

NATURAL AND ANTHROPOGENIC CONTAMINATION AND THEIR EVIDENCE IN GEOLOGICAL HISTORY

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ABSTRACT

Geological surroundings of the Czech Republic were anthropogenically contaminated during last thousand years by heavy metals in connection to extensive ore and other raw materials mining. The following model examples were chosen for evaluating migration and bonding of heavy metals in surroundings which were exposed to exogenic influences: geochemical studies of profiles of fluvial sediments in the area of historically dated ore mining; mineralogical, petrological, and geochemical study of burning mine dumps, and geochemical, petrological, and mineralogical study of deposits of slag after historical ore mining. Thus, the project proposed, besides of outputs with a character of basic research, substantially will contribute also to the evaluation and assessment of contamination of geological surroundings in the Czech Republic from natural and anthropogenic sources during recent geological past and enable to discover and describe differences between contamination from the both type sources.

KEYWORDS: natural and anthropogenic contamination, heavy metals, historical ore mining, fluvial sediments, burning mine dumps, deposits of slag

1. INTRODUCTION

Geological environment of the Czech republic was strongly anthropogenically contaminated over the last thousand years by heavy metals in relation to the extensive mining of ore and other raw materials.

To assess migration and binding of heavy metals in the environment issued by exogenous effects model were selected following examples:

Geochemical study of fluvial sediment profiles rivers in areas of historically dated ore mining; mineralogical, petrological and geochemical study of selected works of burning mine dumps and chemical, petrological, geochemical and mineralogical study of selected dumping sites slag after the historic ore processing.

2. OVERVIEW STUDIED RIVERS

Study of fluvial sediments was focused on three areas with significant historic mining activities.

Zone Krušné Hory Mountains (drainage area Ohře):

Blišanka, Bystřice, Svatava, Podmílský brook

Zone Kutná Hora (drainage area Elbe):

Šembera, Výrovka, Vrchlice, Klejnárka, Brslenka

Zone Příbram and Plzeň (drainage area Berounka):

Litavka, Střela, Mže, Kosový brook, Úterský brook

3. SAMPLES AND METHODS OF THEIR STUDY:

Samples of the water courses were taken from bored cores, and at intervals of 10 cm (a total of 13 drill holes and collected 73 samples).

Methodology:

1. the macroscopic description
2. grain size analysis
3. the measurement of magnetic susceptibility and radioactivity
4. analysis of the total mineral composition
5. chemical analysis
6. detailed mineralogy



Fig. 1 River network Czech Republic where the streams studied.
 (1- Blšanka, 2 - Bystřice, 3 - Svatava, 4 - Podmílešský brook, 5 - Šembera, 6 - Výrovka, 7 - Vrchlice, 8 - Klejnárka, 9 - Brslenka, 10 - Litavka, 11 - Střela, 12 - Mže, 13 - Kosový brook, 14 - Úterský brook)

4. RESULTS

4.1. STUDY OF FLUVIAL SEDIMENTS AND THEIR PROFILES IN THE AREAS OF HISTORICAL ORE MINING

Contamination of sediments lamprey and river network in the Krušné Hory Mts. is associated with the settlement of intensive and extensive mining, treating and processing activities. Numerous documentary sources tell us that the act was done already deep in the Middle Ages, but in the main rate spread in the modern era and persists until the present. Study of contamination, a record of their development during periods of intensification and the decline in mining give us a lot of material to follow their laws. Some elements of oscillation are important for the whole area, sometimes the only local enrichment a certain period and under certain ore processing technology.

As another suitable model area was chosen Kutná Hora area. The results of the work carried out so far confirmed that the contamination of sediments in waterways Čáslavka, Klejnárka, Vrchlice, Výrovka, Šembera depends on the intensity of activities during the changes of population in this area since the late Bronze Age until modern times. The example of the second area (Kutná Hora area) are the results of processing Vrchlice river sediments (Fig. 1).

4.1.1. GRAIN SIZE ANALYSIS

The river Vrchlice can recognize a total of 5 cycles of development of sediment grain size. 1st cycle, the predominant transmission coarser fractions, followed by 2nd cycle with lightly finer particles and 3rd cycle and follow-up by 4th cycle is typical portorage coarse particles and finally 5th cycle, which is against typical of portorage and fine particles (Fig. 2).

