96

# Série Estudos e Documentos

## Mineral resources and territories: human, socio-environmental and economic impacts


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CETEM 40 ANOS

CENTRO DE TECNOLOGIA MINERAL

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# SÉRIE ESTUDOS E DOCUMENTOS

ISSN 0103-6319 ISBN 978-85-8261-090-9

**SED - 96**

## Mineral resources and territories: human, socio-environmental and economic impacts

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**CETEM/MCTIC**
2018

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Fernandes, Francisco Rego Chaves
Mineral resources and territories: human, sócio-environmental and economic impacts / Francisco Rego Chaves Fernandes; Ana Maria Botelho Marinho da Cunha [et al.] __Rio de Janeiro: CETEM/MCTIC, 2018.

78p.:il. (Série Estudos e Documentos, 96)

1. Mineral industry. 2. Mining. 3. Sustainability. I. Centro de Tecnologia Mineral. II. Cunha, Ana Maria B. Marinho. III. Araujo, Eliane Rocha. IV. Souza, Keila Valente. V. Olivieri, Renata Damico. VI. Alamino, Renata de C. Jimenez. VII. Villa Verde, Rodrigo B. da R. VIII. Série.

CDD – 333.77

## SUMMARY

## ABSTRACT

Brazil is the one of the largest producers and exporters of mineral resources in the world, producing more than 70 substances. The mineral industry generates economics growth, but in the mean time, their human activities cause serious social impacts, economic and environmental.

The environmental damage that mining causes, in every stage of operations, including processing and transportation, which remain after the closure or suspension of activities. Mining not only changes the physical environment, but also affects the way and quality of life of populations established in these areas and its surroundings, as such disordered growth, violence and poverty.

The six articles that make up this book, perform a synthesis of these analytical impacts: the first, a national swing focused on a total of 105 projects that were studied, and the five others, the same mining metallurgists ventures, now classified according to your location in the North, Northeast, Center West, Southeast and South Brazil.

**Keywords**
Mineral industry, mining, sustainability, socioeconomic impacts, communities, territory; conflicts.

# 1 | THE MINING INDUSTRY GENERATES WEALTH AND AFFECTS COMMUNITIES AND THE ENVIRONMENT

## 1.1 | Mineral Resources Generate Wealth in Brazil

Brazil has a wealth of mineral resources and is one of the biggest mineral producers and exporters in the world. It produces 72 mineral substances, of which 23 are metals, 45 are non-metals and four are energy minerals. Iron ore is by far the leading mineral, representing 60% of the total value of the country's mineral production, followed by gold, with only 5% (IBRAM, 2018).

Brazil is the world's leading producer of niobium and tantalum, second largest producer of magnesium carbonate and third for iron ore, bauxite, asbestos and graphite. It is also is one of the top producers of precious stones and cladding, phosphate, talc, vermiculite and tin, among other minerals (DNPM, 2018).

This production is carried out in 3,354 mines[1], most of which are small-scale operations (PINHEIRO, 2011). There are a total of 8,870 mining operations[2] registered with the DNPM under the mining concession and licensing regime (IBRAM, 2018).

The following data provides proof of the wealth generated by the extractive industry:

- In 2015, according to official records, the production of the Brazilian mining industry (including oil) was valued

[1] Mines considered active provided that they have submitted the annual mining report (Relatório anual de lavra, RAL) and has had a minimum annual production of 10,000 tonnes of ROM.

[2] Registered in the DNPM's registry.

at US$ 32,5 billion; it directly employed 150,000 workers. These values are underestimated, given that Brazilian mining involves a significant amount of informal operations. The industry accounts for 2% of the country's GDP;

– The Brazilian balance of trade had a surplus of US$ 19.6 billion in 2015, the surplus of the mineral extractive industry (without oil) reached US$ 19.7 billion, with exports of US$ 39 billion (SMB, 2016);

## 1.2 | Socioeconomic and Environmental Impacts

The mining industry undoubtedly generates economic growth, however, it is one of the anthropic activities that causes the most negative socioeconomic and environmental impacts and affects the regions where mining is carried out.

Some argue that these negative impacts of the mining industry are limited because they are sporadic and localised. However, one reason that their effects are so extensive is due to the daily and decentralised nature of their operations: they are spread out over the 3,000 mines and 9,000 mining companies active in the country today. To this, one must add the hundreds of thousands of informal miners and small-scale operators that produce minerals for immediate use in construction and are randomly scattered all over Brazilian. The huge environmental liabilities of inactive, abandoned mines and garimpos from past mining ventures are also worth mentioning. Their exact number is unknown, but is certainly in excess of tens of thousands. This activity has been going on non-stop for over five hundred years in Brazil.

The harm that mining (mines and other types of informal mining operations) does to the environments linked to all phases of the process, from mineral extraction to transportation and processing, and may even extend past the closure of mines or the cessation of activities. In addition, mining significantly changes the physical environment, causing deforestation, soil erosion, contamination of bodies of water, increased dispersion of heavy metals, changes to the landscape and the soil, as well as harm to flora and fauna. It also affects the way and quality of life of the populations settled in the mining areas and surrounding regions.

When these negative effects on the environment go undetected and unsolved, they become an environmental liability, which is often the case in Brazil (PAIVA, 2006). Some examples are shocking, such as abandoned gold mines, many of which date back hundreds of years and are the source of significant pollution today. Coal mining has also left serious environmental liabilities. In the coal fields in Santa Catarina alone, it is estimated that there are a thousand old abandoned mines, most of which are between 50 and 80 years old (AMARAL; KREBS; PAZZETTO, 2008).

