

Mining activity as an important factor of human impact in the Polish Carpathian landscape

Barbara Radwanek-Bąk*

Polish part of the Carpathians occupies about 6% of the territory of Poland. Some of specific features of this region are: diversified morphology with predominating mountain landscape, its geology and numerous areas of high value landscape which are under various forms of protection. This caused, that all forms of anthropopression develop here more intensive as in the other parts of the country. Main negative changes resulting from the mining activity are connected with its impact on superficial, phreatic and underground waters and on a landscape. Some of this changes are briefly described in the presented paper.

Reduction of negative effects of the landscape transformation by open-pit mining in the scale of individual deposit might be temporarily achieved by:

- adequate formation of suitable scarps,
- reclaiming of the post-exploitation terrains,
- secure of the mined areas for transformation in the uncontrolled refuse heaps.

A method to reduction negative effects of mining activity in terms of sustainable landscape planning is working out by the complex strategy of ultimate management of mined terrains. Such strategy should be elaborated for the entire regions of the deposits and then for the individual deposits, best before its mining. The strategy should be a compromise between the extent and manner of the planned exploitation and the state of environment which will be left after finish of the mining activity.

Key words: Polish Carpathians, human activity, mining, landscape, protection, preventive measures

Introduction

Polish part of the Carpathians occupies 18,900 km² which is about 6% of the territory of Poland. Specific features of this region are as follows:

- diversified terrain morphology with predominating mountain landscape,
- numerous areas of high value of landscape which are under various forms of protection,
- relatively small industrialisation when compared with other regions,
- lack of large agglomerations yet high density of rural build-up,

*Polish Geological Institute, Carpathian Branch,
ul. Skrzatów 1, 31-560 Kraków, Poland

— small mineral resources which comprise: mineral and thermal waters, a number of small crude oil and natural gas fields, and common mineral resources (sandstones, ceramic clays and natural aggregates) that are excavated or quarried.

Building and road stone deposits, sandstones mainly, occur in the entire Carpathians and usually occupy small areas, 25% of deposits have resources smaller than 500,000 tonnes, and only 1% has resources exceeding 100 million tonnes (Radwanek-Bąk, 1996).

Ceramic clays occur also in the whole discussed terrain, yet in this group of raw materials, a number of small deposition sites is even higher. Surrounding of Nowy Sącz is an exceptional region where the deposition sites are highly clustered and are intensively exploited.

Deposits of natural aggregates are mainly located in narrow river valleys of: Soła, Skawa, Raba, Dunajec, Wiśloka, San and their tributaries. These deposits are related to Quaternary terrace sediments.

Crude oil fields occur chiefly in the eastern part of the Polish Carpathians (east of Gorlice) and are related, first of all, to the deposits of the Silesian Unit. Natural gas accompanies some crude oil fields or forms separate small fields scattered in the entire area of the Carpathians, including their western part.

At present, therapeutic and thermal waters are the most important mineral resources of the Carpathians. In the Outer Carpathians two main types occur: chloride waters belonging to the Carpathian brine province and acidic carbonate waters. The first type occurs in health resorts in Rabka, Iwonicz, Rymanów where they are exploited as well as in Sól near Żywiec, where they remain untapped. The second type occurs in Poprad (i.a. in health resorts Piwniczna Zdrój, Muszyna, Krynica, Szczawnica), as well as in Iwonicz and Bieszczady regions. In the Inner Carpathian region thermal, weakly mineralized, mainly sulphuric waters predominate.

In case of exploitation of crude oil and natural gas (by drilling wells, in a small scale), the human impact manifests in landscape changes by presence of drilling appliances, drilling, pumps and oil pipes. Effect of that is a transient change in a valuable view, yet without alteration of terrain morphology, and a temporary loss of agricultural property.

Landscape consequences resulting from exploitation of mineral and thermal waters are directly associated with management of these waters, and indirectly with rising a whole infrastructure for a health resort. In a scale of the discussed region these are significant changes as they comprise several resorts, including a few hundred sanatory buildings and balneologic treatment centres which are usually massive housing complexes and which differ from a rural housing by their architectural style.

Landscape changes resulting from mining are chiefly associated with stripping of raw materials and belong to

more important alteration of natural environment caused by this kind of anthropopression (Radwanek-Bąk, 1998).

