



CHARACTERIZATION OF THE ARTISANAL STONE CRUSHING ACTIVITY IN THE INFORMAL SECTOR IN THE COLLINES DEPARTMENT IN BENIN

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Abstract

The artisanal stone crushing activity, which has grown in recent years, has multiple risk factors. Les Collines, a department of 3 health zones, located between parallels 7 ° and 8 ° 45 north latitude, over 13,931 km², is a peneplain area composed mainly of granite rocks whose gravel is in great demand in construction. A documentary review was associated with data collection in the field combining observations and interviews on 5 sites in the communes of Savalou, Dassa-Zoumé and Glazoué. The sample size was obtained by the homogeneous exposure group (GHE) technique. The stone crushing activity includes several stages: removal of the bedrock by pyro-diaclasage on the hill, fragmentation in 2 or 3 phases, reduction to gravel, loading and transport. The tools used are manual, mainly hammers, but also iron bars, shovels, hoes, cutters, metal hoops and used tires with large diameter. Pieces of stone serve as a seat and an anvil. The dominant posture is sitting with bent legs framing the anvil. The work is done mainly in the sun; there are some precarious shelters. The activity is made up of repetitive movements, intense physical efforts, awkward postures, often beyond 10 hours a day, long working times in an atmosphere of heat, complex deafening noises and significant manual vibrations. with exposure to pointed and sharp projectiles and mineral dust. This characterization highlights in addition to the traumatic risk, the risk of musculoskeletal disorders and the cardio-respiratory risk, the major risk to be feared being landslide.

Keywords: Stone crushing, occupational hazards, Hills, mineral dust.

INTRODUCTION

The promotion of decent work for all men and women in the world is a strategic objective of the International Labor Organization (O I T) and a good instrument for improving productivity and economic and social development (International Labor Conference, 2002). This objective is also one of the Sustainable Development Goals (SDGs: 2016 - 2030). The concept of the "informal economy" has been largely documented in relation to its role in development, its contribution to growth and the distribution of income. However, the actors of the informal economy, little known and often overlooked by national policies, escape the official safety, health or inspection services at work. However, with the Convention on the Promotional Framework for Occupational Safety and Health in 2005, a major step forward has been made in the concern of improving working conditions (Elenge, 2008). Thus the protection of all workers, in particular the most vulnerable such as those in the informal economy, must be an objective for the national system, which will have to take measures to ensure the prevention of risks, occupational diseases and injuries. work-related deaths (International Labor Conference, 2005). In Benin, according to the report of the National Institute of Statistics and Economic Analysis (INSAE), the "informal sector" employs nearly 80% of active workers, followed by the modern private sector (11%) and the civil service (9%) (Igue, 2008). The informal sector is full of activities that expose actors to the risk of occupational diseases. This is the case with artisanal stone crushing, an activity long criticized for its deleterious socio-health and

environmental effects and which is unfortunately spreading in a large part of the Collines department. This exploitation of mineral resources is mostly done manually with rudimentary tools, like other developing countries (Mujinga Tshikuta A., 2009). According to Human Rights Watch (2011), artisanal mining is an informal economy activity that employs rudimentary mining techniques that require a large labor force. An income-generating activity par excellence, this form of artisanal mining has seen renewed interest in recent decades in the Collines department due to the strong demand for construction materials. However, this activity is full of many nuisances for stakeholders and local populations. This situation, combined on the one hand with almost endemic poverty in rural areas and on the other hand poor working conditions, makes them particularly vulnerable to health risks (International Labor Office, 2002). In addition to all this, there is too much child labor. Children are exposed, very young, to environmental, organizational and biomechanical risks that are harmful to their health and their psychosomatic development. The almost generalized non-use of personal protective equipment and long working hours increase vulnerability to occupational risk factors such as noise pollution, trauma, toxic fumes and dust with complex compositions, mixed with particles. minerals and various debris (Tossou F., 2001). This chaotic situation deserves many investigations (on environmental and ergonomic risks) and the taking of suitable preventive measures.