Another example is found in Bom Jesus da Serra in the state of Bahia. Brazil's first asbestos mine is located in this municipality. Its activities ceased in 1967, leaving a huge liability for which a solution has yet to be found. The municipality became poorer and, until this day, the local population lives with a huge crater and the environmental contamination resulting from the manufacturing process (PAIXÃO; QUEIROZ, 2009).

Cases of environmental damage are found in many different municipalities, which is the case of: Serra do Navio (Amapá),

Boquira (Bahia), Santo Amaro (Bahia), Caldas (Minas Gerais) and Poços de Caldas (Minas Gerais). The company Indústria e Comércio de Minérios de Ferro e Manganês S.A. (Icomi) exploited a manganese quarry in Serra do Navio for forty years, until it depleted its resources. It left behind huge piles of residue and the arsenic contained in the waste polluted rivers and underground water sources. Due to the lack of planning of other economic activities to be developed after the closure of the mine, the city fell into economic and social decline. Inadequate disposal of waste from the lead extraction mine in Boquira and the lead metalworks in Santo Amaro contaminated springs and soil, causing harm to the population's health. As for the mining towns of Caldas and Poços de Caldas, uranium mining and processing and the disposal of waste from the mines caused acid mine drainage in the pit, the waste site and the tailings pond, affecting the cities' hydrographic basins.

The cases mentioned are but a few examples to show that negative environmental impacts on the lives of local populations is not limited to a mine's useful life. In fact, effects can last for decades or even centuries. When a mine's resources are depleted, the company transfers activities to another location and the population is left to deal with abandoned mines, tailings dumps, disease, economic decline, impoverishment and the contamination of air, the soil, rivers and groundwater.

## 1.3 | Mining and Sustainability

The line of research created and developed by CETEM/MCTIC since 2005 brings together researchers focusing on the issues of large-scale mining operations, APLs (Arranjos Produtivos Locais, Local Production Arrangements) *versus* territory and

communities. In 2007, a concept based on a review of national and international literature on the subject (FERNANDES; LIMA; TEIXEIRA, 2007a and 2007b) was proposed. In 2011, the book *Recursos Minerais & Sustentabilidade Territorial* (*Mineral Resources and Territorial Sustainability)* presented the results of 15 case studies performed on large Mines and APLs by a national network of research institutes' investigation. After evaluating the final texts, the researchers identified 10 different aspects of sustainability[3], which are: social, cultural, institutional, ecological, economic, political, territorial, technological, global and systemic. This means that it is no longer sufficient for mining companies and small-scale operations to focus solely on economic and technological aspects of the venture. Attention also needs to be paid to these other aspects.

In relation to the social dimension, all kinds of conflict pervade the relations between mining operations and society, especially local communities. In terms of culture, it is often noted that mining ventures disrupt communities' values, traditions and way of life. At the institutional level, public and private organisations whose role is to ensure the venture's feasibility, protect social interests and uphold environmental norms are presumed to exist. What was observed, however, was a vacuum that leaves room for "insecurity and litigation at all levels".

The economic aspect is perhaps the dimension that presents the clearest evidence of positive returns from mining, as it increases tax revenues, stimulates local businesses, generates employment, etc. Nevertheless, there are considerable

[3] The text presented below is a synthesis of the article "A mineração das grandes minas e as dimensões da sustentabilidade" (ENRIQUÉZ; FERNANDES; ALAMINO, 2011).

challenges in the territory being mined and the surrounding areas. Mining projects attract large contingents of workers from other regions, which tends to cause the prices of goods and local services to increase. They may also threaten the community's economic independence if no measures are taken to ensure the diversification of production (ENRIQUÉZ; FERNANDES; ALAMINO, 2011).

The political aspect is clearly fundamental to guaranteeing that mining activities develop with a good governance system in place – one that protects the rights of the communities involved and ensures that good environmental conservation practices are adopted. To reduce the negative impacts of mining ventures, state action is fundamental, as it must assume its role of upholding laws, resolving conflicts and guaranteeing that any advances made are not compromised in the process of political succession. The territorial dimension is also vital given that the presence of mineral resources can be a boon, as it can drive development, but also a bane, when it destroys livelihoods or harms the health of the natural environment and the people (ENRIQUÉZ; FERNANDES; ALAMINO, 2011).

Concerning the technological aspect, there is a constant need for mining companies to seek cleaner production technologies and promote the recuperation of degraded areas. The importance of the Brazilian mineral sector at the global level is clear and vice versa, the importance of the global markets for mining in Brazil. However, the greatest challenges for the mining sector are related to the ecological dimension. Finally, we stress that the effects of mining activities are interdependent, as all aspects are interrelated. Therefore, a systemic approach is required for public and corporate policies on mining and its impacts.

## 1.4 | Environmental and Social Licensing

It was only in the 1970s that there started to be greater concern with the effect of mining activities on the environment. This was when the number of environmental accidents multiplied and awareness that our capacity to restore the environment had been seriously compromised increased (FLORES, 2006 apud. TONIDANDEL, 2011). Before then, environmental legislation and trade barriers for potentially polluting products were not particularly demanding. This meant that the majority of companies were unconcerned with their manufacturing processes, as they were able to sell their products on the domestic and international markets with virtually no problems.