Open-pit mining and quarrying brings about a permanent alteration of the terrain morphology, necessity of deforestation or temporary loss of agricultural potential, and as a result a change in landscape value (Chwastek, 1983). Landscape transformation due to mining undergoes in two phases; the first phase refers to dissection of a bed and its exploitation, the second phase — reclaiming of exploited terrains. It is illustrated by the scheme in Tab. 1.

More serious landscape changes in the Polish Carpathians are associated with exploitation of building and road stones, especially in several large and medium size quarries. Because of relief and geologic structure majority of the Carpathian quarries are established at hill slopes. They are usually located within forest complexes or at their border with agricultural land. Due to exploitation, the terrain is deforested, an artificial rock exposure comes into being and then rock material is taken away. Such sites are well visible even from a distant place (e.g. quarry in Klęczany, Osielec, Kozy, Barwałd, Tenczyn Górny — Fig. 1). This type of landscape degradation is sometimes amplified by a presence of dumps of tailings (e.g. in Klęczany near Nowy Sącz, or in Głębiec near Bielsko-Biała — Fig. 2).

In majority the quarries discarded in the past were not reclaimed or reclaimed only fragmentarily by protecting the scarps against fall offs and eventually by fencing. A typical reclaiming practice, declared preliminary in the prefeasibility studies, was afforestation. Such direction seems not to be proper for many of sandstone open-pits. In fact it was not realized in most of abandoned quarries, but it was revealed to natural shrub regrowth and succession.

In case of small quarries, mining activity induced changes disappear in a few years after termination of activity. It might be observed in the quarries that have not been working for years and where reclaiming has not been practiced (e.g. Frycowa near Nowy Sącz, Sobolów near Bochnia). A rate and efficiency of natural processes are controlled by lithology of sandstone and number of shale bands (Uberman, 1988). In the quarries with large and steep walls built of thick-bedded massive sandstones and (or) with a small number of shale bands this recovery goes with difficulty. For example, inactive walls of the quarry Tokarzędka in Brenna village which are overgrown with bushes and small trees, are easy to identify in the field, although 20 years passed since exploitation has terminated there (Fig. 3). Thus, such excavations are not well-suited for afforestation. When planning their recultivation, another approach should be considered, e.g. some walls might be converted in documentary geosites or in climbing walls (Kociszewska-Musiał et al., 1988).

Because of a size of the altered landscape, long-lasting exploitation and its magnitude, large excavations result in

Tab. 1. Alteration of landscape associated with open-pit mining

Type of changes	1st phase — exploitation	2nd phase — reclamation
Alteration of terrain morphology	<ul style="list-style-type: none"> ● redeposition of the overburden and removal of exploited raw material from the deposit ● raising infrastructure associated with stripping and processing plant 	<ul style="list-style-type: none"> ● formation of suitable scarps ● partial or full filling of mined places ● setting up water reservoirs ● partial disassembly of mining infrastructure ● raising a new infrastructure
Deforestation	<ul style="list-style-type: none"> ● tree clearing from the stripping ● deforestation related to infrastructure set-up 	<ul style="list-style-type: none"> ● afforestation of dumps and strippings
Changes in land use	<ul style="list-style-type: none"> ● excluding farmland from cultivation 	<ul style="list-style-type: none"> ● partial land reclamation ● introduction of a new use
Changes in landscape values	<ul style="list-style-type: none"> ● depletion 	<ul style="list-style-type: none"> ● depletion or enrichment

farther-reaching terrain degradation and require a bigger concern and higher investments to offset the environmental damage. In this case, very important becomes a concept of a sustainable management of the deposit site. Such a concept should consider needs and possibilities of an after-exploitation usage of the terrain. An example of the deposit where one managed to avoid a negative alteration of landscape is a large, multi-level quarry Wierchomla, near Nowy Sącz (Fig. 4). The exploitation started in 1954 and has been lasting until now. The method used in the quarry is blasting. In the past, the yearly yield was exceeding even $600\text{--}800 \times 10^3$ Mg, while currently it is limited to $150\text{--}200 \times 10^3$ Mg. The range of blasting zone has been limited by their reduced frequency of blasts and smaller loads. The obtained raw material is used in road building.

