

# Identification of Social and Environmental Conflicts Resulting from Open-Cast Mining

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**Abstract.** Open-cast mining is related to interference in the natural environment. It also affects human health and quality of life. This influence is, among others, dependent on the type of extracted materials, size of deposit, methods of mining and mineral processing, as well as, equally important, sensitivity of the environment within which mining is planned. The negative effects of mining include deformations of land surface or contamination of soils, air and water. What is more, in many cases, mining for minerals leads to clearing of housing and transport infrastructures located within the mining area, a decrease in values of the properties in the immediate vicinity of a deposit, and an increase in stress levels in local residents exposed to noise. The awareness of negative consequences of taking up open-cast mining activity leads to conflicts between a mining entrepreneur and self-government authorities, society or non-government organisations. The article attempts to identify potential social and environmental conflicts that may occur in relation to a planned mining activity. The results of the analyses were interpreted with respect to the deposits which were or have been mined. That enabled one to determine which facilities exclude mineral mining and which allow it. The research took the non-energy mineral resources into consideration which are included in the group of solid minerals located in one of the districts of Lower Silesian Province (SW Poland). The spatial analyses used the tools available in the geographical information systems

## 1. Introduction

Open-cast mining is the source of different advantages as it satisfies needs for raw materials on the national and regional levels (among others, this concerns energy mineral resources) as well as a local level (rock raw materials). It also creates jobs in mining facilities and contributes to economic activation of the region [4]. On the other hand, it can also plant the seeds for environmental conflicts resulting from the location of deposits within legally protected, forest areas or the ones which hold soils of high valuation classes as well as surface and ground water, and social conflicts, when the results of taking up the activity affect a local community residing within or near the future investment [1, 5].

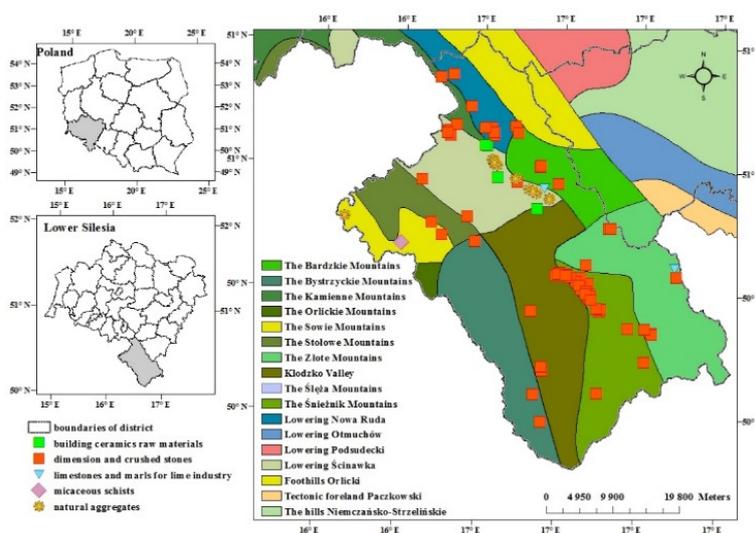
The article identified possible environmental and social conflicts resulting from an open-cast mining activity. The analyses using the selected tools of geographical information systems (GIS) were conducted by taking into consideration seasonally or permanently exploited deposits, initially recognized ones or deposits documented in detail, as well as abandoned deposits. All the analysed



mineral deposits fall within the group of solid minerals providing raw materials for, among others: the building of road and rail infrastructure (sand, gravel, crushed-stone aggregate, cobblestone, flagstone, kerbstone) and housing (sand, gravel, blocks, panels, wall stones). This group of minerals includes loamy raw materials (bentonite, clay, loam), chip materials (sand, gravel) and solid materials (amphibolite, basalt, dolomite, gabbro, gneiss, granodiorite, mica schist, marble, melaphyre, sandstone, and limestone). One of the greater concentrations of these minerals is located within Lower Silesia.

## 2. Description of the research area

Klodzko district, featuring natural, holiday and sightseeing values and located within the area of the Eastern and Central Sudetes, in the south-western part of Lower Silesian province, was selected for the analyses. The district has got a well-developed drainage system, as well as road and rail networks. With regard to its diversified geological formation, the district is affluent in mineral resources applied in power, chemical, building, road and railway industries [8]. **Figure 1** shows the location of the analysed district against Poland and Lower Silesian province. Within the area of the district, there are 66 deposits of rock raw materials including 17 permanently exploited deposits, 10 seasonally exploited deposits, 5 initially recognised deposits, 19 deposits documented in detail, and 15 abandoned deposits.