However, since then, non-tariff trade barriers have been increasing all over the word. Products and services are now forced to comply with international quality standards, for example ISO 9000, and environmental standards, such as ISO 14000. There is also increasing pressure for companies to exercise social responsibility, work in an ethical and transparent way and respect the environment and the communities with whom they interact. Moreover, environmental legislation has become more rigorous.

However, even the companies that have adjusted their management processes to adopt “cleaner” production mechanisms and that market the image of being socially responsible often continue to pollute the environment and cause negative impacts on the communities near their operations. While these impacts have decreased over time, they are still by no means negligible today, particularly on the local populations’ way and quality of life.

To control activities and try to prevent or reduce impacts caused by mining ventures, the Conama Resolution 237 was adopted in 1997. The said resolution requires an operator to obtain a

licence from a competent state body for the “construction, installation, extension and functioning of establishments and activities that use environmental resources, that are considered to be, or are potentially, polluters, as well as those that could in any way cause environmental damage” (BRAZIL,1997) prior to beginning its operations. The licensing of these activities depends on the results of an Environmental Impact Study (EIA) and the respective Environmental Impact Report (RIMA). The EIA/RIMA are always obligatory for mineral extraction, regardless of the type of environmental resources involved (BRAZIL, 1986).

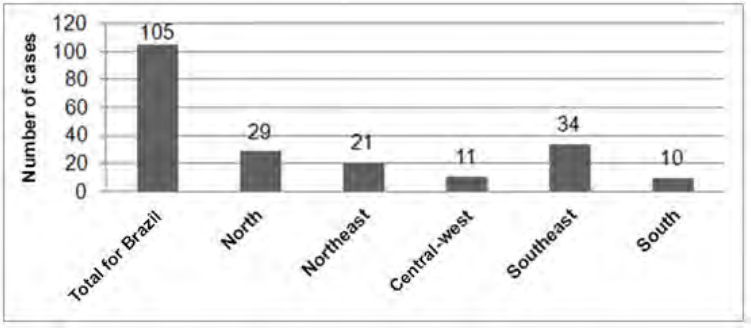
According to Brazilian legislation, social, cultural and economic impacts are also taken into account during these environmental licensing processes, which is different from other countries. In practice, however, the majority of environmental impact studies focus their analysis more on the effects on the physical and biological environment and usually ignore effects on the population (SANCHÉZ, 2010).

Even so, there are examples of communities that have managed to prevent the installation of or significantly modify a mining project that would affect them through social mobilisation. Others have secured social trade-offs in return. This was the case in Juruti, Pará, where a bauxite mining project affected the environment and the way of life of traditional communities. After widespread mobilisation, the local population received a share of the revenues from the mining operation and other social benefits, such as the construction of a hospital, classrooms and water treatment. This case is, however, still rare in the country.

## 1.5 | A Brief Outline of Mining in Brazil by State and Mineral Substance

The book Recursos Minerais e Comunidade: Impactos Humanos, Socioambientais e Econômicos (Mineral resources and communities: human, socio-environmental and economic impacts) contributes to a better understanding of the impacts of mining. It contains over one hundred case studies (105) on all types of mining ventures, which are spread over 22 states and all five regions of Brazil. This systemisation of cases provides a clearer overview of the level of the impacts caused by mining and the possibilities that exist to protect the natural heritage and the affected communities' way of life, values and interests.

The majority of the cases are concentrated in the southeast (34), the region where mining began in Brazil, with gold prospecting in the state of Minas Gerais. The north comes in second, with 29 cases (one of which is on the border with the central-west region), and is currently considered the new mining frontier in the country. It is followed by the northeast, with 21 cases, the central-west with 11 and the south with 10 cases, as shown in Graph 1 below.




**Graph 1.** Case studies on the impact of mining in Brazil, classified by region.

In the ranking of the number of case studies, Minas Gerais stands out in first place with close to 20% of the total (20 different case studies). It is followed by the state of Pará and Bahia (11% each). Rio de Janeiro and Amapá comes in fourth place with 9%, followed by Goiás in fifth (7%) and Paraná in seventh (5%). Amazonas, Rio Grande do Sul, Rondônia and São Paulo appear in four cases, followed by Ceará, Maranhão and Mato Grosso shown in three cases, and then Piauí, Roraima and Rio Grande do Norte in two cases. Finally, Espírito Santo, Mato Grosso do Sul, Santa Catarina and Sergipe appear in only 1 of the cases studies, as indicated in Table 1 below.

**Table 1.** Ranking of case studies of the human, socio-environmental and economic impactsof mining by Brazilian state.

| # | UF | % | # | UF | % |
|---|---|---|---|---|---|
| 1st | Minas Gerais | 19,0 | 12th | Ceará | 2,9 |
| 2nd | Pará | 11,4 | | Maranhão | 2,9 |
| 3rd | Bahia | 10,5 | | Mato Grosso | 2,9 |
| 4th | Rio de Janeiro | 8,6 | 15th | Piauí | 1,9 |
| 5th | Goiás | 6,7 | | Rio Grande do Norte | 1,9 |
| 6th | Amapá | 5,7 | | Roraima | 1,9 |
| 7th | Paraná | 4,8 | 18th | Espírito Santo | 1,0 |
| 8th | Amazonas | 3,8 | | Mato Grosso do Sul | 1,0 |
| | Rondônia | 3,8 | | Santa Catarina | 1,0 |
| | Rio Grande do Sul | 3,8 | | Sergipe | 1,0 |
| | São Paulo | 3,8 | | | |

Source: CETEM/MCTIC, Database.