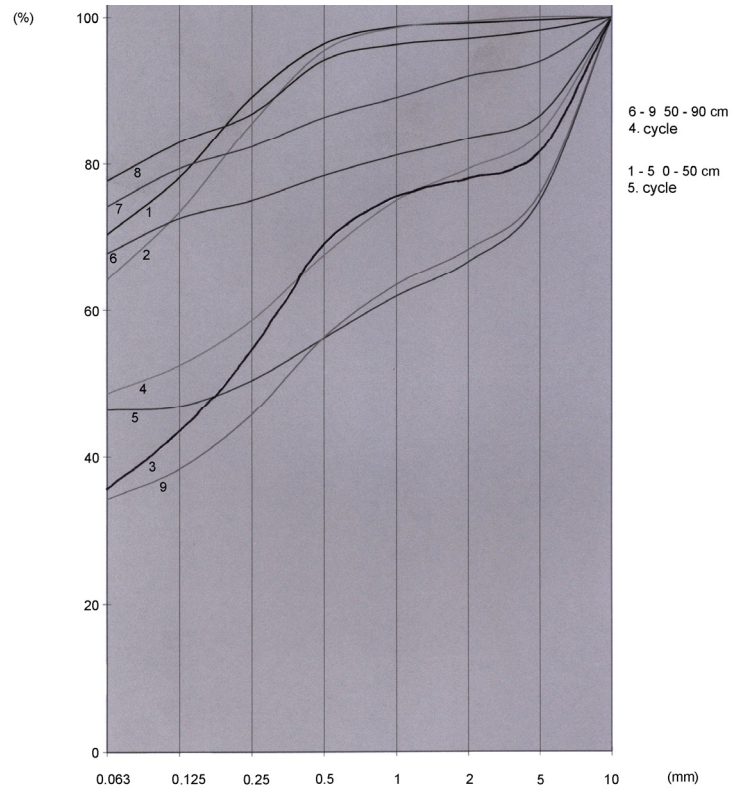
In the early days, while the volatile caused by flooding, there were prevailing portorage coarse particles. After the intervention of man into the landscape prevails portorage and fine fractions of sediment, from about 100 cm depth (Fig. 3).

4.1.2. MAGNETIC SUSCEPTIBILITY

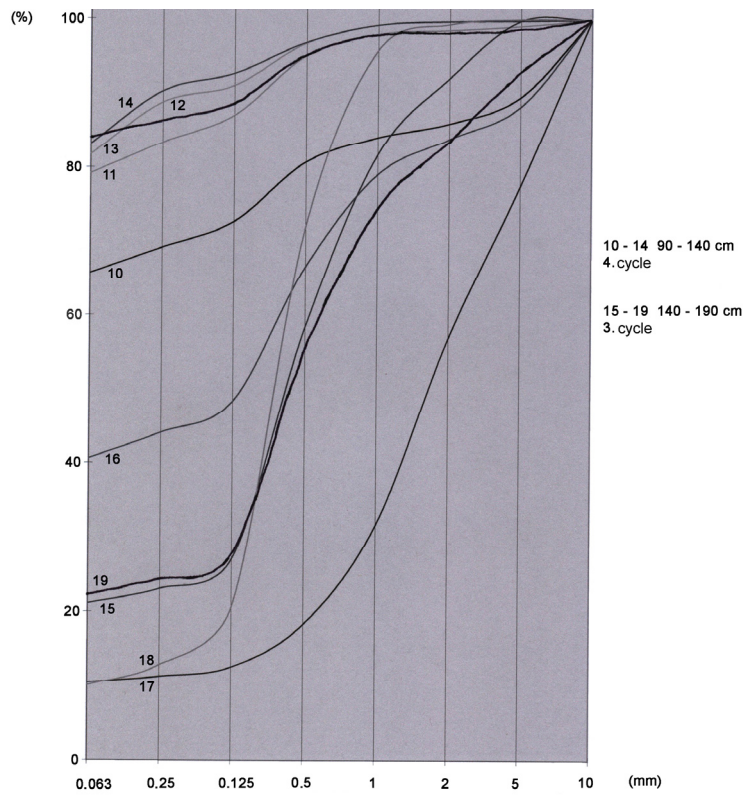
Increased magnetic susceptibility occurs mainly by human interventions in the landscape, where there was mining activity and metals from skarn or serpentinite body and roasting of the ore extracted metals (Fig. 4).