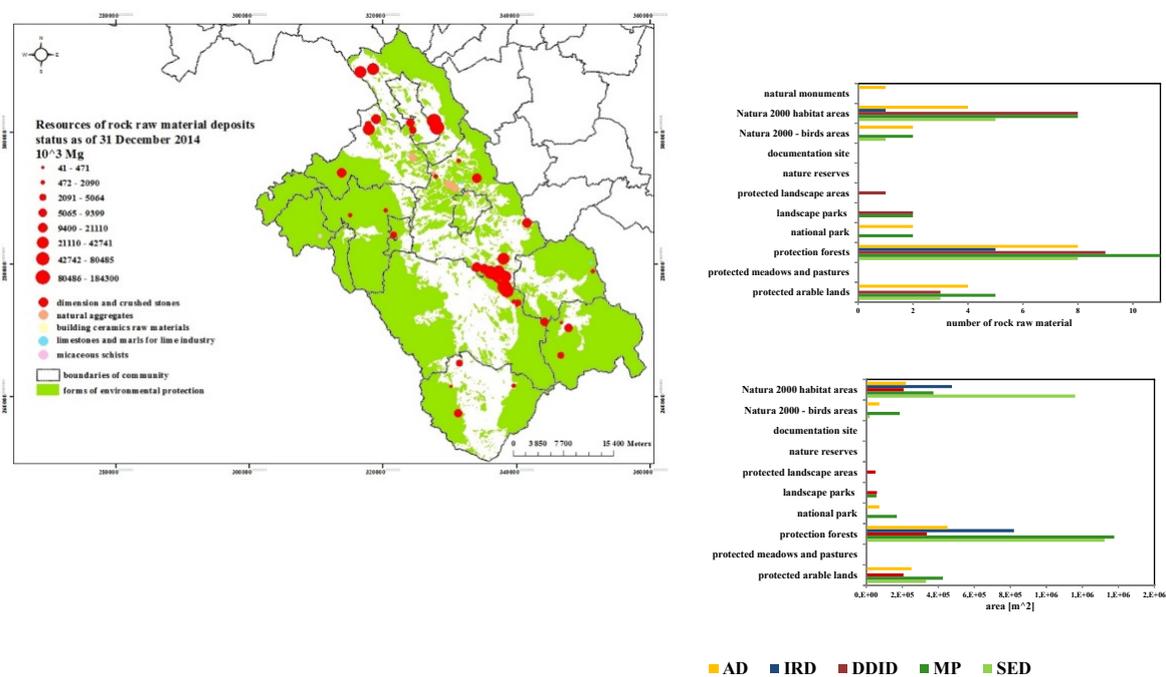
**Figure 1.** The location of deposits of rock raw materials in Klodzko district against the physical and geographical division according to Kondracki [3]

## 3. Identification conflicts resulting from open-cast mining in Klodzko district

In the article, the identification of social and environmental conflicts resulting from open-cast mining of rock raw material deposits in Klodzko district was carried out by means of the selected tools available in GIS systems. The first step was creating a geobase with input data needed for further analyses. Input geospatial data were obtained from the Polish National Geological Institute (mesoregions, major groundwater reservoirs and deposit boundaries: status as of 31 December 2015), the General Directorate of Environmental Protection (national parks, landscape parks, nature and landscape complexes, nature reserves, documentation sites, ecological sites, natural monuments and Natura 2000 areas) and Voivodeship Surveying and Mapping Resource Centre in Wrocław (administrative division, protected arable land, protected pastures and meadows, protection forests, built-up areas covering residential buildings, public utility facilities, industrial facilities and other, drainage system, and floodplains). The data were obtained in ETRS89/Poland CS92 coordinate system.