FRAMEWORK, MATERIALS AND STUDY METHODS

Study framework: The Collines Department (Figure 1) is located in the central part of the Republic of Benin, between 7

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$^{\circ} 30'$ and $8^{\circ} 50'$ north latitude and between $1^{\circ} 30'$ and $2^{\circ} 50'$ east longitude. It occupies an area of 13,931 km² and shares its borders with the departments of Zou to the south, the departments of Borgou and Donga to the north and the Republics of Togo to the west and Nigeria to the east. Administratively, it is subdivided into 6 Communes namely: Bantè, Dassa, Glazoué, Ouessè, Savalou and Savè. These 6 municipalities are organized into three (3) health zones, according to the national health pyramid: SABA, DAGLA and SAO. The main feature of the relief is the presence of hills and mountains (altitudes of 200 to 400m, or even beyond). From a climatic point of view, the Collines department is in a transition zone and is subject to the influences of the subequatorial climate of the south and the humid tropical climate of the north. The dry season lasts from mid-October to March, or 5 months, compared to 7 months for the rainy season (April to mid-October). The temperatures are characterized by high heat in the middle of the day (36°C), and marked freshness at night and in the early hours of the day: around 21°C (ASECNA, 2019). The harmattan goes through a much longer and harsher phase in January and sometimes in early February. The monthly average temperatures vary between 27°C and 31°C . The months of February to April are the hottest months and the months of July to September are the least hot months).

Hydrography and vegetation

The department is crossed by a major Y-shaped road axis that links the south of the country to the northeast and Niger on the one hand and to the northwest and Burkina Faso on the other. The population of the department, estimated at 828,309 inhabitants in 2018 (RGHP 2014), is dominated by the Nago (46.2%) and the Fon and related (38.5%). It is predominantly agricultural (Gomez, 1995). But more and more, this population is engaged in artisanal stone crushing. The geomorphological context of the environment corresponds to a granito-genosic peneplain with the presence of hills. This is an old flattening surface of granitic and gneissic rocks on which the topographic substratum is interspersed with residual forms of relief (hills, inselbergs). The numerous inselbergs in this region show the bedrock, with marked curves giving steep slopes. It is thus an environment of great availability of stones, object of artisanal crushing. Indeed, the rocks in place have undergone a strong alteration causing many scree to dispose of which constitutes the material to be crushed. Also, the fragility in places of the rocks means that they do not withstand the temperature of the fires used for their bursting

Sampling

Sample sizes were obtained using the Homogeneous Exposure Group (GHE) technique. The statistical units were determined by no sampling on the lists of names of groups of craftsmen. The exclusion criteria were people under 15 and absent. A sample of 60 people was selected for data collection in the period from August 16 to 24, 2019.

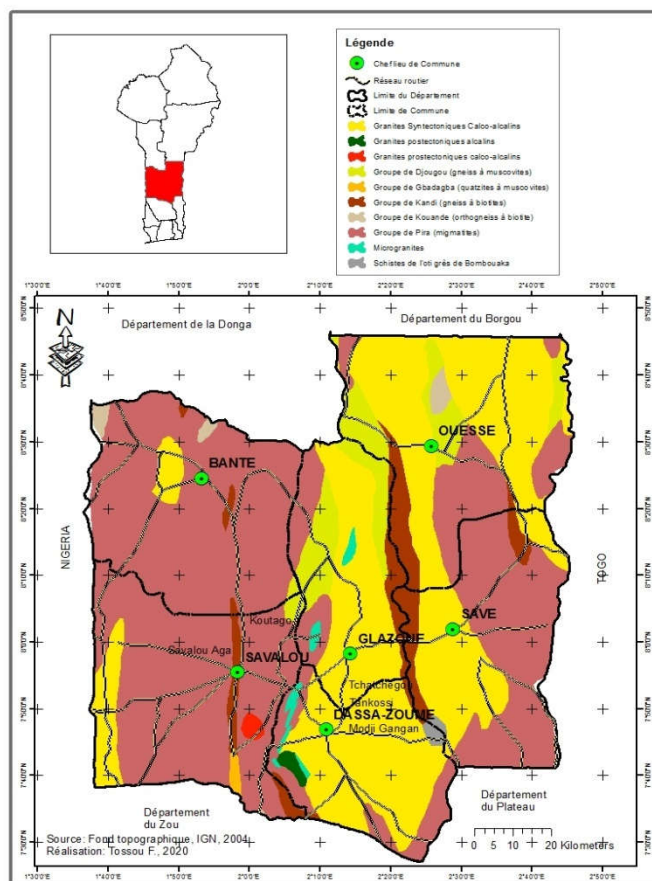


Figure 1. Geological characteristics of the Collines department

Data collection tools and materials

Given the nature of the qualitative and quantitative data, several tools and materials were used. The information was obtained using questionnaires, interview guides and an observation grid. Using a GARMIN 60 GPS, the mining sites were geo-referenced and translated into figures showing the spatial distribution of granite crushing sites in the department. A camera was used to take pictures which served to illustrate the work.