The discussed sandstone deposit is within the range of the Poprad Landscape Park, in a forested area, close to the health resorts of Piwniczna Zdrój and Żegiestów Zdrój. It occupies a summit and slopes of a forested hill (650 m a.s.l.) rising above the road Nowy Sącz–Krynica near settlement Wierchomla (Fig. 5). Along 30 km the road follows a course of the Poprad, the boundary river between Poland and Slovakia. The quarry is located so as it is visible neither from the road nor from majority of hills in the surroundings. Its presence and arduousness is known to the visitors by boards warning about danger zones related to blasting. The outlook onto the quarry is from the ridge at its western side, along of the Wierchomlanka stream, being a tributary of the Poprad, and from a local road leading to Wierchomla village. The floor of excavations is above the Wierchomlanka stream and the Poprad river, which determine the ground water level.

Owing to a closed, armchair pattern of particular excavations, emphasized by a layout of outer dumps, and to a regular arrangement of particular exploitation levels, this quarry may be an enriching element of the landscape. In order to reduce the area altered by mining, a manufacturing plant is located at the rim of the second working floor while tailings are stored in the internal dump at the first, lower, working floor. A current reclamation of the existing dumps is carried out by afforestation. The latter supports stabilization which is very important as the dumps are located along the banks of a mountain stream as well as restoration of vegetation which camouflages the presence of the stripping. Because the deposit is located within the landscape park, deforestation is limited to minimum. For a few years (when the upper working floor was open) forests have not been cleared, because excavation works are being done within the range of the formed quarry. As a stand of seed trees occurs in the upper, north-eastern summit part of the discussed hill



Fig. 1. The view on the Tenczyn Górny quarry in Beskidy Mts. All photos by Bogusław Bąk

Fig. 2. The dump of tailings which enter to the forest — by Głębiec mine near Bielsko-Biała

Fig. 3. Inactive wall at the Tokarzówka quarry near Bielsko-Biała

Fig. 4. The Wierchomla quarry near Nowy Sącz and surrounding forest

and on the reason of landscape protection, it has been accepted that farther exploitation of the deposit eastward should not extend beyond the ridge line. The changes in landscape, although non-renewable, will not deplete landscape value as it had been attempted to evidence. Other negative influences of exploitation on the environment have also been reduced. A planned reclaiming practice in this quarry is afforestation. Protection banks, existing at all levels, will be used to initiate reclamation work.

Although the deposit causes many disputes and is arduous for a local community, its exploitation should be continued. The above is in agreement with a principle of sound environmental management and in agreement with the Nature Protection Act, including the one on protection of non-renewable resources. The above is upheld by economic premisses — mainly a high capital investment on rendering and handling the deposit as well as an attempt to satisfy a regional demand on road stones. Social aspects are

also important as the quarry has been providing jobs for a group of inhabitants living near-by. An alternative solution — termination of exploitation of the deposit and rendering of a new one in another locality is unfavourable from the environmental point of view and economically ill-grounded.

Exploitation of brick clays brings about similar issues, yet the scale and intensity is generally smaller than in the case of building and road stones (Fig. 6). As such clays often occur in cultivated regions, their environmental effect is a temporary stopping of farming practices. Alteration of a terrain morphology is not so extensive because of a smaller size of excavation sites. The changes are more pronounced where multi-level slope excavations are set (e.g. deposits of Biecz, Żółków, Biezdziadka, Biegonice) and less pronounced where the deposit is exploited by tiny deep-seated excavations. Large, deep-seated excavations, where exploitation hazards are mainly related to a lowering of a groundwater table (e.g. deposit in Sobniów near Jasło) are rare. A typical