### 3.1 Forms of environmental protection

With regard to the attractiveness of Klodzko Land, its vast areas have been covered with different forms of environmental protection. It was calculated that the analysed forms of protection constitute 64.5% of the district's area and that causes quite considerable ecological restrictions concerning, for instance, an open-cast mining activity, which may result in difficulties in mining and production of rock raw materials from deposits located within the protected areas. Figure 2 shows a range of the analysed forms of protection. In Klodzko district, the following forms of environmental protection were identified: national park (1), landscape parks (2), protected landscape areas (2), nature reserves (7), documentation site (1), Natura 2000 areas (20), natural monuments (312), protection forests as well as protected meadows, pastures and arable lands. After identification and grouping of all forms of environmental protection, the location of rock raw material deposits was analysed in connection with the forms. Below, one can find the resultant map (**Figure 2a**) together with charts showing the number (**Figure 2b**) and area of the deposits (**Figure 2c**) located in the particular forms of protection.



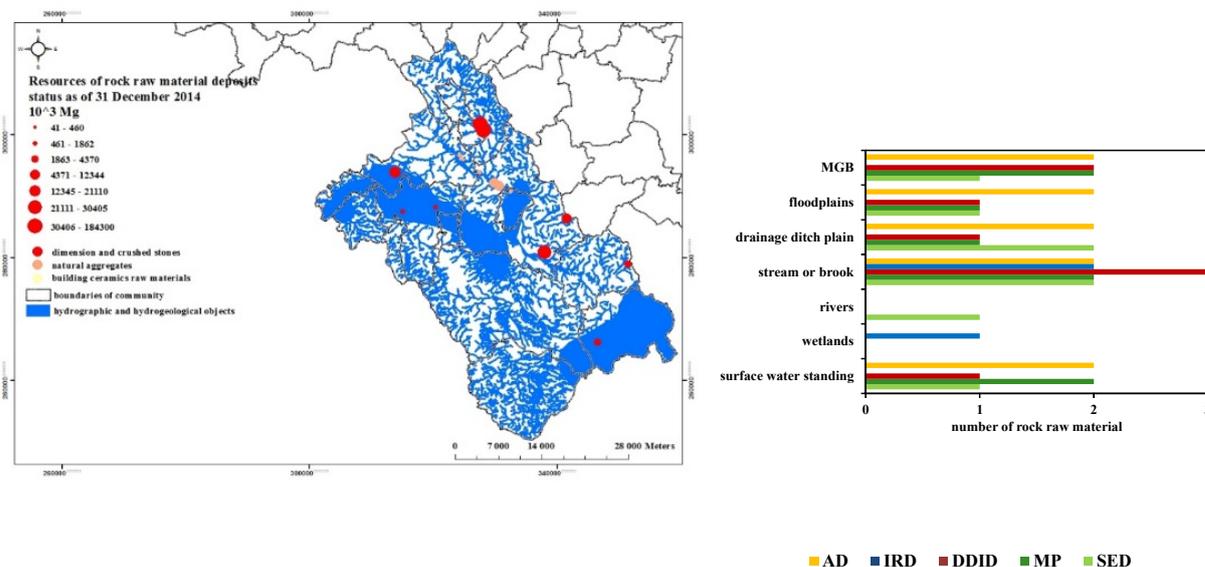
**Figure 2** Spatial location of the forms of environmental protection occurring in Klodzko district including rock raw material deposits (a), number (b) and area (c) of rock raw material deposits located within the analysed forms of environmental protection in Klodzko district (where: AD – abandoned deposit, IRD – initially recognised deposits, DDID – deposit documented in detail, MP – mined deposits, SED – seasonally exploited deposits)

The analyses showed that within the protected areas, mining of rock raw materials takes place in case of 27 deposits, including 10 seasonally exploited deposits, and 17 permanently mined deposits. The most permanently and seasonally mined deposits concern dimension and crushed stones (19) and gravel aggregates (6) as well as there are loamy raw materials for building ceramics, and mica schist, one deposit each. These deposits are mined in Stołowe Mountains National Park (Radków sandstone deposit), Śnieżnik Landscape Park (Lutynia basalt deposit and Nowa Wieś gneiss deposit), within Natura 2000 birds and habitats areas, in protection forests and protected arable lands. This means that the protected areas enable one to mine in compliance with proper technologies and protection principles resulting from legal regulations concerning mining for rock raw material deposits. This offers a possibility of future exploitation of undeveloped deposits located within the protected areas. In the analysed case, there were 5 initially recognised deposits of dimension and crushed stones with the

resources of 128091 thousand Mg and 11 deposits of dimension and crushed stones with the resources of 63670 thousand Mg; 3 deposits of natural aggregates with the resources of 2546 thousand Mg, and 2 deposits of limestone and marl for the limestone industry documented in detail.

