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Characteristics of landscape features related to mining and metallurgy in the Olkusz region

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Introduction

Many centuries of mining in the Olkusz area degraded the natural landscape. Today this area is very diverse morphologically. In many places there are pits and ore heaps left from mining; the landscape feature most harmful to the environment is the flotation tailings heap in Bolesław (Cabała and Sutkowska 2006). In addition to heaps there are remains of older pits, mounds, hollows, tailings ponds, pit shafts, artificial water channels, large sand pits and other smaller features (Fig. 1). Local contamination by heavy metals is one of the main consequences of mining and smelting. Land relief, soil chemistry and groundwater levels shape the landscape, affect the development of vegetation types, and determine their floristic composition (Grodzińska and Szarek-Łukaszewska 2002; Nowak *et al*. 2011; Woch *et al*. 2014).

This chapter gives an overview of the most important surface features associated with past and present lead, zinc, silver and iron mining and metallurgy, and with sand quarrying, in the Olkusz region. The region includes areas historically associated with Olkusz, which today are within the municipalities of Bolesław, Bukowno, Jerzmanowice-Przeginia, Klucze, Pilica, Olkusz, Skała, Sławków, Sułoszowa, Wolbrom and Żarnowiec (Feliksik 2011).

Landscape features created by historical mining and smelting can be divided into three groups: (1) sites of ore extraction, usually with an open pit, sunken shafts and adits, accompanied by gangue slag heaps varying in metal content; (2) sites of ore treatment, selection, pre-processing and enrichment, characterised by accumulations of crushed ore and slag, generally of extremely high metal content; and (3) ore smelting sites, where furnaces and kilns were located and highly metal-contaminated slag and ore heaps accumulated. In places where smelters were very close to mines the composition of the substrate is very diverse, reflecting various production stages and yields of metals.

The dominant elements of the landscape surrounding Olkusz are three types of features associated with industrial activity: (1) mining and smelting waste heaps, (2) extensive open