Data collection techniques

The data was collected in two stages: an exploratory phase and an in-depth investigation phase. During the exploratory phase, the entire department was visited, which made it possible to identify the arrondissements that are engaged in the activity. Contacts have been made with the operators and the heads of artisan associations. The in-depth investigation phase began with sampling the sites, following a reasoned choice of 3 out of 6 municipalities (or 2 out of 3 health zones). The districts selected are those which have easy-to-access crushing sites, either because they are in built-up areas or because they are located not far from the two main roads that cross the department.

Table I. Sample size

Municipalities retained in the department	Glazoué		Dassa-Zoumé		Savalou
Sites selected at municipal level	Tankossi	Tchatchégou	Modji Gangan	Koutaago	Savalou Aga
Workforce (N) of crushers per site (according to existing list)	76	90	31	114	42
Size (n0) of the sample drawn per site (according to GHE)	14	14	11	14	11
Size (n) of the study sample	60				

Data processing

The data collected were entered into the SPSS 21 software for their analysis and the calculation of some averages, then the Excel 2013 software was used to transform certain tables into a graph.

Results and discussion

Map data

Using the ArcGis 10.4 software, the coordinates of the crushing sites were projected onto a base map of the study environment, which made it possible to produce Figure 2 showing the spatial distribution of artisanal stone crushing quarries in the Collines department.

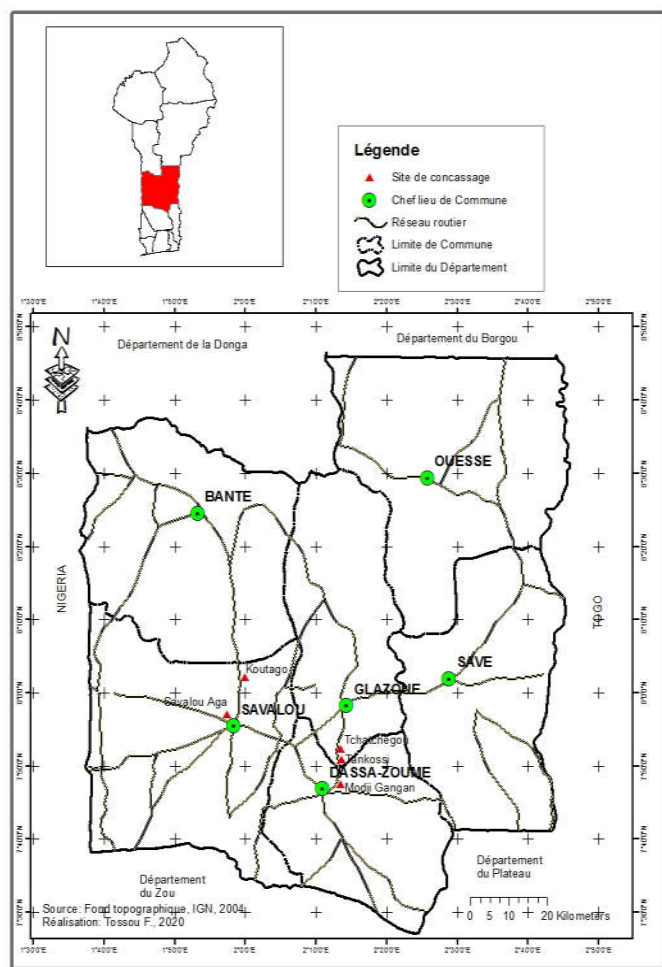


Figure 2. Distribution of gravel crushing sites

Socio-economic characteristics of artisanal stone crushers in the Collines department

This is to highlight the social categories that invest in this sector of activity and their motivation.

