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Geological mapping of old mining underground workings – a unique tool to recognition of geology in Sudety Mts.

Abstract
Geological plans of selected old underground mining workings in the Sudety Mts. (SW Poland) were shown in a paper below. Geological mapping of such objects is presented as a method of very precise geological data collection. The results obtained are part of description and protection of geoheritage and geodiversity. Four examples of geological plans were shown, made for: Upper Adit in Kowary (on the old mine “Freedom” mining field), Gertruda adit in Złoty Stok, a small adit in Janowice Wielkie and Osówka object (element of Nazi military complex “Riese”).

Key words: geological mapping, mining heritage, geodiversity, Sudety Mts.

Introduction
The old underground mining workings, both available for tourists, as well as not adapted for sightseeing, are the objects of scientific research. Such studies relate to issues of chiropterology, microbiology, dendrochronology or are the basic mapping studies (see several articles on [9]). In the field of earth sciences mostly the mineralogical works are performed (eg [4,7]). Basic geological works including

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geological mapping of such excavations are rarely carried out. Currently, in the Sudety area, research of this kind are carried out only by staff of the Institute of Mining, Wroclaw University of Technology (e.g. [6,10,12,15–17]).

The study includes a detailed, long-term field work, characteristics of rock types, description of mineralization, characteristics of tectonic phenomena, and finally, on this basis – a generation of a geological plan. Such work should be the first step in a scientific investigation of any underground facility.

Sudety is a complex mountain range located in SW Poland which is a very attractive area for conducting geological mapping in the old underground workings. This is a consequence of the complicated block-structure (so called “mosaic-structure”) of this area. At each site, even close to each other, you can observe a completely different geological units, mineral deposits, tectonic structures.

The paper presents briefly the results of geological mapping of selected old underground objects in Sudety (Fig. 1).

![Fig. 1. Location of sites described in the text](image)

### Kowary

Several historic mining workings were penetrated in the Upper Kowary, on the field of former uranium and iron mine “Wolność” (“Freedom”) [10,11,12,14]. So-called Upper Adit has been investigated in detail, its geological plan was made on a scale of 1:1000 (Fig. 2).

The most important structure described in this adit is a contact surface of granitoid Karkonosze massif and its eastern metamorphic cover (Fig. 3). Perfectly visible is variability of a granite in zone close to the contact. We can distinguish coarse-grained, porphyrocealous granite in a distance of over 50 m from the contact, thin-grained porphyrocealous granite and narrow zone of various thin-grained granites adjacent to the contact. The biotite streaks and enclavas occur in coarse-grained granite. A number of rocks of the Podgórze ore-bearing formation were described, such as: hornfels varieties, as well as marble and skarn.
In this adit occur dislocation zones of various orientation. Within the metamorphic complex the presence of several blocks of different tectonic foliation and type of fold deformations was documented. In one of the vein rocks (fine-grained granite) an interesting set of indicators of magma flow direction was described [13].
Złoty Stok

Three adits in Złoty Stok, in old mine of gold and arsenium ores, were shown on the geological plans. They are now part of an underground tourist route “Gold Mine in Złoty Stok” – these are: Gertruda adit, Czarna Górna (Upper Black) adit and Czarna Dolna (Lower Black) adit. Preliminary work has been done as part of the diploma thesis [5]. In 2010, detailed geological plans and the proposed geotouristic route were presented in a paper [16].

The mine is located in an area of complicated geological structure, within the so-called Złoty Stok–Skrzynka dislocation zone. There is a number of lithological varieties of metamorphic rocks there, which were formed in several phases of regional and dynamic metamorphism [8].

In adits available as a tourist route, the basic lithological types of Złoty Stok deposit are visible, these are mostly blastomylonitic mica schists and lephtites, less frequently dolomitic marbles and serpentinites and rarely – pegmatites and tectonites. Outside the tourist route it is possible to observe in situ löllingite mineralization.

An interesting, possible to trace, phenomenon is here a variability of orientation of rock foliation. Analysis of the cartographic view lets you indicate a range of large-scale fold deformations (Fig. 4). On the side walls of excavations different smaller folds are also visible – these are broad and isoclinal, disharmonic and intra-foliation folds [16, 17].