With regards to the mineral substances identified in the 105 case studies, two of them represent almost 40% of the total: gold is mentioned the most and appears in 20 cases (19% of the total), followed by iron ore which appears in 17 entries (16%). Coal, copper and decorative stones come next, each appearing in five cases, while aluminium, asbestos, lead, phosphorite, metallurgy, uranium and zinc each appear in four cases. Diamonds and manganese appear in three studies each, followed by emeralds, nickel and quartzite, which each are mentioned twice. The remaining substances appear in only one case study each (clay, limestone, kaolin, tin, magnesite, heavy metals, opal, other precious stones, potassium, waste, rare earths and tungsten), as shown in Table 2 below.

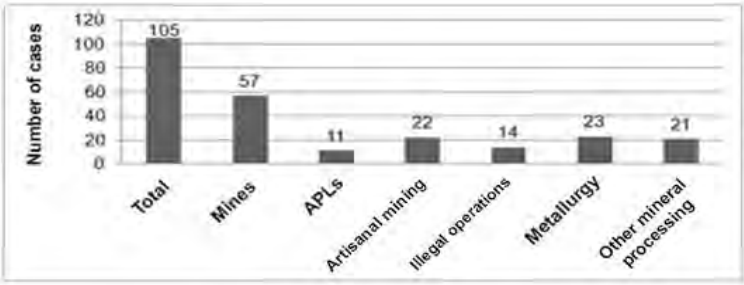
**Table 2**. Ranking of the principal substances that appear in case studies on the human, socio-environmental and economic impacts of mining.

| R | Substance | % | R | Substance | % | R | Substance | % |
|---|---|---|---|---|---|---|---|---|
| 1st | Gold | 19.0% | | Uranium | 3.8% | 21st | Tin | 1.0% |
| 2nd | Iron | 16.2% | | Zinc | 3.8% | | Gemstones | 1.0% |
| 3rd | Coal | 4.8% | 13th | Diamonds | 2.9% | | Magnesite | 1.0% |
| | Copper | 4.8% | | Manganese | 2.9% | | Heavy metals | 1.0% |
| | Decorative stones | 4.8% | 15th | Emeralds | 1.9% | | Opal | 1.0% |
| 6th | Aluminium | 3,8% | | Nickel | 1.9% | | Precious stones | 1.0% |
| | Asbestos | 3.8% | | Quartzite | 1.9% | | Potassium | 1.0% |
| | Lead | 3.8% | 18th | Clay | 1.0% | | Waste | 1.0% |
| | Phosphorite | 3.8% | | Limestone | 1.0% | | Rare earths | 1.0% |
| | Metallurgy | 3.8% | | Kaolin | 1.0% | | Tungsten | 1.0% |

Source: CETEM/MCTIC, Database.

## 1.6 | Furthering the Analysis on the Human, Environmental, Social and Economic Impacts on Mined Territories

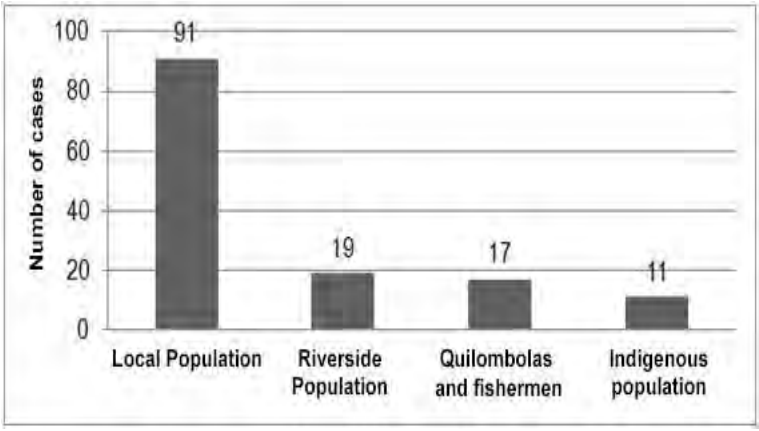
The focus of the case studies (105) are: official mines (57); APLs – Local Production Arrangements (11); artisanal mining operations (22); illegal mining (14); metallurgy (23),and other mineral-based processing industries (21), as shown in Graph 2 below.




**Graph 2.** Case studies on mining impacts in Brazil classified according to the type of operations.

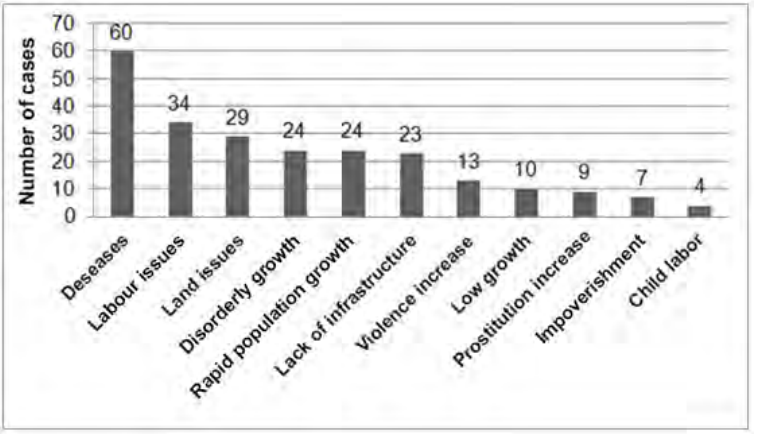
The majority of the 105 ventures studied are mines (58). Most are located in small municipalities with up to 50,000 in population (69 cases). In seventy-five cases, the mining ventures are currently operational and seventy-two have been running for over 20 years. Only thirteen are in the development phase and the mobilisation of the local population prevented one from beginning its activities.

