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Since the mines in the Olkusz area were closed down, water levels have risen gradually, leading areas like this to become flooded

Traces of Medieval Mining and Smelting

Nothing says more about us than what we leave behind. That makes ancient refuse an inexhaustible source of information for archaeologists.

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In regions where ore-bearing deposits are found, the content of heavy metals in the surrounding natural environment and water is naturally elevated. This phenomenon has been studied on the macro- and micro-scales for decades. Many years ago, for example, the area around the town of Olkusz in south-central Poland (an area where zinc and lead deposits occur) was found to exhibit elevated levels of heavy metal in the groundwater. Unfortunately, as a result of mining and smelting of these metals from ores, those naturally higher levels have been magnified by a significant factor.

If smelting processes continue for centuries, it becomes difficult to distinguish between modern-day contaminants and the ones that originated in other historical periods. Nature can adapt to such situations. Classic examples include the flora of calamine soils – in other words, the plants that are abundant near old zinc and lead mine workings. Observations of this phenomenon are important for historical and archaeological research. Some plant species even first came to the lands of today's Poland together with miners migrating in search of work.

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A bypass in Bolesław near the town of Olkusz, severely damaged by a sinkhole. This road is unfortunately unlikely ever to be opened for traffic

Environmental time-bombs

When the cadmium and lead content at 12 sites in and around Olkusz was analyzed many years ago, it became evident that their levels surpassed permissible limits. At some of those sites, the limits were exceeded quite significantly: for instance, by 66% in the Pazurek nature reserve, located north of Olkusz, and by 74.6% in the town center itself. How can we determine what portion of this contamination should be attributed to over a millennium of silver and lead smelting in the area, and what portion is a more modern or contemporary contribution? This is a very important question.

Archaeological evidence of medieval metallurgical activity is chemical in nature and can be described as a kind of environmental time-bomb that has been lying hidden in the soil for centuries. Signs of mining activity, spanning from the Middle Ages onward, can be observed in many ways – the lidar detection method being exceptionally efficient in this regard. Once employed, it can reveal tens of thousands of traces of past exploration of ore-bearing deposits. Such observations have been made in the vicinity of Tarnowskie Góry, Olkusz, Dąbrowa Górnicza, Trzebinia, Jaworzno, and Siewierz, to name only the best mapped areas of mine workings in Poland.

Smelting took place together with mining, in furnaces positioned in the close vicinity of mining shafts. Evidence of such exploration in earlier times is now further exacerbated by signs of industrial mining activity from the past two centuries. As a result, nowadays collapsing sinkholes are slowly surrounding the towns of Olkusz, Trzebinia, and other areas where intensive exploration continued for centuries. Previously, water was pumped out of the mines and directed to specific locations. Since the mines were closed down, however, water levels have risen gradually, leading to the flooding of the Olkusz area.

In 1999–2009, medieval furnaces for lead smelting were discovered in the Łosień district of Dąbrowa Górnicza together with a considerable amount of post-smelting contaminants. One of the furnaces had even been left abandoned with the batch of material being processed still left inside. The precise reasons for this remain unclear, with potential scenarios including a sudden armed attack on the twelfth-century smelting plant, or technological mishaps during the smelting process. The find is located in the yard of a family house, less than a foot underground. This means that hundreds of kilograms of toxic lead com-

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Post-mining sinkholes in the Olkusz area

pounds were present in the immediate vicinity of a residential home for centuries.

Gains and losses

Obviously, the development of mining and smelting also had – and still has – its advantages. This perspective was articulated by the German scholar and metallurgist Georgius Agricola in his famous sixteenth-century work *De re metallica*: "For this reason we learn from the history of nearly all ages that very many men have been made rich by the mines, and the fortunes of many kings have been much amplified thereby. (…) prosperous Republics, not a few kings, and many private persons, have made fortunes through mines and their produce." This statement appears to hold relevance for all the past epochs and, in my opinion, will remain valid well into the future. Despite being a great enthusiast of industry, Agricola adds elsewhere in his work, "(…) the woods and groves are cut down, for there is need of an endless amount of wood for timbers, machines, and the smelting of metals. And when the woods and groves are felled, then are exterminated the beasts and birds (…)" And, consequently, so are humans.

These words are perfectly suited to describe the Błędów Desert, Europe's largest desert. Situated near Olkusz, this sandy area is actually the result of an environmental disaster caused by excessive felling of trees for the purposes of the local smelting industry, in both medieval and contemporary times. As is demonstrated by this case (and by that of other similar deserts in the Olkusz region), environmental disasters are certainly not something confined to the twentieth-century economy.