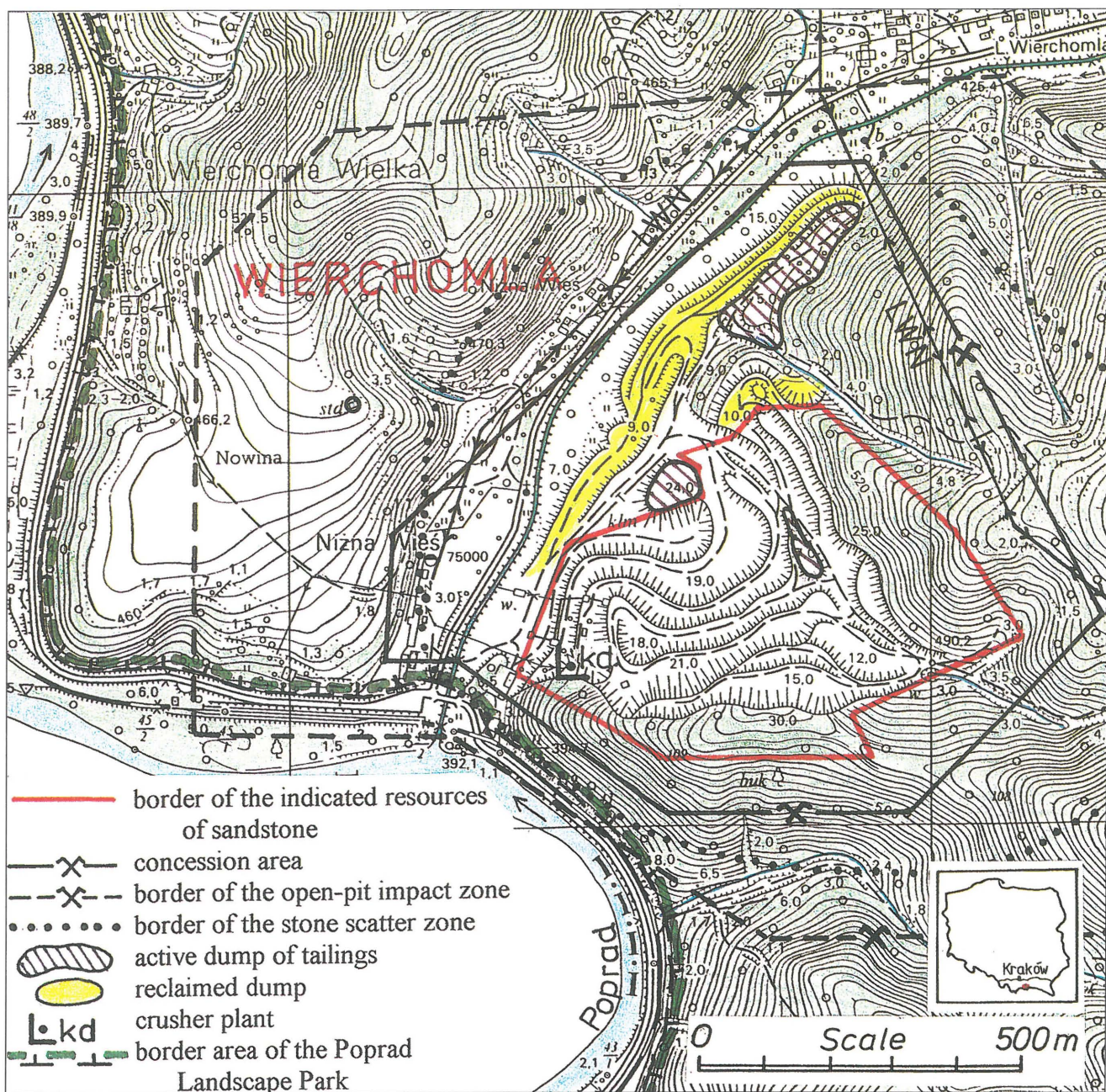


Fig. 5. Location sketch of Magura Sandstone deposit Wierchomla

problem in the case of clay excavation sites is a threat of surface mass movements. Their development may lead to changes in terrain configuration in a large scale, may be hazardous to exploitation process and hinder reclamation works.

It should be emphasized that the deposits of clay raw materials where exploitation has been finished are much better reclaimed than exploited deposits of other materials. Agricultural restoration is a predominating direction in reclaiming. Communal restoration, i.e. converting of abandoned excavation sites in refuse heaps (e.g. Żywiec, Zawada near Nowy Sącz), which is hold up by geological structure of numerous deposits and by a bedrock character, is a rarer practice.