According to graph 3 below, most of the people affected by mining are in urban communities: the local population living near the mine or the surrounding area (91).Other groups of people are also affected, such as river communities (19), traditional people (17) – such as small-scale fishermen and quilombolas – and indigenous people (11).



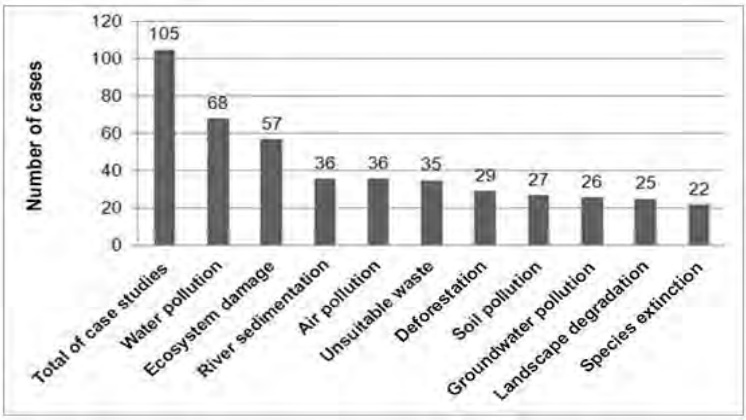

**Graph 3**. Case studies on the human impacts of mining in Brazil according to the different population groups living near the mining projects.

Of the socioeconomic impacts caused by mining, the most significant one was the spread of disease. This was mentioned in 60 case studies, the equivalent of over half of the studies. This is followed by labour complaints involving the mining corporation (34), land issues (29), disorganised growth of the municipality (24) and rapid population growth, also cited in 24 of the case studies. Furthermore, in 23 studies, the lack of infrastructure to meet the needs of the local population was mentioned. Increased violence was another impact identified and was present in 13 studies, followed by slow economic and social growth in the affected municipalities (10), an increase in prostitution (9), impoverishment of the population (7) and child labour (4), as seen in Graph 4.




**Graph 4**. Case studies on the socioeconomic impacts of mining in Brazil: the number of mining projects associated to a type of negative impact (number of case studies).

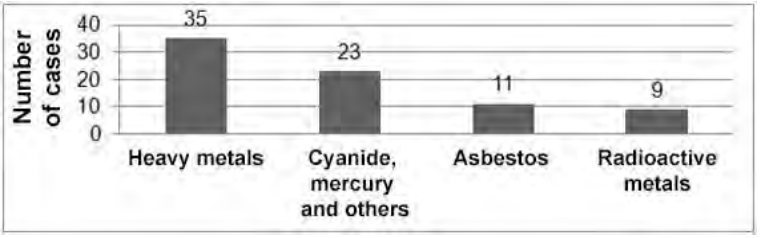
With regards to environmental impacts, the most significant problem cited in the case studies is water pollution, with 68 references. This is highly plausible given that this is the main resource used for mining. This is closely followed by damage to the local ecosystem (57), river sedimentation (36), air pollution (36), inadequate disposal of waste and slag (35), deforestation (29), soil pollution (27), pollution of groundwater (26), impact on the landscape (25) and the extinction of plant and/or animal species (22). Finally, other complaints include operations in environmental protection areas (11), the illegal logging of native wood (8) and dam bursts (7) (see graph 5). Moreover, in the case studies on abandoned mines, the inadequate use of waste and problems related to mine closure each appeared six times.



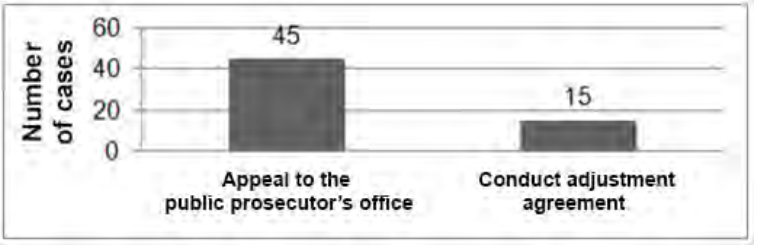

**Graph 5**. Case studies of the environmental impacts of mining in Brazil.

As contamination from hazardous substances is very common in mining activities, it was analysed separately. The most common issue in the studies carried out is contamination from heavy metals present in the mineral composition (35); followed by substances used in the mining process, such as cyanide and mercury (23); substances that are naturally dangerous, such as asbestos (11) and radioactive metal (9) (see graph 6).

Conflict resulting from mineral extraction often requires the intervention of the public prosecutor's office at either the federal or state level, or even both. In the studies, the public prosecutor's office intervened in 45 cases, 15 of which resulted in signing a conduct adjustment agreement (TAC, for its acronym in Portuguese). A TAC is a document signed by both parties in which they commit to meet certain conditions to resolve the problem they are causing or to compensate for damage already done. It is a valid alternative means of extrajudicial conflict resolution (graph 7).