4.1.3. MINERAL COMPOSITION

Also reflects the mineral composition of human activity and its influence on sediment contamination and enrichment of certain minerals. A typical example is eg. the content of calcite in the sediment. Its high content is visible at the base profile, which caused the deforestation and then at a depth of 100 cm, which caused the intense human activity (Fig. 5).



a



b

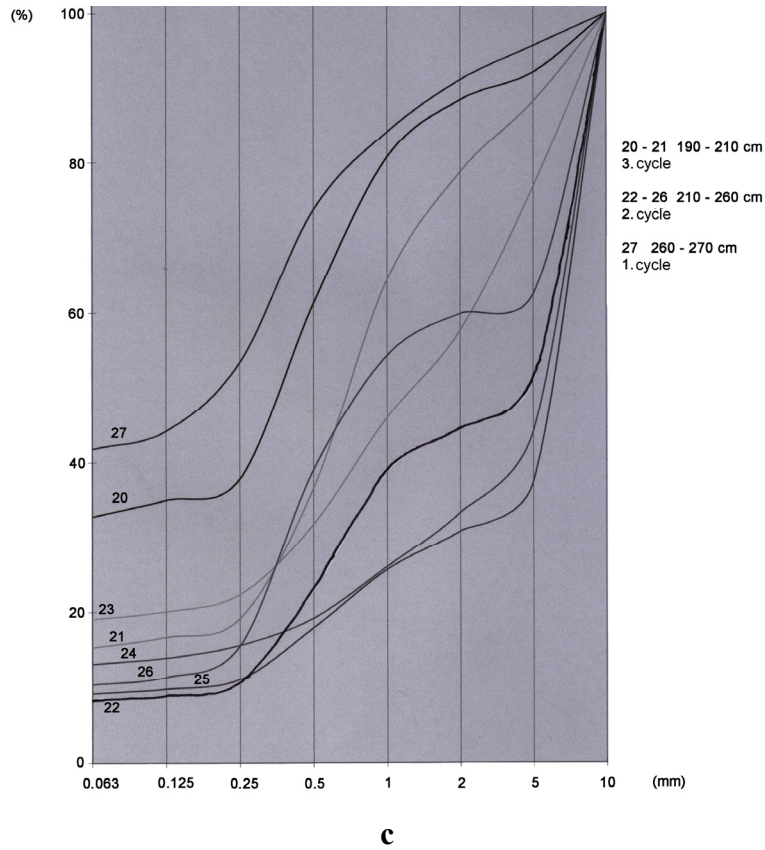


Fig. 2 Grain size curve of profile Vrchlice.

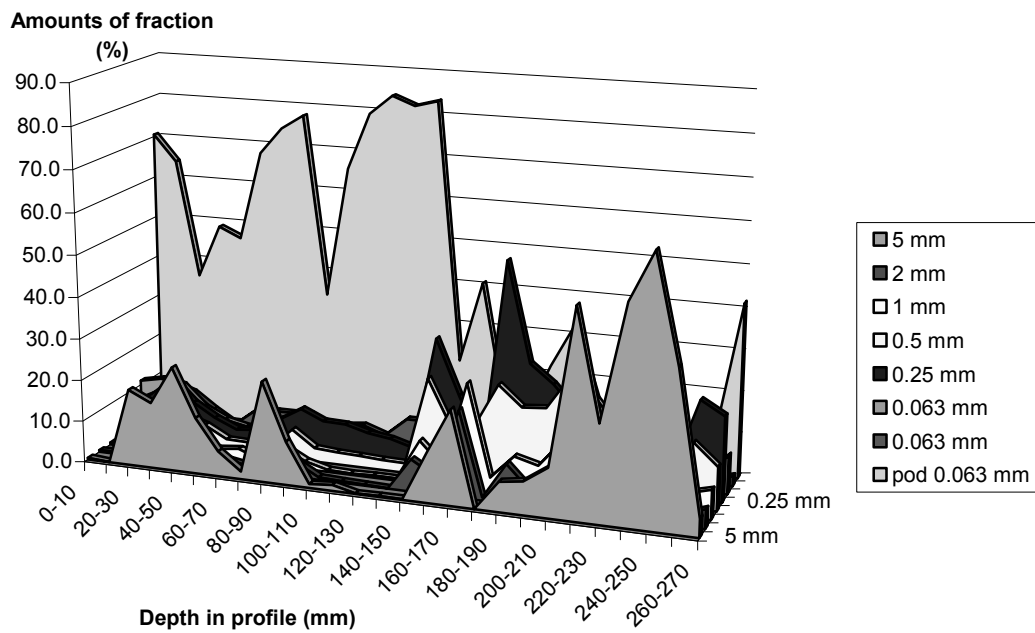


Fig. 3 Content of the particle different fractions in the profile of sediments Vrchlice.