Sociodemographic characteristics (ethnicities, ages, sexes, seniority) of the crushing actors

The artisanal stone crushing activity in the Collines department is carried out by a population made up essentially of two ethnic groups: the Fons and related (Mahi) and the Nago and related. Table II presents the socio-demographic characteristics of the crushing players in the Department of Hills. Analysis of Table II shows that the population engaged in the stone crushing activity is dominated by the Nago and related people. They represent 61% of farmers against 39% for Mahi (Fon and related). These two ethnic groups are the most numerous in the general population (46.2% for the Nago and 38.5% for the Mahi). Regarding gender, the artisanal stone crushing activity involves men and women with a predominance of women. They constitute 81.2% of the actors against 18.8% of men. The latter are much more involved in extracting the large blocks of granite (photo a, plate 1) while the women crush them into small pieces of stone (gravel). This activity is carried out specifically by men because it requires enough energy. The women take care of the actual crushing as shown in photo b of plate 1. They also take care of the transport as shown in photo b. Regarding the ages of the crushing actors taken into account according to the inclusion criteria, the median age is 44 years with a minimum age of 18 years and a maximum of 71 years. The age group between 18 and 55 is the largest and represents 84.38% of the population employed in quarries. People over 55 are not negligible (15.62% of operators). Note that children under 15 were not taken into account in this study. Nevertheless, their presence at the crushing sites was very noticeable. This category is made up of out-of-school children and young people who have come to help their parents in carrying out this activity. The smallest declared seniority is 1 year and the largest is 36 years, with an average of 16.23 years and a mode of 10 years.



Photo a: Fragmentation of stone blocks by men **Photo b:** Loading of stone blocks by women

Plate 1: Fragmentation and loading of stone blocks by crushing actors in the Municipality of Dassa

Shooting: Landéou, 2018

Activity requiring appropriate organization and techniques

The stone crushing activity brings together two main players. These are massiers and crushers.

Table 2. Socio-demographic characteristics of crushing players in the Department of Hills

Sociodemographic characteristics	Ethnicities		Sex	
	Nago	Mahi	Hommes	Femmes
Effective	39	25	12	52
Age of crushing actors	Minimum	Maximum	Mode	Median
	18 years	71 years	50 years	44 years
Seniority in the crushing activity	1 year	36 years	10 years	15 years
		Average	50 years	44 years
		43,2 years	10 years	15 years

Massiers

Grouping only the men, the massiers are responsible for extracting and feeding the crushers into blocks of granite. Generally, they use fire to crack the rock (pyro-diaclasage). After cooling the cracked rock block, the hammer or chisel is used to strip it (Plate 2).



Plate 2. Heating and stripping of stone blocks by crushing actors in the Municipality of Dassa

Shooting: Landéou, 2020

Plate 2 describes the techniques used by massiers in the context of their activities. The photo shows the fire to cause cracks in the stone blocks to make them brittle. Photo b shows a young man with a long chisel extracting a piece of stone by stripping. These techniques are very archaic and expose the massiers to the risk of accidents during their activities. To extract the stone blocks, several tools are used by the massiers. These are the sledgehammer, the crowbar, the pointed chisel, the flat chisel, the pickaxe, the daba or the hoe (Plate 3).



Plate 3. Heating and stripping of stone blocks by crushing actors in the Municipality of Dassa

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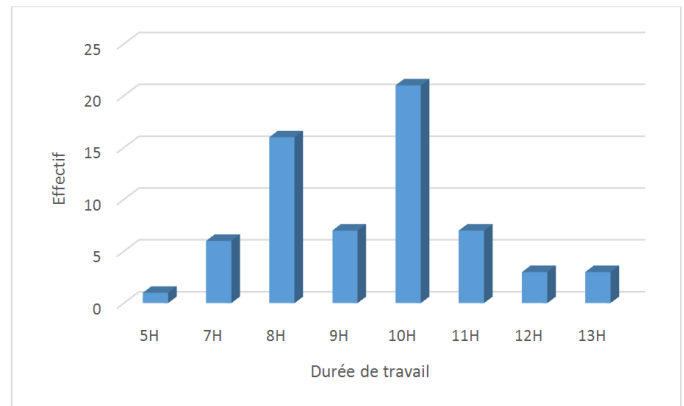
Plate 4. Woman and children in full crushing activity in the Municipality of Savalou

Shooting: Tossou F. August 2019

As shown in Plate 4, the actual crushing activity is the preserve of women and children. At this level, the tools are lighter and less physical force is used.