**Graph 6**. Case studies on the impacts caused by contamination from hazardous substances as a result of mining.




**Graph 7**. Case studies of conflicts caused by mining: appeals to the public prosecutor's officeand conduct adjustment agreements.

## 1.7 | Other Initiatives Under the "Mineral Resources and Society" Line of Research

Four other initiatives to develop databases of case studies focused on conflicts and impacts on people's economic activities and the land carried out by research teams from institutions other than the CETEM – two in Brazil, one in Latin America and one in European Union (Barcelona, Spain) – are worth mentioning. The first one is the 'Mapa de Conflitos Envolvendo Injustiça Ambiental e Saúde no Brasil' (Map of Conflicts involving Environmental Injustice and Health in Brazil). This map is the result of a project carried out by Fiocruz - Oswaldo Cruz Foundation and FASE–The Federation of

Institutions for Social and Educational Assistance, with the support of the Ministry of Health's Department for Environmental Health and Workers' Health. The map can be consulted online at <http://www.conflitoambiental.icict.fiocruz.br/index.php>. It includes approximately 300 cases spread over the whole country, with geo referencing. Mining is mentioned in 91 cases. This work has been enhanced by the publication of the book Injustiça Ambiental e Saúde no Brasil: o mapa de conflitos (Environmental Injustice and Health in Brazil: The map of conflicts) (PORTO; PACHECO; LEROY, 2013).

The second is the 'Mapa dos Conflitos Ambientais de Minas Gerais' (Map of Environmental Conflicts in Minas Gerais). This map was the result of a research project by the Grupo de Estudos em Temáticas Ambientais da Universidade Federal de Minas Gerais (GESTA/UFMG, or the Study Group on Environmental Issues at the Federal University of Minas Gerais), in partnership with the Núcleo de Investigação em Justiça Ambiental da Universidade Federal de São João Del-Rey (NINJA/UFSJ, or the Environmental Justice Research Group at the Federal University of São João Del-Rey) and researchers from the Programa de Pós-graduação em Desenvolvimento Social da Universidade Estadual de Montes Claros (PPGDS/UNIMONTES, or the Postgraduate Programme in Social Development at the State University of Montes Claros). The researchers gathered information on 541 cases of environmental conflicts in Minas Gerais between the years 2000 and 2010. These can be consulted at <http://conflitosambientaismg.lcc.ufmg.br/>.

The third and fourth, the Observatorio de Conflictos Mineros de América Latina (OCMAL, Observatory on Mining Conflicts in Latin America) and the Observatorio Latinoamericano de

Conflictos Ambientales (OLCA, Latin-American Observatory of Environmental Conflicts) have a database on conflicts related to mining called the 'Sistema de Información para la Gestión Comunitaria de Conflictos Socio-ambientales Mineros en Latinoamérica' (Information System for the Community Management of Socio-Environmental Mining Conflicts in Latin America). Available at <http://www.conflictosmineros.net/>, the database contains information on 160 case studies, including documents, articles, videos and press cuttings.

Finnally, the fifth and last, the Ejolt Atlas – Mapping Environmental Justice – an initiative supported by the European Union between 2011 and 2015 and hosted in Universidade de Barcelona. In 2018, it accounts 2,500 registered cases from approximately 100 countries (https://ejatlas.org/).

By presenting over 100 concrete cases about mineral resources field in Brazil, this article aims to stimulate reflection on the principal problems related to the Brazilian mining industry and on alternatives for the sustainable development of the industry. These alternatives must take into account the limits of the natural environment and especially the dignity and values of the most vulnerable peoples directly affected by these ventures.

## 2 | CENTRAL-WEST REGION AN OVERVIEW OF MINING IN THE CENTRAL-WEST REGION

The central-west region of Brazil is composed of the states of Goiás, Mato Grosso and Mato Grosso do Sul, plus the Federal District of Brasília. Together, these states cover an area of 1,606,403 km², which is a little more than twice the size of France or three times the size of Spain.

With an estimated population of 14,993,194 people in 2013 (IBGE, 2013a), the central-west region is home to sizeable deposits of gold, nickel, iron-manganese, tin and kaolin. In 2011, the Departamento Nacional de Produção Mineral (DNPM, National Department for Mineral Production) registered a total of 1,075 mining companies. Major investments in the mining sector for the 2012-2016 period are expected to reach a total of close to US$ 2.8 million (IBRAM, 2012).

In 2011, Brazil collected R$ 1.6 billion in royalties through the Compensação Financeira pela Exploração Mineral (CFEM, Financial Compensation for Mineral Exploration) mechanism. Goiás and Mato Grosso do Sul placed fourth and six, respectively, on the list of mining states. Together, they accounted for close to 6% of the total amount collected (IBRAM, 2012).

Two important challenges for mining in the central-west region are: first, to ensure the sustainability of operations set up in the middle of two biomes – the Cerrado and the Amazon (in the northern part of the region); and secondly, to maximise the benefits that mineral extraction and/or processing can generate for the population of mining municipalities. Informal or artisanal mining operations can also be found in the region and, in some

cases, social tensions and conflicts with local indigenous peoples or riverine communities exist.

Of the 105 entries in this book, 11 case studies on mineral resources and society are situated only in the central-west region. To this total, one may add one more case study that extends past the political-administrative boundaries of the central-west region due to its interface with the North: this case discuss the situation of indigenous people from the Kayapó indigenous group and informal mining activities in the states of Mato Grosso and Pará.