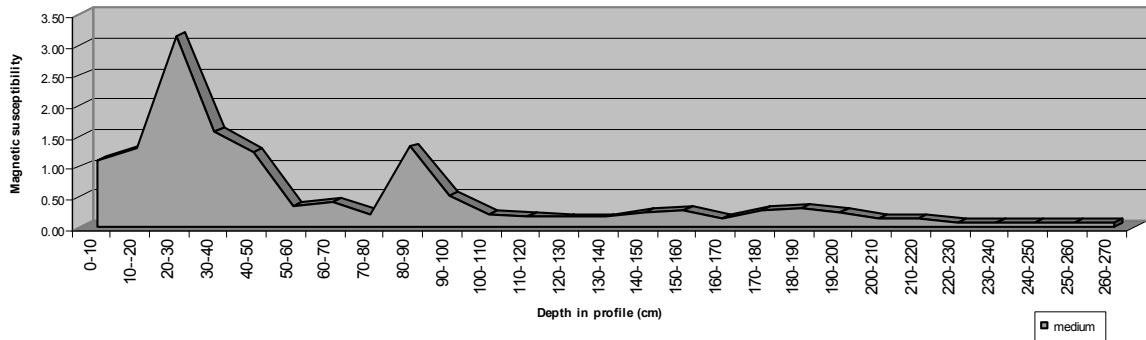


Fig. 4 Magnetic susceptibility (Vrchlice) depends on concentration of magnetic particle from technogeny contamination - wustite (smelting waste) and mining in outcrops of the skarn and serpentinite rocks (magnetite, hematite).

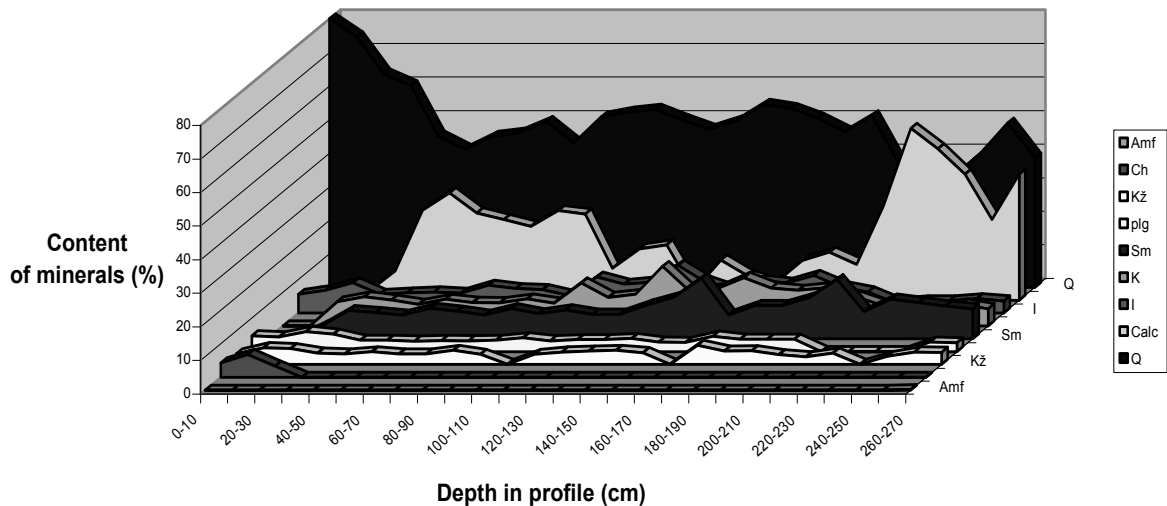


Fig. 5 Oscilation contents of the mineral (Vrchlice) depends on weathering of cretaceous sedimentary cover and crystallinic basement and then more later, on quartz and later on different human activity (agriculture and building), and from mining processing and smelting (Amf - amphibole, Ch - chlorite, Kz -feldspare, plg - plagioclase, Sm - smectite, K - kaolinite, I - illite, Calc - calcite, Q - quartz).