### 3.2 Hydrography and hydrogeology

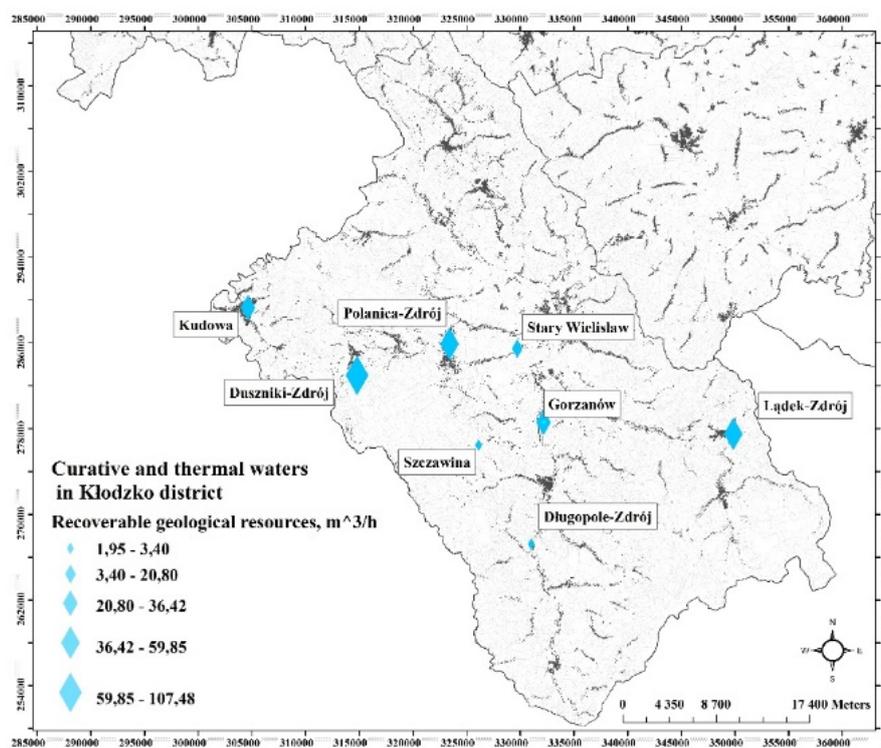
In the next step, hydrographic and hydrogeological objects located within the area of Klodzko district were identified. 96 % of the analysed district falls within the Odra River basin and the Baltic Sea watershed region where the main river is Nysa Klodzka. This river, together with its tributaries (Ścinawka, Bystrzyca, Bystrzyca Dusznicka and Biała Łądecka), is of great importance in the water management since it is a source of drinking water for the city of Wrocław. In the area of the district, there are three undocumented major groundwater reservoirs (no. 341 Intra-Sudetic Basin Kudowa-Bystrzyca, no. 339 Śnieżnik-Góry Białskie Reservoir and no. 340 buried valley of the Nysa Klodzka River) [6, 7]. During the analysis showing the environmental conflicts concerning the location of the deposits in the close proximity to (buffer considering the width of rivers, streams and creeks up to 5 m) the hydrogeological and hydrographic objects occurring within the area of Klodzko district, the results shown in **Figure 3** were obtained. The discussed objects hold 21 rock raw material deposits, including 9 deposits of dimension and crushed stones with the resources of 440,536,000 Mg including 4 permanently and seasonally mined deposits (gabbro, basalt and sandstone deposits), and 3 deposits recognised initially and in detail (granodiorite and marble deposits); 11 deposits of natural aggregates with the resources of 21,918,000 Mg including 5 deposits mined permanently and seasonally, and 3 deposits documented in detail as well as one deposit of loamy raw materials for building ceramics which has been abandoned with the resources of 1,759,000 m<sup>3</sup>.