Workingtime

The results of the field work are presented in Figure 5. The working time, most of the time exceeding 8 hours per day (64%), is a risk factor, being one of the elements of the physical workload of intense work.



Source: Field work, Tossou F. août, 2019

Figure 5: Breakdown of crushers according to working time per day

Only 36% of the populations who engage in this activity work 8 hours or less per day. This work overload can be the basis of many microtraumas, precursors of more serious pathologies such as musculoskeletal disorders (MSDs) of the upper limbs or accidents. We find repetitive movements and intense physical efforts due to the weight of the hand tools used (up to 20 kg). The majority (85.9%) of these populations work 6 days a week and enjoy only 'a weekly day of rest.

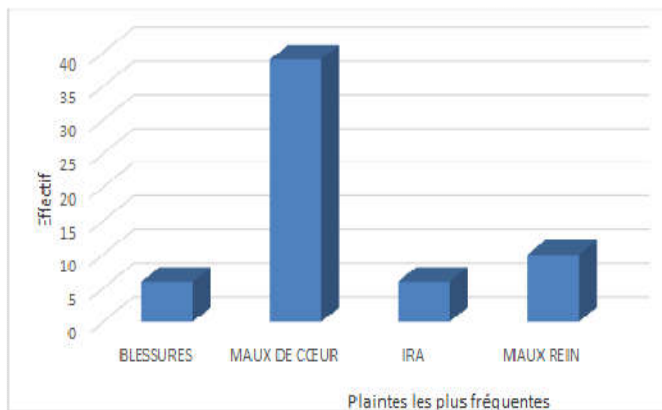
Work posture

On all the crushing sites visited, a seated position with bent legs framing the anvil is the posture adopted by all those involved in the crushing itself. As for the massiers, they are rather standing leaning forward most of the time. Finally, very few preventive measures are taken. In places, plaques were seen bearing messages prohibiting child labor. This work is done manually in the absence of personal protective equipment, even simple shoes. There is a quasi-generalization of the wearing of pants among women, to protect their genitals.

Health effects of the artisanal crushing activity in the Collines department

Granite operators complain of certain symptoms, the most frequently mentioned of which are shown in Figure 5. Heartaches are the main complaints recorded among crushing operators. This complaint was raised by 64% of the players. To a large extent, it is chest pain. Then come the kidney ailments that 16% of the actors cited as ailments attributable to their activity. This is in fact the designation of musculoskeletal disorders of the lower back (lumbago, lumbar sciatica, etc.). Traumas referred to as injuries (eye and skin trauma due to projections of solid particles), as well as acute upper and lower

respiratory infections (bronchitis and pneumonia manifested by coughing) were reported by 1 in 10 workers. For children, who engage in this work for several hours a day, the health risks are more numerous and greater. Because of their mothers' presence at the sites, even babies are exposed from a young age to mineral dust and the sound of hammer impacts.



Source: Tossou F. fieldwork; August, 2019.

Figure 6. Most frequent complaints among stone crushers in the Collines department

The long-term health risks are:

- Broncho-pulmonary affections of allergic or infectious mechanism and pneumoconiosis, in particular silicosis;
- Irreversible occupational deafness, due to the noisy atmosphere and the length of exposure;
- Musculoskeletal disorders (MSDs) of the upper limbs and lower back;
- Skin and eye trauma;
- Retardation of somatic growth and psycho-affective development.

The precarious nutritional situation of the crushers is another risk factor at the sites studied. In many cases, the daily ration is limited to the family evening meal and a midday snack made from cassava flour and peanut fritters. This very poor diet fails to compensate for the energy needs of the day.

Socio-economic and environmental effects of artisanal mining of gravel quarries

The production of gravel is a major source of employment and income for poor families. The development of the construction sector (construction of buildings, residential houses as well as infrastructures such as schools, bridges and roads, churches), roads, railways are at the origin of a growing demand. Artisanal quarrying is an activity of people who have difficulty finding more remunerative employment and is a major source of environmental degradation. Artisanal gravel crushing, like many other human activities, has major impacts on the management and protection of the environment. The block extraction techniques do not respect environmental standards. The operators we met are all unanimous on the fact that this activity presents risks and dangers for the natural environment. Environmental risks due to the exploitation of gravel quarries include degradation of plant cover, soil degradation, landslides and air pollution. Moreover, at the educational level, there is a high level of absenteeism and wastage in the crushing zones. Children often drop out of school, forced to work with their parents, who take them with them to the stone crushing sites.