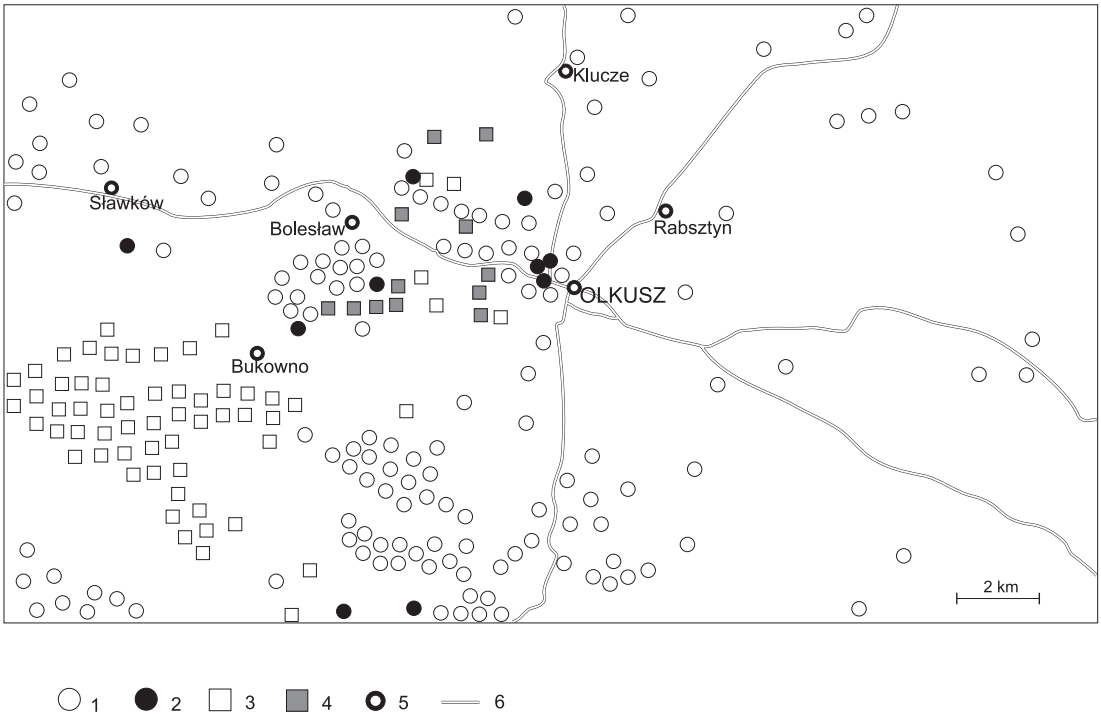

Fig. 1. Distribution of sites of deposit extraction and processing in Olkusz Ore-bearing Region. 1 – old heaps and quarries, 2 –major places of enrichment, roasting or smelting of ores, 3 – sand quarry pits, 4 – currently operating mining facilities, 5 – cities, 6 – main roads (M.W. Woch and U. Korzeniak)

Ryc. 1. Rozmieszczenie miejsc wydobycia i przetwórstwa kopalin na terenie Olkuskiego Okręgu Rudnego. 1 – warpie i kamieniołomy, 2 – ważniejsze miejsca wzbogacania, prażenia lub przetopu rud, 3 – piaskownie, 4 – nadal funkcjonujące obiekty górnicze, 5 – miasta, 6 – główne drogi (M.W. Woch i U. Korzeniak)

pits from sand quarrying, (3) smaller pits, quarries, zinc and lead mine drainage tunnels, and exploration shafts.

Traces of historical mining and metallurgy

The earliest extraction of metal ores is associated with shallow areas of residual Triassic metal formations (natural outcrops). The oldest relics of mining are in the Olkusz area and Sławków. Sławków's deposits were known and exploited before those in Olkusz, where the oldest mines were in Stary Olkusz (Godzik and Woch – Chapter 3, this volume). The village is associated with the oldest settlements in the region, which were miners' households (Kiryk 1978). Processing of ores, and trade, often developed in the vicinity of mines at that time (Malik 2005). Numerous medieval remains from lead and silver ore enrichment have been found in the vicinity of Hutki, Sławków, Strzemieszyce and Ząbkowice (Molenda 1972; Pietrzak 2004; Rybak 2004). Excavations in Stary Olkusz indicate that a functioning manufacturing settlement probably existed there in the Middle Ages (11th and 12th/13th centuries) (Rozmus 2010).

Up to the 16th century, mining developed mainly in the relatively small area of Sławków, Stary Olkusz and Starczynów; later industrial activity and urbanisation obliterated most of its traces, so the most valuable and least disturbed remnants of that activity are often far from city centres.

Heaps

The characteristic and most recognisable feature of the landscape surrounding Sławków and Olkusz, associated with ore reprocessing, consists of tailings reaching ca. 350 m a.s.l. (ca. 25 m above ground level) (Fig. 2), covering 110 ha (Sadzawicka 2005). Still adding to the heap is waste generated by the Bolesław Mining and Metallurgical Plant (ZGH Bolesław), which consolidated the *Bolesław* (closed in 1998), *Olkusz* (closed in 2003) and *Pomorzany* (still operating since 1974) mines (Liszka and Świć 2004). The landfill is a particular environmental hazard due to strong movement of dust on dry, windy days, and environmental pollution from groundwater leaking from it. Efforts to reclaim this area during the last century did not give satisfactory results. Vegetation was introduced directly on flotation sludge using high amounts of fertilisers but those plants did not survive even one growing season, due to high accumulation of metals in their tissues (Krzaklewski and Pietrzykowski 2002). Since 2008, fragments of turf with substrate from

Fig. 2. Flotation tailings heap of Bolesław Mining and Metallurgical Plant (ZGH Bolesław) in Bukowno (photo G. Szarek-Łukaszewska)

Ryc. 2. Hałda odpadów poflotacyjnych Zakładów Górniczo-Hutniczych Bolesław S.A. (ZGH Bolesław) w Bukownie (fot. G. Szarek-Łukaszewska)

other heaps colonised by spontaneous succession have been experimentally transplanted to the heaps (Szarek-Łukaszewska 2011). In some parts of the ore heaps, self-seeding plants are emerging.