**Figure 3** Location of rock raw material deposits in the hydrographic and hydrogeological objects in Klodzko district

Kludzko district is one of the biggest in Poland with regard to the resources of curative groundwater (it constitutes 25% of the resources of national mineral water). Within the described area, these are mineral or poorly mineralized waters (bath and drinking waters) with the following types [6, 7]: Polanica Zdrój area (sorrels and carbonic acid waters HCO<sub>3</sub>-Ca), Długopole-Zdrój area (sorrels and carbonic acid waters HCO<sub>3</sub>-Ca-Mg-Na, Fe, Rn), Szczawina area (sorrels and carbonic acid waters

HCO<sub>3</sub>-Ca-Mg-Na, Fe, Rn), Kudowa-Zdrój area (sorrels and carbonic acid waters HCO<sub>3</sub>-Na-Ca, Fe, As, S, B), Jeleniów area (sorrels and carbonic acid waters HCO<sub>3</sub>-Ca-Na-Mg, Fe) and Łądek-Zdrój area (thermal waters S, F, Rn). Figure 4 presents the location of the deposits of curative and thermal waters of Kłodzko district including their recoverable geological resources in place.

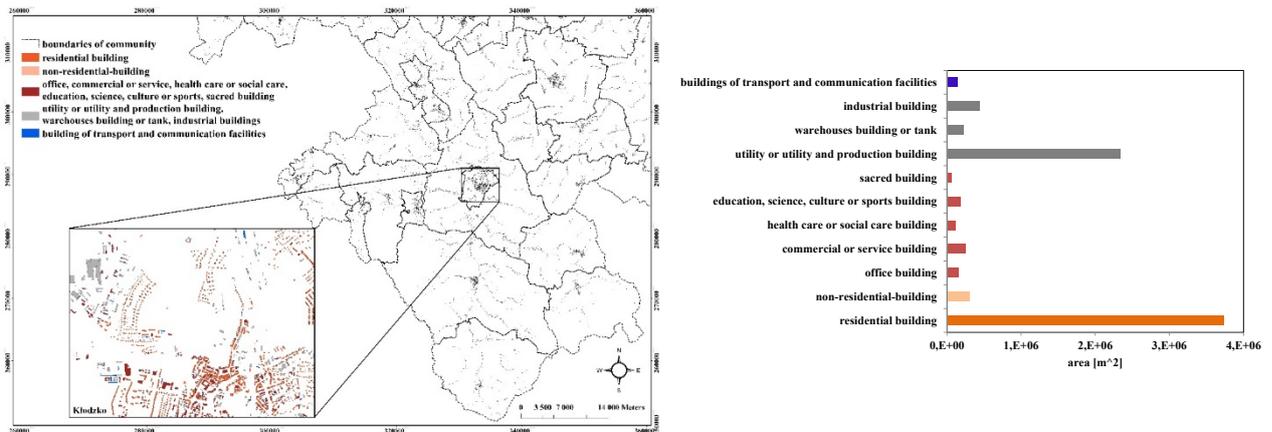


**Figure 4** Location of curative and thermal waters in Kłodzko district

When analysing the conflict that may result from the location of the objects in the vicinity or in place of rock raw mineral deposits, the impact of the discussed deposits' neighbouring of the deposits of curative and thermal waters was assessed. A limestone deposit is located within the area confining one of the deposits (Łądek-Zdrój), which is recognised in detail (unexploited). Within the radius of up to 500 m from four deposits (Długopole-Zdrój, Polanica-Zdrój, Duszniki-Zdrój and Kudowa), exploited deposits (1 sandstone deposit) and seasonally exploited deposits (1 sand and gravel deposit) as well as abandoned deposits (1 sandstone deposit) and recognised in detail (1 sandstone deposit) deposits are present. Given the above, one should acknowledge that the presence of rock raw material deposits in the vicinity of curative waters does not disqualify any of the minerals.