The majority of the studies are on mines in the state of Goiás (8 of the 11 from the region), which is a reflection of the key role that the state plays in mining in the region. Most of the ventures studied have been operating for over 20 years and one has been shut down. Mines and artisanal operations are the main objects of study of the articles in this chapter, although Local Production Arrangements (APLs for their acronym in Portuguese), illegal mining and processing industries are also discussed.

There are 467 municipalities in the central-west region (IBGE, 2013a). Half of the reports refer to mining ventures that extend over more than one municipality and the other half involves only one municipality. All are in small cities, with up to 50,000 inhabitants. In the cities mentioned, the population residing in urban areas are affected the most, even though in some cases, riverine and indigenous communities have also been affected by formal and informal mining activities.

In the central-west region, 33% of the population are migrants (IBGE, 2013b). It is common for big mines to attract a large number of people who leave their homes in search for better

work opportunities and quality of life in more prosperous cities. However, municipalities whose economy revolves around mining often have difficulties satisfying the demands of the families who migrate to them.

The negative socioeconomic impacts identified include the disorderly growth of the cities due to the rapid increase in the population and the absence of adequate infrastructure to meet the population's needs. Harm to resident´s health and labour-related problems are also worth highlighting. On a smaller scale, other problems observed were: land conflicts, working conditions analogous to slavery and child labour.

As for environmental issues, the majority of case studies observed some type of harm to the local ecosystem, especially due to pollution of the air, soil, rivers and groundwater, river sedimentation and deforestation. These negative impacts normally culminate in drastic changes to the natural landscape and the extinction of vegetable and animal species.

A total of six studies noted incidences where waste was released into the environment, resulting in the contamination of the area by hazardous substances, including heavy and radioactive metals. It was found that although the Public Prosecutor's Office had not intervened in most cases, it did so in four. A conduct adjustment agreement was signed in only two of them.

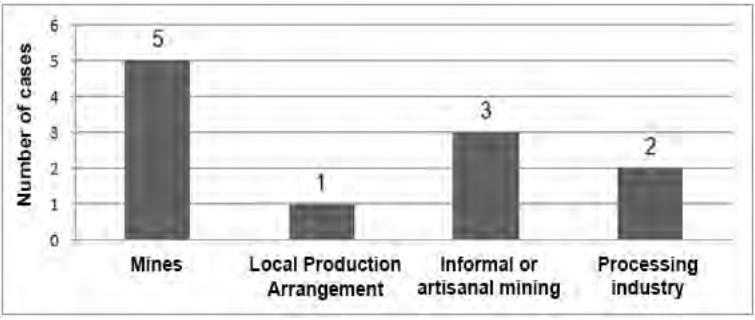
## 2.1 | Goiás in the Lead in the Region

The state of Goiás plays a leading role in mining in the central-west region. In 2011, it registered the highest positive balance in employment terms in the mineral extraction industry in the

region, with the creation of close to 600 jobs (this does not include the oil and natural gas sectors). Two of the 28 municipalities where the mining industry employed the most workers are in Goiás: Crixás and Niquelândia (DNPM, 2012). Corumbá (MS) is the only municipality in the centre-west that outperforms Crixás and Niquelândia. However, the situation in Corumbá is unique, as it has the largest manganese deposit and the third largest iron ore deposit in the country (CORUMBÁ, 2013).

Furthermore, Goiás collected the fourth largest amount of funds through the CFEM in 2011 (3.7% of the national total), coming in behind the states of Minas Gerais, Pará and São Paulo only (DNPM, 2012).

The mining ventures studied in this chapter have been operating for over 20 years. Officially established mines represent the main productive activity, followed by informal mining operations, the processing industries and one APL (see graph 8).

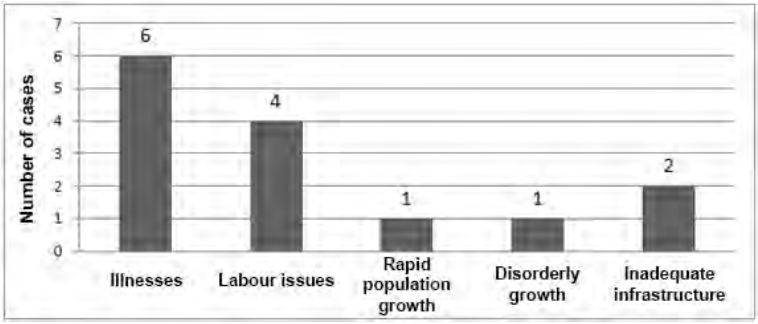



**Graph 8**. Classification of the different productive activities in the mining sector in the state of Goiás.

In the state, the people affected the most are the ones who live in the urban centres where the mining ventures are located. Riverine communities are also subjected to the impacts of the exploitation of mineral resources in Goiás (see graph 9).