4.1.4. TRACE ELEMENTS

Contamination of sediments and river lamprey network was linked by the settlement of intensive and extensive mining, treating and processing activities. Numerous historical documentary sources indicates that these different activities have already taken place deep in the Middle Ages, in the main level, however, be extended in the modern era and persisted almost until the present.

Distribution of selected contaminants in relation to the succession of sedimentation in selected water flow has some patterns reflecting the historical development of the area. Some elements are essential

for the whole area, sometimes only to enrich the local bound for a certain period and the usage of a technology for processing metal ores (eg. washing, roasting, amalgamation, compaction). Our study has given some further results for the expansion of knowledge about the beginnings of the use of natural resources and development of contamination throughout history (Figs. 6-8).

4.2. STUDY OF THE BURNING COAL WASTE PILES

Mineralogical and petrological study of materials of the burning coal waste piles provides unique data on the reactions of a number of chemical elements

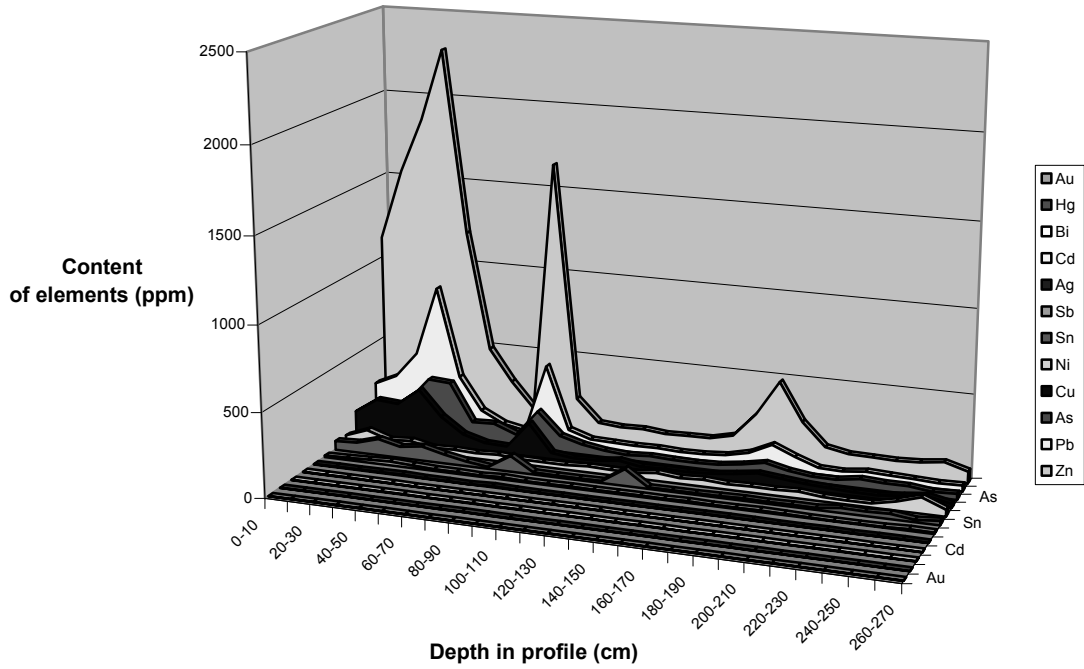


Fig. 6 Technogenic contamination evidence (Vrchlice) in different ages based on human activity. At the first panning of gold and tin ore at the Celtic Age, mining and smelting iron ore in barbaroromain Age and mining and smelting of the silver ore since April 1281, later complex polymetallic ore Zn, Cu, Pb, As, Ag and recycling dumps in 18th century.

