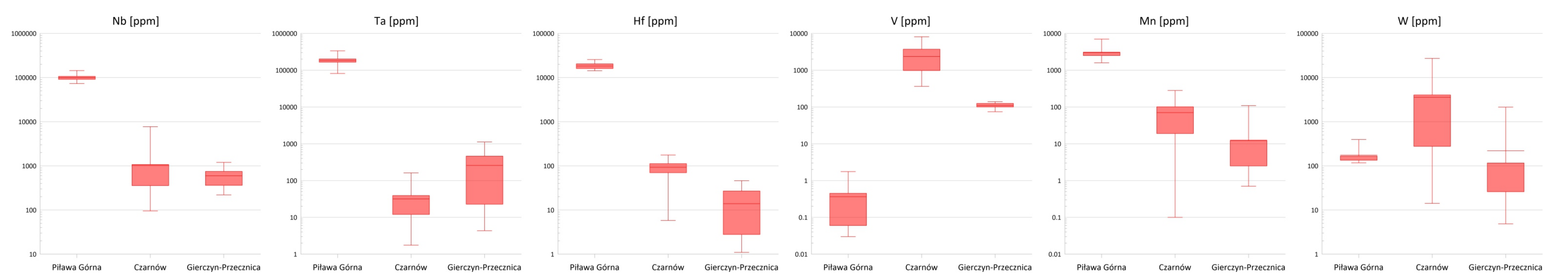

Figure 3. Trace element composition of cassiterite from investigated areas.

Geochronology

The small grain size made the analyses difficult, and those that were successful, point to 353±14 and 360±5 Ma age of the translucent cassiterite, whereas "spongy" grains yielded younger dates towards 318±6 Ma (Figure 5 A-C). Results from Czarnów (332±1 Ma) are older than the Re-Os age (312 ± 3 Ma) (Figure 5D) obtained for Co-bearing arsenopyrite by Mikulski and Stein (2011). Similarly, cassiterite from Piława Górna (404±1 Ma) gave age slightly older (Figure 5E) than previous geochronological studies (e.g., 377.6-380.7 Ma). Difference of approximately 6% between established ages and results for Czarnów and Piława Górna presented here might be partially due to non-matrix matched standard used for analyses. However, even assuming that similar differences exist for cassiterite from Gierczyn and Przecznica (there is no geochronological data for comparison), translucent cassiterite still seems to precede the emplacement of the Karkonosze Granite. Devonian/Early Carboniferous ages are coeval with the regional metamorphism which might suggest that the obtained data could in fact represent the resetting of U-Pb ages during metamorphism. Younger, "spongy" cassiterite age is contemporaneous with the emplacement of the Karkonosze Granite.