Even in antiquity, there was a notable awareness of the relationship between the properties of metals and human health. Lead compounds are highly poisonous, and its effects on human health have long been studied, including in the historical context. Some of them were already evident in ancient times. The Roman architect Vitruvius mentioned harmful water flowing from numerous springs often located near gold, silver, and lead mines. He even described symptoms of poisoning resulting from the consumption of such water.

However, theories that the fall of ancient Rome was allegedly caused by the consumption of contaminated water supplied to the Eternal City through a network of lead pipes can be conclusively put to rest. Such pipes were used, but a certain understanding of their harmfulness did exist. Vitruvius placed great emphasis on this fact, stating in his work *De architectura,* "(…) water from clay pipes is much more wholesome than that which is conducted through lead pipes, because lead is found to be harmful for the reason that white lead is derived from it, and this

is said to be hurtful to the human system. Hence, if what is produced from it is harmful, no doubt the thing itself is not wholesome. This we can exemplify from plumbers, since in them the natural colour of the body is replaced by a deep pallor. For when lead is smelted in casting, the fumes from it settle upon their members, and day after day burn out and take away all the virtues of the blood from their limbs. Hence, water ought by no means to be conducted in lead pipes, if we want to have it wholesome. That the taste is better when it comes from clay pipes may be proved by everyday life, for though our tables are loaded with silver vessels, yet everybody uses earthenware for the sake of purity of taste." Pliny the Elder, the author of the first encyclopedia ever written, also argued that clay pipes were superior. Nevertheless, such warnings had little impact. We know that lead pipes were used not only in settlements, but also in legion camps. In practice, they continued to be used until the modern times.

Ancient mines and smelters

Signs of industrial activity from earlier eras are visible on a large scale in certain locations. Microtraces and remnants of metallurgical processes in the form of slag serve as evidence of intensive metallurgic activity in diverse regions of the world. Here, it is worth citing several illustrative examples. The Bronze Age site of Khirbat Hamra Ifdan, located near the Jordan river valley, is notable for the discovery of an estimated 5,000 tons of slag from smelting furnaces and bronze workshops. Similar discoveries of heaps with hundreds of tons of smelting by-products have been made at many other sites dating back thousands of years, including Kestel in Turkey. During the final phase of the Migration Period, the Danube region was home to many active metallurgical centers. Based on a fifth-century account by Rutilius Claudius Namatianus, Michael McCormick, a historian specializing in economic history, reported the presence of over a million tons of slag resulting from the metallurgical melting of galena in the Danube area.

Substantial waste was also generated by the centers of iron production in bloomeries from the period of Roman influence located in the area of the Świętokrzyskie Province in today's Poland. Their notable size caught attention in the early nineteenth century – they were described by the Polish Enlightenment-era philosopher and geologist Stanisław Staszic in 1805. In the interwar period, the metallurgical facilities in the Central Industrial Region purchased iron slag and delivered it in wagons. In the interwar period, iron slag from the fields in today's Świętokrzyskie Province was purchased from farmers at a rate of 10 zlotys per metric ton, to be used in the ironworks in Starachowice (Wierzbnik). The extent of the modern-era efforts to recover lead and zinc from slag heaps in the Olkusz area in the nineteenth century remains uncertain, but such efforts were undoubtedly