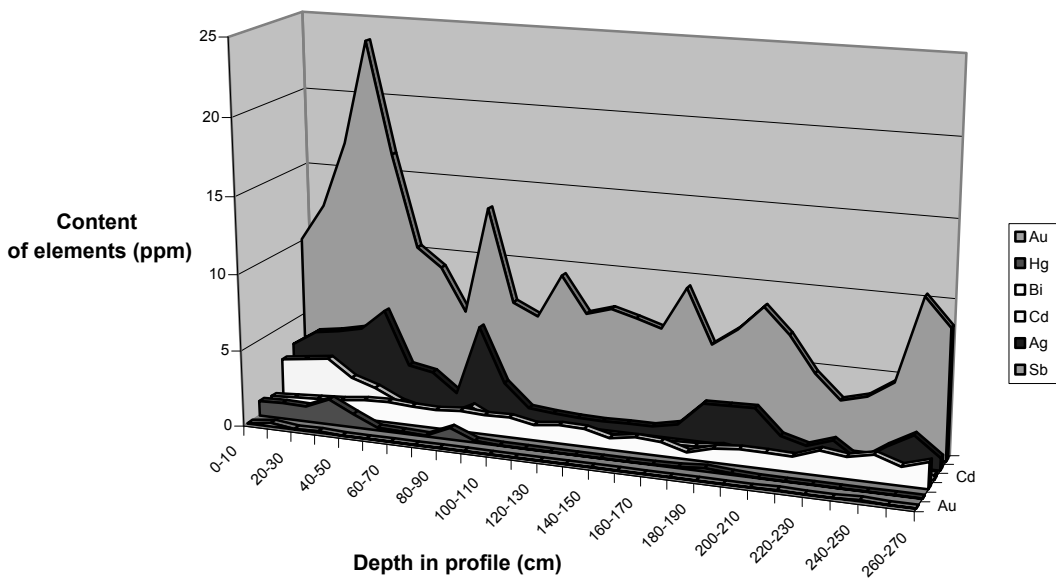


Fig. 7 High similarity curen depend on mining and on processing. Elements as Sb, Ag, Hg, Ag and Au in upper part of the diagram.

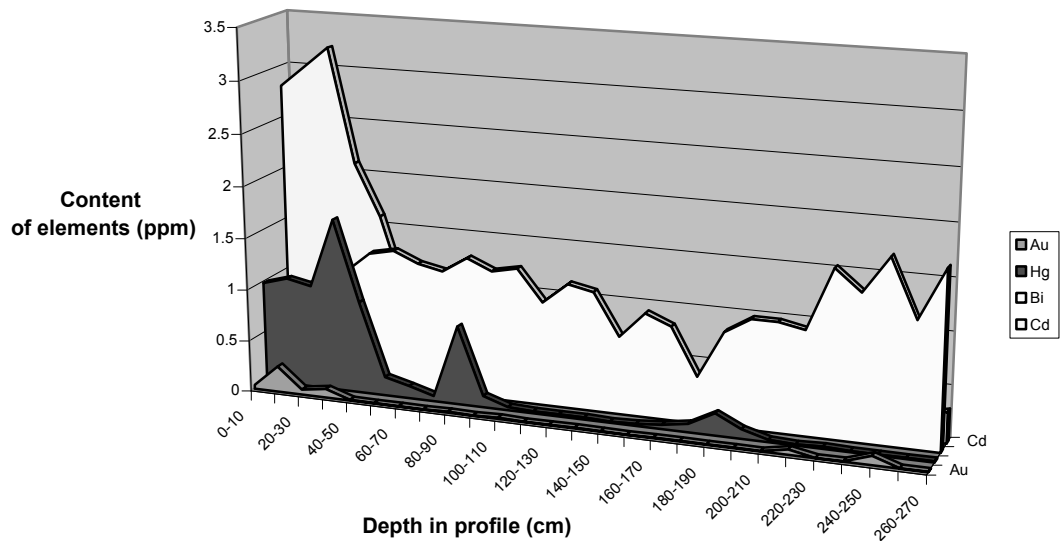


Fig. 8 Polymetallic ore vosting caused higher content Hg and Cd in the last period of mining and reworking old dumps (esspecially with slag).

with difficulty in the laboratory imitable geological conditions, as well as it provides a range of informations about possibilty of regional and local contamination of geological environment. Research focused on finish of study rich mineral association containing heavy metals from waste piles down to the Lower Silesian basin (Radvanice), which was completed it a detailed analytical study of large-scale mineral associations (tens identified phases) with a strong representation of Sn, Ge, Cd, Pb, Sb, As and In, and the results were interpreted in detail. The processing of manuscripts during 2008 hindered the problematic relationship of the Commission for a new classification of minerals and their point of view IMA at anthropogenically resulting minerals. To a greater extent in recent years, continued work on the occurrences around Kladno (heap down Schoeller and Max) and the neighbourhood of Brno (Zastávka), focused on caustic metamorphosed rocks in the basins of burning (association with periclase, brucite and srebrodolskite; minerals group of ellestadtite; association the occurrence of anomalously F and Cl-rich silicates, has placed more from volcanic areas).

4.3. STUDY ACCUMULATION OF SLAG AND OTHER MATERIAL OF HISTORICAL ORE MINING

Were studied massive slag and small intrusions in the sediments of the archaeological site Roztoky u Prahy (Šrein and Šťastný, 2008c; Fig. 9).

