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Research paper

Chemistry of water from the inflows to the “Franciszek” dipheading in the “Pomorzany” Zn-Pb mine in the Olkusz Area (SW Poland)

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ABSTRACT

The “Franciszek” dipheading is one of the main components of the transportation infrastructure in the “Pomorzany” zinc and lead mine in the Olkusz ore district. The heading was cut out of the aeration zone, created by mine drainage in Quaternary sands and Middle and Lower Triassic carbonates. This study presents the results of the examination of the chemical composition of water leaks identified in the dipheading. It was found that the chemical composition of the water under examination depends on geogenic factors, mainly the mineralogical composition of the rocks that are infiltrated by the meteoric waters which feed the leaks, as well as the geochemical processes associated with metal sulphate weathering in the carbonate rock environment (with dolomites and limestones). The significant influence of anthropogenic factors was also identified, including the most important one linked to the migration of polluted waters from the surface mine facilities.

1. Introduction

The “Franciszek” dipheading is one of the main components of the transportation infrastructure of the “Pomorzany” Zn-Pb Ore Mine. The volume of the inflow to the mine over the last 20 years, was between 200 and 280 m^3/min, depending on the precipitation level (Motyka, Adamczyk, & Juśko, 2016). The dipheading connects the surface with the underground workings of the mine. It is 940 m long, and, considering that the altitude difference at the dipheading's entrance on the land surface and at the place of connection with the underground working network equals 74.5 m, an approximate slope of the dipheading can be estimated at 7.9‰. The facility is cut into dolomites, with a short section cut into the limestones of the Middle and Lower Triassic. 19 water inflows were recorded in the dipheading, the majority of which appear temporarily as a consequence of increased rainfall or thick snow cover melting. Water samples were collected for the purpose of chemical testing in 1997–2016, and the test results are presented in this study.

The chemical composition of leak water samples from the “Franciszek” dipheading was formed under the influence of operation of geogenic and anthropogenic factors. The main geogenic factor was identified as the mineral composition of the rocks infiltrated by meteoric waters. This is another essential geogenic factor consisted in the metal sulphate weathering process in the carbonate rock environment, with the presence of dolomites and limestones. The migration of pollution from the surface mine facilities, situated around the “Dąbrówka” shaft, was an anthropogenic factor that was also significant in the chemical composition of leak waters collected from the “Franciszek” dipheading.

It was technically difficult to examine the leak waters of the “Franciszek” dipheading. Owing to the present function of that facility, the traffic of heavy mining machines is ongoing there and thus the possibility of conducting any kind of work inside, including examinations associated with the mining operations and industrial safety, is quite limited. That is further augmented by temporary copious leaks, depending on the rates of meteoric waters migrating through the aeration zone, in which the dipheading is situated, into the saturation zone. High instability of the water flow conditions in the aeration zone creates considerable difficulties in the local interpretation of the results of leak-water chemical composition testing. Such difficulties are, however, quite typical for underground mine workings and this needs to be taken into account in such conditions.

There are four aquifers in the Olkusz zinc and lead mining area: Quaternary, Jurassic, Triassic, and Carbonian-Devonian. The

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Quaternary aquifer is formed by fluvioglacial sands, with the inclusion of gravel and rubble. This underground aquifer is of the porous type. The Jurassic aquifer is composed of Upper Jurassic (the Malm formation) limestones. This occurs in the northern and eastern sections of the Olkusz Area (Fig. 1).

The Jurassic aquifer is of the fissured-karstic type. The Triassic aquifer is composed of the dolomites and limestones of the Middle and Lower Triassic (Muschelkalk and Upper Bundsandstein). Owing to its high porosity of diploporous dolomites (Middle Muschelkalk) and cell dolomites (Upper Bundsandstein – Röt formation), the carbonate Triassic formations build an aquifer of the porous-fissured-karstic type (Motyka, 1998; Zuber & Motyka, 1998). Outcrops of Triassic aquifer formations on the land surface or under the Quaternary deposits are in the western section of the Olkusz area (Fig. 1). The Carboniferous-Devonian aquifer is built by limestones and dolomites. This aquifer is of the fissured-karstic type.

The "Franciszek" dipheading, runs from the land surface to the underground "Pomorzany" mine workings, cutting through older and older carbonate rocks, belonging to Middle and Lower Triassic that is the Middle Muschelkalk and Upper Bundsandstein (Röt formation). The initial dipheading section is cut into the diploporous dolomites and ore-bearing rocks (Middle and Lower Muschelkalk), the short middle section in Gogolin beds (Lower Muschelkalk), and the final section in Röt dolomites (Upper Bundsandstein). In the upper part of the initial section of the dipheading, diploporous dolomites are covered by a thin layer of clay formations of the Upper Triassic (the Keuper formation). The Triassic rocks are covered by fluvioglacial Quaternary sands, with its maximum thickness reaching nearly 55 m in the lower section of the dipheading (Fig. 2).