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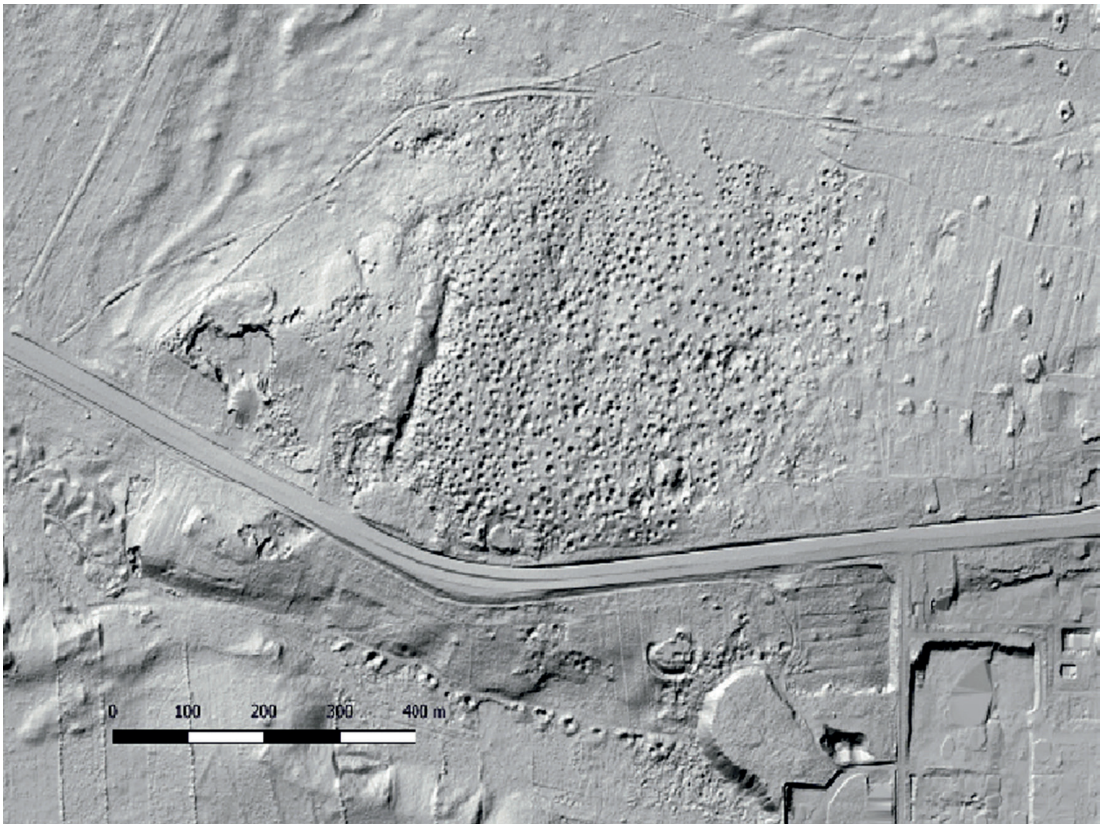
The small *gord* (early medieval fortified settlement) near Stary Olkusz, together with the relics of St. Andrew's Church from the fourteenth century. On the right, one can see the partially overgrown slag heap, encroaching upon the *gord*. Had it not been for an intervention, the historic site would likely have ended up buried beneath heaps of industrial waste



Lidar evidence of medieval and modern-day mining activity in the Stary Olkusz area

made. Slag was also used in Olkusz for paving streets and the town's central market square.

The digging of deep ore and coal mines brought about significant hydrological changes. The subsequent closure of these mines entailed some drastic consequences. First of all, over the span of two centuries, vast mine dumps and heaps were formed, potentially concealing archaeological sites. Good illustrations include the towering heap near the small *gord* (medieval fortified settlement) located west of the town. Had it not been for an intervention on the part of the conservation service, the remains of the historic medieval fortification would likely have ended up buried beneath heaps of industrial waste from the Olkusz mine.

Hidden evidence

Remnants of metallurgical activity are not always visible on the surface – chemical compounds resulting from such processes often persist in the soil. For this reason, soil analysis is a very good indicator of such processes. For example, let's imagine the following minerals were found in the surface layer of soil at a particular site: cerussite, lead oxides (litharge), as well as metallic lead, baryte, lechatelierite, aluminosilicates, and such lead phosphates as pyromorphite. The composition of contaminants of lead compounds in the soil alone can be used to determine if metallurgical processing of lead ores took place at the given site. In this case, litharge can only come from the processing of other lead compounds, primarily galena – lead sulfide. This is especially true as litharge was also the final product of smelting processes. Briquetted pieces of litharge were distributed widely as a component used to glaze ceramics and produce lead glass and even ointment to treat scabies. The findings of these analyses can be used in the search for bloomeries for silver and lead ore smelting. The substances found at a site are directly related to the historical smelting process. Chemical soil analyses and geophysical surveys are therefore useful in advance of traditional archeological excavation works, quite accurately identifying potential search areas.

Finally, it is necessary to address the legal aspect of environmental degradation. In modern times, we know (at least theoretically) what action can be taken by those seeking compensation for damaged houses, and against whom. However, the scenario becomes unclear for those who have unwittingly built their houses on environmental time-bombs from earlier epochs, even dating back to the very beginnings of medieval Polish history (the era of the Piast dynasty).

Study of industrial history offers fascinating and multifaceted insights. Both now and in the distant past, economic development has depended heavily on the mining and metallurgical sector – a relationship that is bound to continue far into the future. ■

Further reading:

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