DISCUSSION

The results show that the socio-demographic structure of the actors of artisanal stone crushing of the Collines department is diversified. This activity is practiced mainly by an ethnic group, the Nago and related, which represents 61% of the actors. This result can be superimposed on that of Kouadio (2008) who found a strong presence of the Malinké in the artisanal miners compared to other ethnic groups. Regarding the distribution by age, 84.38% of the actors are between 18 and 55 years old, the working age group par excellence. These results corroborate those of Mogba et al. (2007), who showed among artisanal miners in the Central African Republic that the age groups between 25 and 55 years are the most numerous. In addition, the present study reveals that the activity of artisanal stone crushing is mainly carried out by women who represent 81% against 19% of men. This female predominance on quarry sites is also found by N'Diaye (2013) in his study on mines and quarries in Burkina Faso, Mali and Togo. This author underlines that in these three countries, girls outnumber boys on all the sites visited. He justifies this predominance by the fact that girls are used in addition (in addition to economic activities) for reproduction tasks such as monitoring young children and small household tasks such as collecting and rinsing mud. Next, the economic opportunity represented by artisanal stone crushing is a source of motivation for the local population to turn to this activity. In his work in the semi-mountainous region of western Côte d'Ivoire, Ettien (2005) also notes that the income generated by mining attracts the local population. An income-generating activity, stone crushing makes it possible to meet the priority needs according to Maslow of families, namely: meeting daily food needs, educating children, taking care of themselves and dressing. This is also the observation made by Mogba et al. (2007), who found that funds from mining are at various scales invested in family expenses, household expenses and various investments. The results obtained clearly show that stone crushing has a deleterious effect on the environment.

The environmental problems encountered at crushing sites are destruction of vegetation cover and air pollution. The studies carried out by Mogba et al, (2007) in the Central African Republic confirm this reality. The authors point out that diamond production leads to deforestation when exploitation takes place in the forest. They also note the impact of this activity on the soil, as evidenced by the old diamond workings which often present the image of an ecological ruin. The formerly exploited areas have rugged relief characterized by the existence of numerous holes of varying diameters. Konlani (2015) in his study on sand quarries in Togo shows that from an environmental standpoint, sand mining is a highly polluting activity that leaves many marks on the landscape. A chaotic landscape made of crevices and pits more than 6 meters deep. The vegetation on the various sites is completely destroyed and the soil becomes vulnerable to the phenomenon of runoff due to the destruction of the layers. Regarding the pathogenic risks associated with the artisanal stone crushing activity, the results of the present study showed that cardiovascular complaints (64%), MSD complaints (16%), respiratory manifestations (10%) and trauma (10%) are the main ailments reported by craftsmen in the Collines department. These results can be superimposed on those of Kinigbe (2013), who studied the socio-economic and environmental impacts of granite crushing and in the Commune of Bantè, also located in the Collines department in Benin. The author discovers that granite miners

suffer from certain ailments, the most common of which are stiffness, headaches, injuries to the fingers, feet and eye disorders.

Conclusion

Artisanal stone crushing is a booming activity in the Collines department. It responds to the need to satisfy the strong demand for gravel generated by the meteoric spatial dynamics of Benin. The gravel production sector is a major source of employment and income for poor local populations. Despite the financial advantages, the exploitation of granites drains behind it disastrous consequences for the environment and human health. The study shows that this activity, although practiced in an artisanal way with rudimentary means, is a source of environmental degradation and involves enough health risks. The destruction of plant cover and atmospheric pollution are all damages caused by this activity to the environment. Indeed, the slaughter of saxicolous species to make fires used to fragment the rock has impacts on biodiversity. The stripping of the rock blocks modifies the tourist landscape presented by these environments. Crushing pollutes the atmosphere through the dust it gives off. These different problems expose the users of the crushing sites, and even the surrounding population, to various pathologies and risk creating serious environmental imbalances in the mining area in the long term.

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