Fissures and bedding planes provide the main water flow paths in Triassic dolomites and limestones and they were cut through by the "Franciszek" dipheading. We can also observe numerous small caverns, with diameters of up to several centimetres. This rock environment is characterised by high heterogeneity of hydrogeological properties. The values of carbonate hydraulic conductivity relating to the Triassic rocks usually amounts to 10^{-5} m/s, although several orders of magnitude are covered by their range (Motyka & Wilk, 1976). In natural conditions, the groundwater level remained at the interconnected Quaternary-Triassic aquifer of the dipheading area at the altitude of ca. +312 m asl. As a result of the dewatering of carbonate Triassic rocks and Quaternary sands, owing to the effects of the "Pomorzany" mine's workings, the groundwater level was lower in that area, to an altitude of +180 m asl. Consequently, a young aeration zone was developed and the "Franciszek" dipheading was cut out of it.

Analyses of water chemical composition in the Franciszek diphead were performed to assess the impact of natural factors. Including: the mineral composition (???) of rocks inifiltrated by waters flowing into the diphead, pyrite weathering processes, and neutralization of acid drainage (AMD) in the carbonate rocks and the presence of contaminants from the surface (anthropogenic factor).

2. Materials and methods

The water inflows in the "Franciszek" dipheading originate from the aeration zone. For that reason, their discharge, reaching 1 L/min in the most productive inflows, depends to a large extent on the rate of the fluxes meteoric waters. 19 leaks were recorded in the dipheading the majority of which appear temporarily either after high rainfalls spread over time or during a short amount of time but with intense rainfall or thaw. The appearance of temporary inflows and the time of their operation is stochastic in nature.

Investigations of water inflows' (leakages) chemistry started in the "Franciszek" dipheading in 1997, as part of the Polish-American

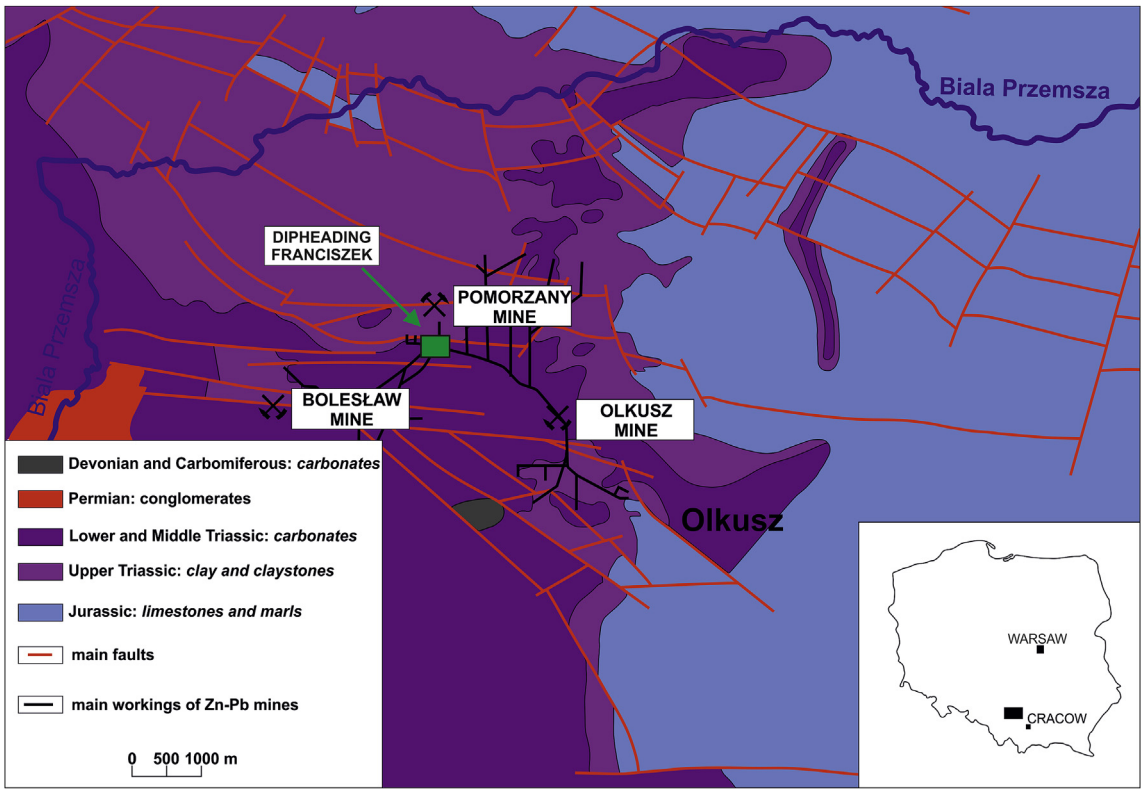

Fig. 1. Geological map of the Olkusz area.

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