Sand pits

The western part of the Olkusz region has extensive deposits of Quaternary sands. In the 20th century they began to be exploited for industry and construction on a large scale. The largest area (3100 ha) is occupied mostly by a reclaimed quarry of the Szczakowa sand company, reaching as far as Bukowno's eastern and southern parts (Skawina 1963; Raczyński 1992) (Fig. 3). Pits west and east of Olkusz near Bukowno and Pomorzany are still open. In the Olkusz area and Bukowno there are also a number of smaller pits, usually not exceeding 5 ha, usually covered with pine forest.

In the 1960s, when the sand had been fully exploited, years of reclamation began at the pits, aimed mainly at afforestation. First the excavation usually is leveled, then the surface is covered with soil taken from other deposits and fertilised. Legumes are sown first, mainly large-leaved lupine (*Lupinus polyphyllus*), followed by trees and shrubs. The reclaimed area is then handed over to the State Forestry Service, which later manages the area. The sand pits are cut by a system of ditches

Fig. 3. Planted *Pinus sylvestris* on the reclaimed *Pole Pomorzany* pit of the Szczakowa sand quarry in Olkusz (photo P. Kapusta)

Ryc. 3. Nasadzenia *Pinus sylvestris* na zrekultywowanym *Polu Pomorzany* Kopalni Piasku Szczakowa w Olkuszu (fot. P. Kapusta)

and drainage channels which contribute to drainage of the surrounding area (Skawina 1963; Raczyński 1992). In the Olkusz region the *Pole Bukowno* and *Dąbrówka* sand pits (total area 45.68 ha) have undergone reclamation (Sadzawicka 2005).

Many studies have shown, however, that leaving this type of pit without reclamation increases its habitat heterogeneity and in turn the diversity of spontaneously growing vegetation (Řehounková and Prach 2008; Mudrak *et al*. 2010; Tischew *et al*. 2013). Diverse psammophilous grasslands dominated by grey hair-grass (*Corynephorus canescens*) or bristly haircap moss (*Polytrichum piliferum*) grow on dry excavations. If the excavation reaches the aquifer, valuable natural peat and water communities are formed, which, along with wooded areas of diverse ages, spatial structure and species composition, create valuable natural areas (Woch 2007; Czylok and Szymczyk 2009). It has also been shown that unreclaimed excavations have a smaller share of neophytes but more rare and protected species (Woch 2007; Kirmer *et al*. 2008, Tomlinson *et al*. 2008; Tropek *et al*. 2010). The low fertility of such habitats promotes the growth of plants that are stress-tolerant but have weak competitive abilities, two features that usually characterise rare and protected species. This makes unreclaimed excavations an important element of nature protection (Marrs 1993; Tischew *et al*. 2013).

Other post-mining landscape features

One of the most interesting post-mining landscape features in the Olkusz area consists of small pit shafts left from lead, zinc, silver and iron mining; these pit shafts are ringed by rounded mounds of rock waste. A number of them are in beech and pine forests that were planted or else grew by spontaneous succession (Fig. 4). Forest-free features can be seen closer to villages and cities, in areas used for agriculture and industry. The second-largest mining centre in this region, next to Olkusz, was Sławków and its satellite settlements, including the then-village of Bolesław. Most traces of mining activity are preserved in very good condition there, despite the construction of ZGH Bolesław facilities in the 20th century. The historical Zn-Pb mining sites most valuable to naturalists and historians are concentrated in areas directly east, north and west of ZGH Bolesław.