Another type of visible landscape changes related to excavating in the Carpathians is associated with an intensive exploitation of natural aggregates deposits that concentrates in narrow river valleys. A peculiar case is the exploitation of aggregates in localities where water reservoirs are planned. There, intensive exploitation is strongly supported by economy (obtaining of large amounts of natural aggregates from a singular site, increase in a volume of a planned reservoir etc.) and by protection policy of raw materials due to a full utilization of a given resource prior to the investment works. The obtained material should be used both to rise hydrotechnical constructions and to satisfy local and regional demands. In this case, the landscape alteration is treated as a secondary and temporary issue, yet the range of it should be adapt to the modification associated with the planned water reservoirs (Fig. 7). Under Polish conditions, because of a very long time of investment (even up to several tens of years), excavation practices are not synchronic and usually precede reservoir constructing for many years. Numerous preliminary projects of the 1960s and 1970s have not been executed until now and it is not certain whether they will be realised and when. Meanwhile, deposits of aggregates have been exploited in uncontrolled way and without any reclamation practices in majority of these terrains for many years. Examples might be here the terrains of the planned reservoirs on the San river or the Jasiołka river. In users opinion, the planned constructing of the reservoirs is a satisfactory excuse for an unsustain aggregates exploitation.

Intensive exploitation of the natural aggregates contributes to the landscape degradation also in other sections of the rivers: e.g. Jasiołka and Ropa near Krosno.

Such exploitation was often carried out wastefully and without any licence. It brings in effect damaged and non-reclaimed terrains which are often converted in waste land or local wild dust-heap (Fig. 8). Moreover, such exploitation brings numerous hazards to the environment, among which the most dangerous are related to changes in surface runoff and to formation of terrains susceptible to flooding which often happens in mountain terrains. What is more, such exploitation is in contradiction to a reasonable management of the resources and their protection, because chaotic charakter of excavation works, which increase losses of the mineable reserves.

The exploitation of natural aggregates from the Dunajec river near Stary Sącz (Fig. 9) has an especially large extent.



Fig. 6. One of typical Carpathian small brick clays open-pits (Olszanica near Lesko in east part of Polish Carpathians)



Fig. 7. Natural aggregates excavation in the area of Czorsztyn water reservoir



Fig. 8. A gloomy example — transformation of the abandoned mining area into the uncontrolled refuse heaps (Dunajec river valley)

Numerous deposits of a high quality of aggregates have been proven here. Out of a vast area (several dozen hectares) under excavation practices, only 10% have been reclaimed and converted in rest areas. The remaining terrain is unmanaged and subjected to a natural overgrowing with vegetation.