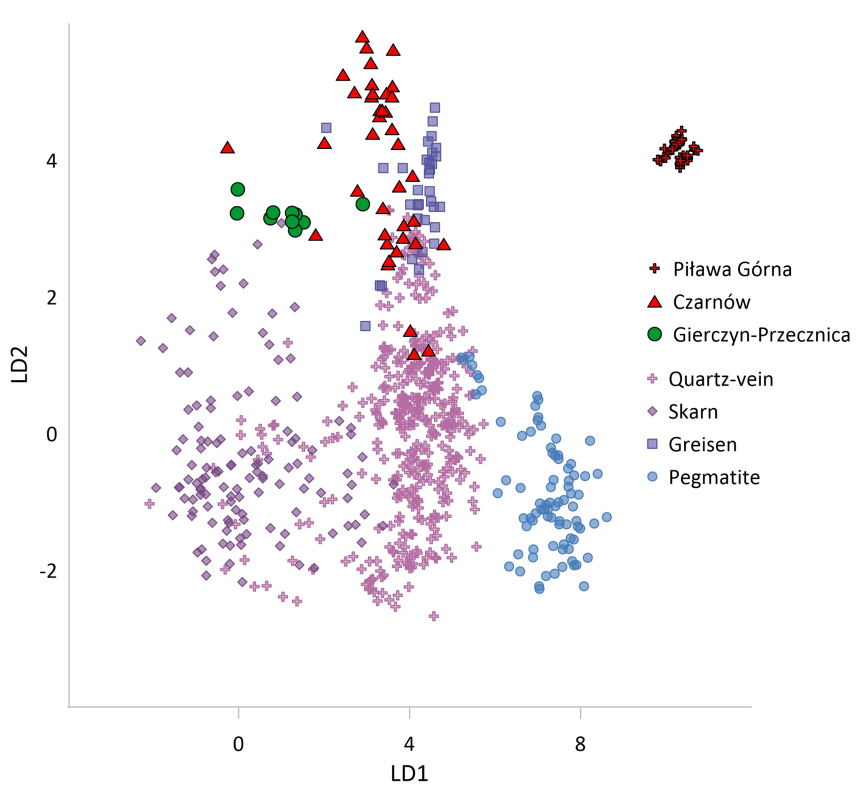

Figure 4. Discrimination diagram for the mineralisation types of cassiterite based on the fingerprint elements after Wang et al. (2022)

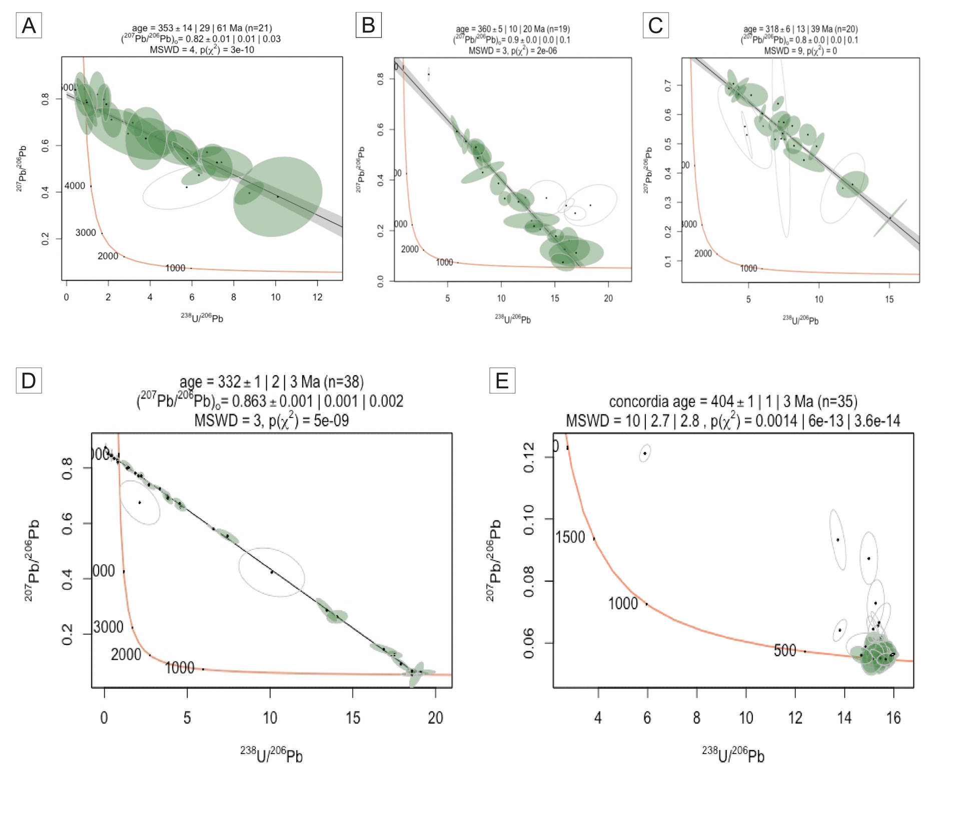

*Figure 5. Tera–Wasserburg U–Pb plots for cassiterites from the Gierczyn-Przecznica tin deposit **(A-C)**, Czarnów **(D)** and Piława Górna **(E)**. The cassiterite age for the Gierczyn-Przecznica - 353±14, 360±5 Ma and 318±6 Ma. The cassiterite age for Piława Górna – 404±1 Ma and for Czarnów – 332 ±1 Ma*

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