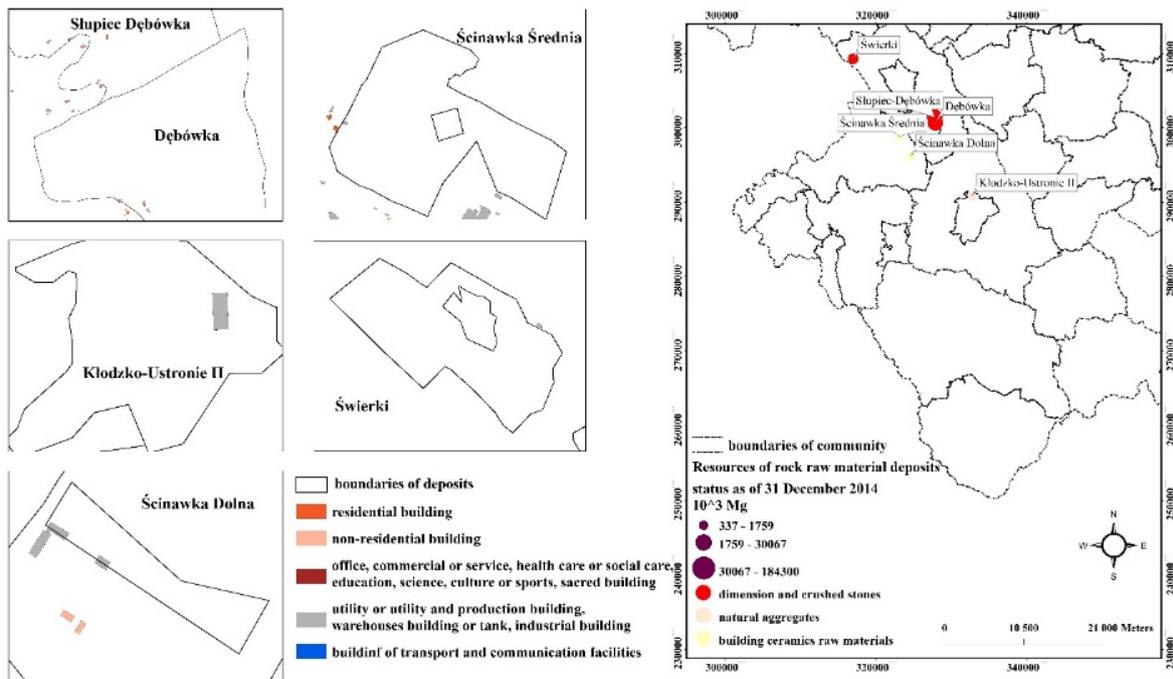
### 3.3 Built-up areas

There are residential, non-residential, office, commercial or service, health care or social care, education, science, culture or sports, sacred, utility or utility and production buildings, warehouses or tanks, as well as industrial, transport and communication facilities located within the area of Kłodzko district. **Figure 5** shows the location of the built-up areas altogether and the space occupied by the particular types of buildings. The largest area is taken by the residential buildings and the buildings of utility and utility-production facilities.



**Figure 5** Built-up areas in Klodzko district

The analyses showed that within the limits of 6 rock raw material deposits, taking all their development methods into consideration, there are buildings located. Within the area of two adjacent gabbro deposits, there are residential and utility or utility-production buildings. They are located near the boundaries of the deposits (**Figure 6**). One of the deposits (Debowka) is seasonally mined and the other (Slupiec Debowka) is permanently mined. In the areas of other deposits, including permanently mined (1 sandy gravel deposit), recognised in detail (1 clay deposit) and the abandoned deposits (1 clay deposit and 1 melaphyre deposit), utility or utility-production buildings were identified. On the basis of the aforementioned results, one can state that the presence of residential buildings is permissible within the limits of a deposit. In the discussed cases of mined deposits, these buildings are located at a safe distance from an excavation and processing plant.



**Figure 6** Resources of rock raw material deposits located within the built-up areas

#### 4. Conclusions

The article identified environmental and social conflicts resulting from the open-cast mining activity taken up or planned within Klodzko district. The environmental conflicts resulted from the possible or current impact of open-cast mining on the forms of environmental protection as legally protected areas, hydrographic and hydrogeological objects, while the social conflicts were connected with the influence on the built-up areas. By comparing locations where the mining activity is permanent or seasonal, and their coexistence with the buildings that may cause the above-mentioned conflicts, it was stated that, within the legally protected areas, the minerals are mined (e.g.: Radków sandstone deposit, Lutynia basalt deposit and Nowa Wieś gneiss deposit). They are also mined near hydrographic objects (Bierkowice 1 sand deposit, Klodzko-Ustronie II sandy gravel deposit, Lutynia basalt deposit, Radków sandstone deposit and Słupiec-Dębówka gabbro deposit) and, near active mining excavations, there are built-up areas (Dębówka and Słupiec-Dębówka gabbro deposits). The identified examples of such exploitation show that it is possible within the possibly conflict generating areas and it offers a chance for mining for precious deposits of rock raw materials recognised initially or in detail with the use of proper mining technology minimising its unfavourable influence on the environment and people. Before applying for the mining concession, one should analyse in detail the initially identified deposit within a conflict generating area – in other words, identify the impact of the deposit at the particular stages of its life on the surrounding elements of the environment and local residents.

#### Acknowledgment(s)

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