In a study conducted jointly with the archaeologists objects with estimated production of lime has been investigated. Detailed mineralogical research has shown destruction of clay minerals and the presence of very fine magnetic particles. The findings led to the conclusion that this was the later sedimentary CaCO_3 saturation of objects, which also increased levels of P_2O_5 and K_2O showed by production methods, using the ashes of the primeval treatment processes (tanned hides) this is probably the first such scientifically examined by a preserved object. It was also dealt with the chemical composition of slag and the question of the origin of ore founded near the village of Ořech near Prague (Šrein, Šťastný 2008a), where even the minimum number of samples for the study showed the use of sedimentary limonite-rich ore forming the basis of the Cretaceous sediments of the wider area of Ordovician outcrop games ironbearing positions. Other examines items from the Moravia molded dish of Olomouc (handled in collaboration with Dr. Jelínek from AUB AS CR v.v.i.), in which detailed research and chemical research showed the tin with lead and copper from the early Slavic settlement (Šrein and Šťastný, 2008b). Those research reports were submitted by professional colleagues from the archaeological environment and will be published with their archaeological research in the periodicals.

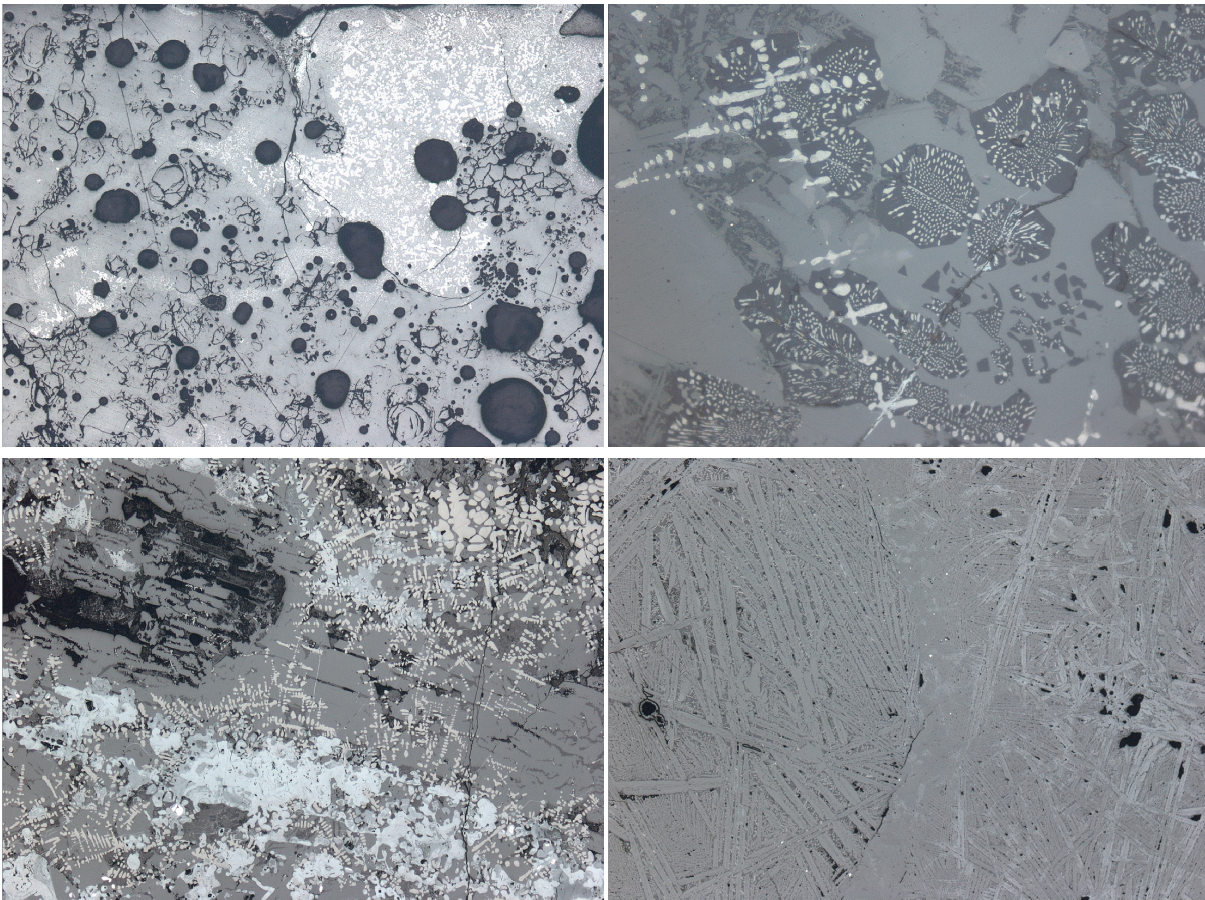


Fig. 9 Samples of iron slag from the archaeological sites of the Roztoky u Prahy.