Mining workings in Złoty Stok allow to observe several faults and wider zones of dislocations. Biggest of them are large deformation zones with a thickness of up to several meters, with bands of irregular surfaces of displacement and plenty of fault meal. These zones were created in a various physical conditions – from ductile to completely brittle, what indicates the different time of their creation. Minor faults have very variable amplitude, thickness of displacement zones, orientation, and the character of the surface. Available to watch are, among others, polished surfaces, fault striae and reorientation of foliation at the faults. Within the above-mentioned broad zones of dislocation bands of small secondary faults are visible [16].

An interesting group of tectonic phenomena may be observed in the northern part of the upper level tunnel of Gertruda adit. This is a complex of faults with amplitude of about 1 m, with perfectly visible reorientation of rocks foliation close to the fault surfaces. They limit a tectonic block elevated in compressional regime and deformed into an anticline [16].
Osówka

"Osówka" is a large object arose during World War II as part of Nazi military complex called “Riese”. It is a set of intersecting corridors and halls, with two entrance adits (Fig. 5). The total length of corridors reaches 1700 m. Their regular, orthogonal system provides a unique opportunity to track the variability of geological structures.

"Osówka" is situated in the Sowie Mts. Massif. The dominant varieties of rocks in this unit are structurally diverse, highly metamorphosed paragneisses. Their protolith was built during the Late Riphean – (maybe) Middle Cambrian [2], and the maximum intensity of metamorphic processes occurred in the period 384–370 million years ago [18].

The main type of rock in “Osówka” is a monotonous, gray, medium-blastic gneiss with constant orientation of foliation around 45/80. Dark, fine-blastic or aphanitic gneisses, transition varieties of gneisses and highly shattered migmatitic gneiss, occurring near the larger zones of dislocation, are clearly in the minority [6].

A more interesting group of rocks are here igneous rocks – reomorphic granites occurring in veins, lenses and nests. Three structural varieties of these rocks were described here. You can also observe the occurrence of pegmatite. An interesting phenomenon are clusters of granite veins (“swarms” of veins) occurring near to the entrance of adit No 1 (Fig. 5, 6). In some places these veins are clearly boudinaged [6,17]. Such a scale of these structures is not to be seen anywhere else in the Sowie Mts. Massif.
Fig. 5. Geological map of the tourist rout in „Osówka” object; the occurrences of quartz (Q), pegmatite (P) and secondary mineralization (M) are marked; description of mining workings: K – halls, G, J, p – drifts), (after [6])
Fig 6. Veins of reomorphic granites in Osówka (after [17]; view on a roof)

**Adit in Janowice Wielkie**

The last of objects discussed is a small, unknown in the older literature, adit located in the southern part of Kaczawa Mts. Its length is about 140 m, in the final part there is a large chamber work (Fig. 7) [15].

This area is mostly built of greenstones with greenstone-schists and lenses of marbles (crystalline limestone). These rocks represent the oldest part of Kaczawa Metamorphic Unit. Age of protolith (basalts, basaltic tuffites and limy mud) shall be determined on the Middle Cambrian – Lower Ordovician [1, 3]. The adit is located in the close vicinity of the most important dislocation zone in Sudety Mts. – the Intra-Sudetic fault zone.

In the adit dominates monotonous greenstone but there is also an approximately 30-meters-long lens of marble here. The internal variability and lithological boundaries of marble are perfectly visible (Fig. 7, 8) [15]. The occurrence of number of faults, with the two largest, probably genetically related to the Intra-Sudetic fault zone, was ascertained.
Fig. 7. Geological plan of adit in Janowice Wielkie [15]

Fig. 8. Internal variability of marble and its contact with greenstone
Conclusions

The need of described in article kind of work in various excavations is due to: 1) lack of archival maps (especially in the case of small, isolated objects), 2) the availability of mining maps only, 3) low precision of the available geological maps, in relation to the amount of data possible to obtain in old adits.

Well analysed underground mining workings provide incomparably more, more precise geological data than surface investigations. This is particularly important in areas poor or devoid of outcrops of rocks.

Geological mapping of old underground mining works is an element of precise description of geoheritage and geodiversity and helps in protection of these values.

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References