Fig. 4. Post-mining relics in the vicinity of Galman, a former mining settlement, covered with pine forest (top) and beech forest (bottom) (photo A.M. Stefanowicz and M.W. Woch)

Ryc. 4. Relikty pogórnicze w okolicach dawnej osady górniczej Galman, porośnięte borem sosnowym (góra) i lasem bukowym (dół) (fot. A.M. Stefanowicz i M.W. Woch)

The degree of preservation of historical Zn-Pb mining sites is influenced by the length of time that has elapsed since their abandonment, erosion processes, and later human activity. Thus, sometimes the only evidence of mining activity is slightly uneven terrain or a patch of vegetation distinctly differing from its surroundings. The youngest and best-preserved historical Zn-Pb mining sites, such as deep pit shaft holes surrounded by a high rock heap, are fairly easy to recognise. The ones altered by erosion or later human activity can be identified from soil profiles, chemical analyses of material, x-raying, or classical archaeological excavations. Some remnants of opencast mining are often mistaken for old quarries or natural unevenness of the terrain.

In forests and agricultural areas, post-mining surface features are easy to identify not only by topography but also by the overgrowing plants. Such places are characterised by xerothermic conditions (dry substrate, high insolation) and are often rich in heavy metals. They contain valuable grassland communities (Nowak *et al*. 2011; Woch *et al*. 2014) (Fig. 5). When the deeper layers consist of impermeable substrate, such recesses are sometimes filled with water, forming small reservoirs.

The substrate of these historical Zn-Pb mining sites is usually porous soil with high calcium and magnesium content but often low nitrogen and phosphorus content. Calcium and magnesium originate from gangue dolomite (calcium magnesium carbonate, $CaMg\ [CO_3]_2$), while nitrogen and phosphorus originate from organic material, the amount of which depends on the duration of abandonment and the extent of vegetation development. A feature of these substrates that attracts naturalists is their high content of heavy metals, particularly lead and zinc, and also cadmium and thallium, which contributed to the emergence of the specific floras of these areas (Szarek-Łukaszewska and Grodzińska 2008, 2011; Stefanowicz *et al*. 2014; Woch *et al*. 2014).

A lot of information about the distribution of old pits is given on old maps made in the 17th and 18th centuries. Mines were inventoried and reactivated during this period. In other documentation, expert reports on the status of mining in Olkusz mention 400 sunken pit shafts. They also contain information about the location of five smelters and several mining areas (Molenda 1978). During the reign of Stanisław II August, a time of efforts at economic renewal, in 1769 Eisler Rensch made another mining map of Bolesław, Olkusz and Starczynów, on which 2000 sunken pit shafts are marked (Molenda 1978).

The *Aleksander* pit shaft, which operated even in the first half of the 20th century, is associated with the origins of the old waste heap in the southern part of Bolesław. Overburden that was removed to get to deposits with higher zinc content was dumped there. The vegetation growing on it today makes it one of the most valuable post-mining features. It is under partial protection as a Natura 2000 area (Szarek-Łukaszewska and Grodzińska 2008; Kapusta *et al*. 2010).

Near pits and ore extraction sites there are places often more contaminated with metals from ore processing and enrichment. The first step in that work was washing and processing of excavated material in scrubbers, the bottom of which was a water-impermeable layer of loam (Feliksik 2011). Places known as sites of this include Hutki, Parcze, Poniki, Pomorzany and Starczynów, and also Ujków and Bolesław near the *Ulisses* and *Krążek* mines and near the *Kozioł* mine near Sławków. Often the scrubbers were located near watercourses and adits, such as the Brodka which flowed from Stary Olkusz to Hutki, Warwas stream in Bukowno, the Ponik flowing from Pomorzany to Hutki,

Fig. 5. Post-mining relics left from the *Aleksander* mine in Bolesław, covered with xerothermic grassland (photo A.M. Stefanowicz and M.W. Woch)

Ryc. 5. Obiekty pogórnicze pozostałe po kopalni *Aleksander* w Bolesławiu porośnięte murawą kserotermiczną (fot. A.M. Stefanowicz i M.W. Woch)

the Sztoła river, the Białe Bagno in Ujków, and near Płoki at Kozi Bród brook (Cabała 2009; Feliksik 2011). The *Staroolkuska* scrubber operated in Stary Olkusz, and the biggest one was the *Józef* scrubber commissioned in the late 19th century in Pomorzany (Cabała 2009).