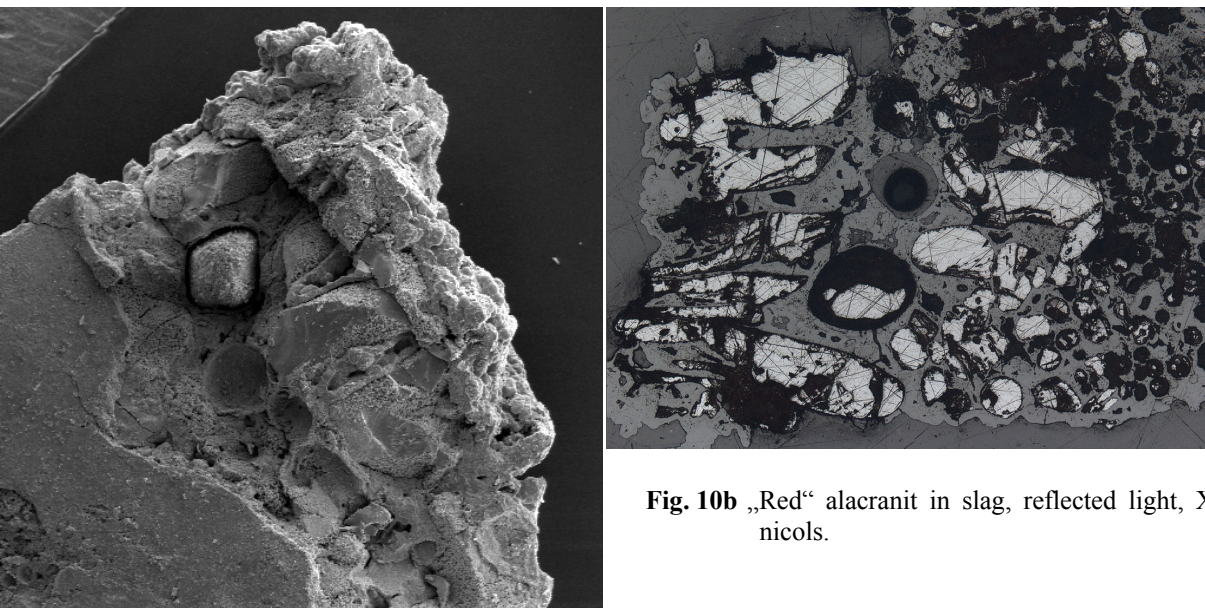


Fig. 10b „Red“ alacranit in slag, reflected light, X nicols.

Fig. 10a „Red“ alacranit in slag, in view of BSE.

LIST OF ALL OUTPUTS OF THE GRANT PROJECT FOR THE ENTIRE SOLUTION

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PŘÍRODNÍ A ANTROPOGENNÍ KONTAMINACE A JEJÍ ZÁZNAM V GEOLOGICKÉ HISTORII

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ABSTRAKT:

Geologické prostředí České republiky bylo v průběhu posledního tisíce let výrazně antropogenně kontaminováno těžkými kovy v souvislosti s rozsáhlou těžbou rud a dalších nerostných surovin. Pro posouzení migrace a vazby těžkých kovů v prostředí vystaveném exogenním vlivům byly vybrány následující modelové příklady: geochemické studium profilů fluvialních sedimentů říčních toků v oblastech historicky datované těžby rud; mineralogické, petrologické a geochemické studium vybraných hořících odvalů důlních děl a chemické, petrologické, geochemické a mineralogické studium vybraných deponií strusek po historické těžbě rud. Projekt tak vedle výstupů charakteru základního výzkumu přispěl i k posouzení kontaminace geologického prostředí České republiky z přírodních i antropogenních zdrojů v nedávné geologické minulosti a umožnil zjistit i rozdíly mezi kontaminací z obou typů zdrojů.