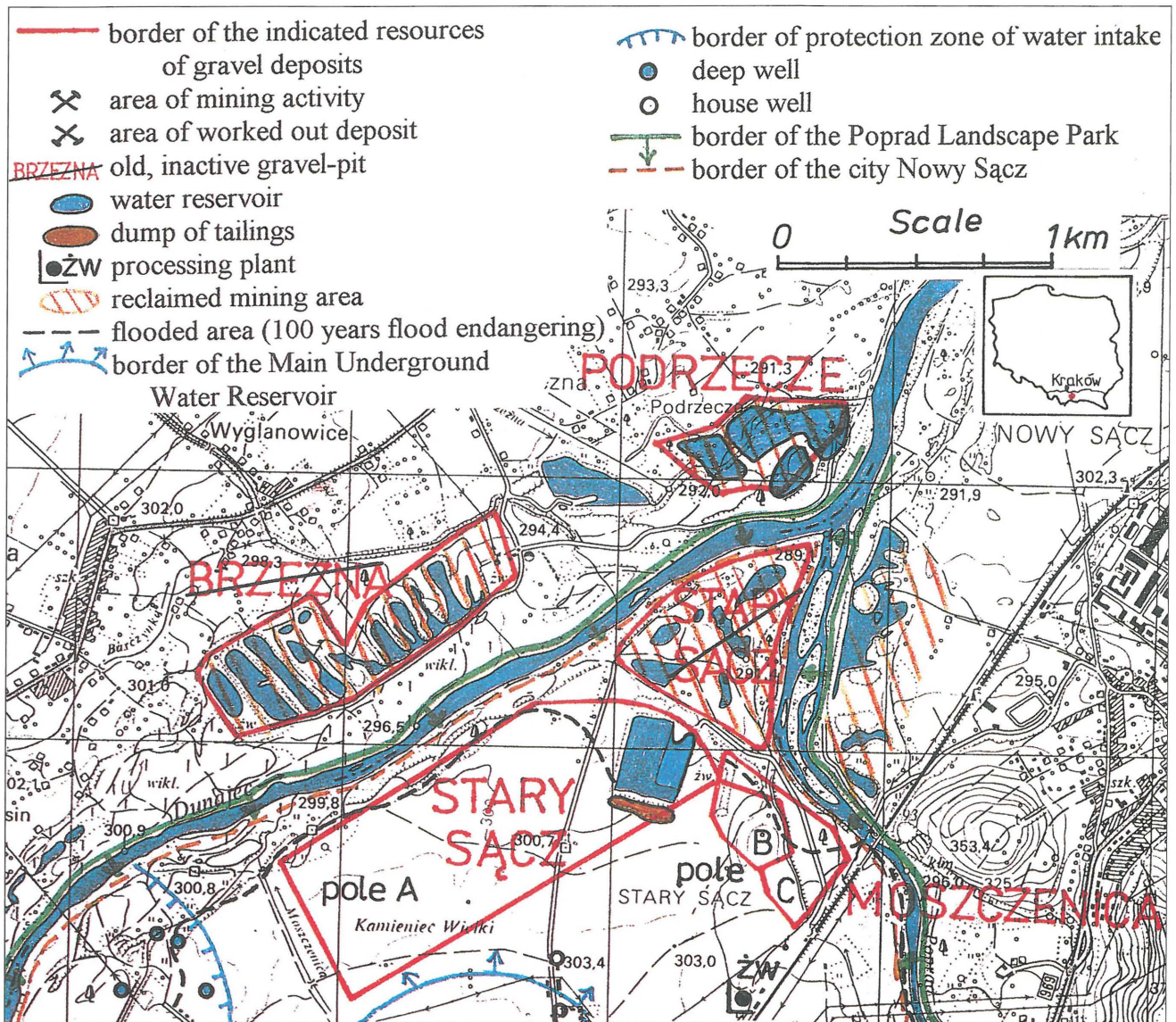


Fig. 9. Location sketch of natural aggregate deposits on the Dunajec river terraces

Fortunately, in the surrounding of Stary Sącz one succeeded to avoid the converting of the old excavation sites in uncontrolled dumping yards as it happens in other places.

In the regions of the intensive, progressing exploitation of aggregates it is necessary to determine a threshold clustering of excavation sites for protecting surface and groundwater as well as to work out a complex strategy for management of the after-exploitation terrains which would include a landscape planning. The reclaiming aspect is very important in many regions of the Carpathians because of a specific worth of the nature and unique cultural values. Such strategy should be worked out by a team of experts in the fields of geology, mining, ecology and landscape planning prior to exploitation. Stages of exploitation of the deposits and their reclaiming should conform to this strategy. In the areas that are being exploited, the adequate strategy should synchronize activities aiming at reclaiming the mined terrains. This would also help to direct the new mining activity towards sustainable practices. Local authorities and concession offi-

ces should be given a priority role in control and adequate execution of the adopted strategy. The above is expected to succeed due to changes of domestic administration and related to it, shift of decision making to a district (powiat) level. This new administration unit because of its extend, seems to be best suited for environmental management in that scale.

References

- CHWASTEK J. 1983 — Wpływ eksploatacji surowców mineralnych na środowisko. Wszechnica PAN, Ossolineum.
- KOCISZEWSKA-MUSIAŁ G., BARTOCHA E. & KISIELNICKA D. 1988 — Gospodarcze wykorzystanie wyrobisk. *Prz. Geol.*, 36: 531–533.
- RADWANEK-BAK B. 1996 — Building stones and other material deposits in the Carpathians and the Silesian-Cracovian region. [In:] *Building stones in Poland*. Państw. Inst. Geol., Warszawa.
- RADWANEK-BAK B. 1998 — Wpływ działalności górniczej na środowisko naturalne Karpat. *Gór. Odkryw.*, 40: 201–214.
- UBERMAN R. 1988 — Techniczno-technologiczne czynniki eksploatacji odkrywkowej złóż i ich związek z ukształtowaniem środowiska terenów górniczych. *Zesz. Nauk. AGH. 1222 Sozol.*, 26: 37–51.