Beginning from the 16th century, drainage adits of significant size became part of the mining infrastructure. Five of them, with a total length of 32.5 km, were built in the Olkusz region: *Czajowska* (also called *Leśna*, built between 1564 and 1590), *Ostrowicka* (also called *Centauryjska*, built between 1566 and 1590), *Pilecka* (also called *Staroolkuska*, built between 1576 and 1615), *Ponikowska* (1563–1621) and *Starczynowska* (also called *Królewska*, 1548–1576) (Głowa *et al*. 2010). These are the biggest and most easily distinguished elements of the post-mining landscape. A large part of Olkusz and Pomorzany is still affected by the adit's impact (Cabała and Sutkowska 2006).

Opencast mine pits left after 20th-century exploitation of zinc-lead ores can be reclaimed under the relevant laws. According to data from the Bolesław Municipal Office (2005), the following landscape features have been reclaimed or are being afforested: the *Hałda Michalska* opencast (area 2.9 ha), settling ponds in Krzykawka (3.72 ha), the *Bolesław* opencast (6.8 ha), the area around the former *Józef* scrubber (8.3 ha), the *Krążek* opencast (7.5 ha), the Ujków-Północ excavation area (9.28 acres) and the *Hałda Galman* waste heap located near the *Bolesław* opencast (3.5 ha) (Sadzawicka 2005).

Fig. 6. Heap of material from the *Józef* mine in Czerna-Zakopane covered with a valuable xerothemic grassland (top) and during removal (bottom) (photo A.M. Stefanowicz and M.W. Woch)

Ryc. 6. Usypisko materiału z kopalni *Józef* w Czernej-Zakopane porośnięte wartościową murawą kserotermiczną (góra) i w trakcie rozbiórki (dół) (fot. A.M. Stefanowicz i M.W. Woch)

Many slag heaps and other landscape features left from mining and metallurgy have been obliterated by natural erosion, or when material from there is used for construction. Material from historical Zn-Pb mining sites has sometimes been used to make road beds and embankments, or else leveled. The vegetation cover of those places was destroyed. One example is the heap from the *Józef* mine in Czerna, which was removed and used for road construction in 2012. Earlier this heap was covered with valuable calamine grassland (Fig. 6).

Closing remarks

Knowledge about post-mining and post-smelting sites is important because they comprise the legacy of regional mining traditions and because they may endanger people's health. Local knowledge of the majority of the landscape features formed during the thousand-year mining history of the Olkusz region is quickly forgotten. Research on 19th- and 20th-century mining in the United States has shown that such knowledge fades very quickly, leaving gaps in the data on locations of sites contaminated with heavy metals; this poses a threat to human health because farming is often done in those areas later (Eckel *et al.* 2001, 2002). For safety reasons there needs to be continuous documentation of those places.

It is increasingly recognised that landscape features remaining after mining and industry are testimony to civilisational development and regional traditions, and that they have

important roles to play in education and conservation. The greater habitat diversity of many of these places has led to the creation of unique phytocoenotic systems which emerge spontaneously or which constitute secondary habitats for rare and protected plant and animal species (Grodzińska and Szarek-Łukaszewska 2002; Woch 2007; Řehounková and Prach 2008; Kowolik *et al*. 2010; Mudrak *et al*. 2010; Tischew *et al*. 2013). That is why various post-industrial areas around the world are protected as designated Sites of Special Scientific Interest (SSSI) or Urban Nature Parks (UNP) (Tokarska-Guzik 2000). Laws that have been in force in Poland for a long time allow such landscape features to be placed under legal protection, as in Germany, where calamine grasslands are protected in this way (Heibel 1999).

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