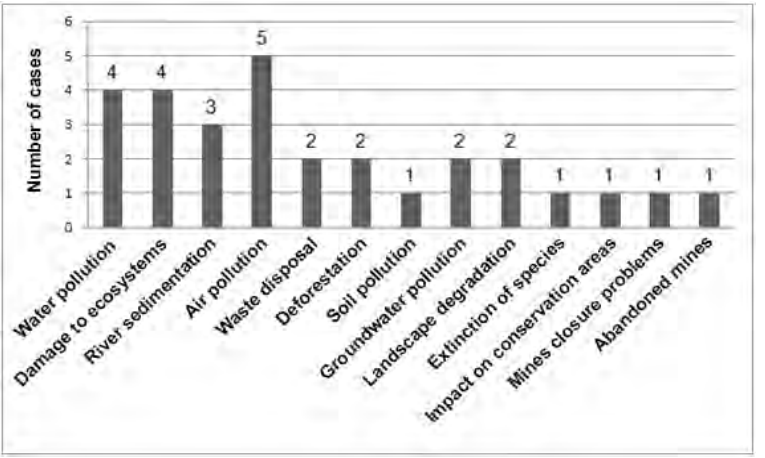

**Graph 9**. Population affected by mining in the case studies conducted in the state of Goiás.

Among the negative impacts found, health problems and labour issues related to mining appear the most. On a smaller scale, but equally as important, problems related to uncontrolled territorial occupation and exploitation of mineral resources stand out. These problems include: uncontrolled growth, rapid increase in the population and the lack of adequate infrastructure for responding to the needs of a rising number of residents (graph 10).



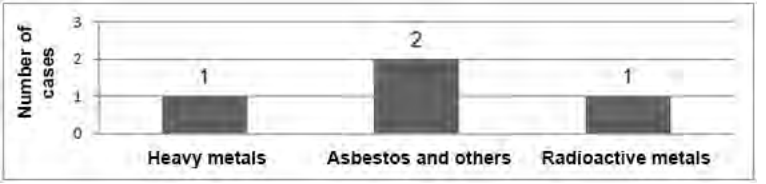

**Graph 10**. Negative impacts associated with mining in the state of Goiás.

As for environmental impacts, the most common ones are air and water pollution, which cause harm to ecosystems in Goiás. Inadequate waste disposal, river sedimentation, deforestation and changes to the landscape were also noted (see graph 11).




**Graph 11**. Environmental impacts of mining identified in the case studies in the state of Goiás.

There are also cases of contamination of heavy metals, radioactive substances and asbestos, among others, which aggravate environmental problems (see graph 12). The native vegetation in Goiás, in general, is typical of the Cerrado biome. However, the situation of the biome is critical.




**Graph 12**. Case studies on the impacts caused by the contamination of hazardous substances as a result of mining in the state of Goiás.

Mining, agribusiness plantations, extensive cattle raising and the construction of hydroelectric dams are the main components of the deforestation process in the Cerrado, the second largest vegetation formation in South America, second to only the Amazon. Half of the Cerrado's original formation has already been eliminated (WWF, 2013).

Goiás is a Brazilian state and it is practically entirely covered by the Cerrado biome. Mining in the state faces the challenge of reconciling economic development with the sustainability of the mining ventures. It therefore draws to itself, or in partnership with public authorities, the task of restoring the environment in areas that have been devastated. Finally, only two case studies mentioned that the Public Prosecutor's Office intervened to resolve problems related to the mining operations analysed in this chapter. One of the cases ended with the signing of a conduct adjustment agreement (TAC, for its acronym in Portuguese), whose function is precisely to ensure that the best practices of the mining sector are outlined and adopted in accordance with the legislation in effect and to deliver the socio-environmental development that society demands.

## 3 | NORTH-EAST REGION MINING IN THE NORTH-EAST REGION OF BRAZIL: CURRENT SITUATION AND PROSPECTS

Twenty percent of the case studies presented in this book, or 21 of the total of 105 cases, were conducted in the Brazilian north-east – a region with a long-standing tradition of mining. Over 50% of these mining operations have been operational for over 20 years. The population living near the operations studied reside in small cities with up to 50,000 inhabitants.

Among the negative impacts found in the studies, harm to human health came first, followed by labour-related problems and land issues. Water pollution also appears as an important negative impact on local ecosystems and is a challenge in the region. The north-east region has 27 of the largest mines in the country, which rank among the top 200 in Brazil. These include operations that exploit gold in Jacobina (BA), uranium in Caetité (Bahia, BA), potassium in Rosário do Catete (Sergipe, SE), talc in Brumado (BA) and copper in Jaguarari (BA) (MINÉRIOS & MINERALES, 2012).

In Jacobina, the gold mine managed by the Canadian-based Yamana Gold Group stands out. Uranium mining in Caetité is causing high levels of uranium uptake in the population: close to 100 times higher than the world average (PLATAFORMA DHESCA, 2013). In Brumado, magnesite and talc, together with other anthropic activities, were identified as being responsible for the environmental degradation of the Antônio River micro-basin. In Jaguariri, copper mining is contributing to the contamination of the Caatinga biome due to the release of sulphuric acid, copper waste and dust emissions. However, in Rosário do Catete, the introduction of state-of-the-art

technology in these mining activities has recently reduced their negative environmental impacts, as is the case of the potassium mine, where complex technology was developed for underground mining.

Of the 11 cases published in the book, four of the Local Productive Arrangements (APLs for their acronym in Portuguese) are in the North-East. The APLs contribute positively to local economies by increasing the number of jobs and improving family incomes (SOUZA et al., 2011). This was the case of the APL that produces opals in Pedro II (Piauí, PI), where its main benefit has been the changes introduced to working conditions and routines to make them safer. However, there are other APLs in the region that still employ practices that violate environmental regulations. For example, the APL for the exploration of ornamental stones in Jacobina is linked to problems such as deforestation, river sedimentation, the loss of water sources, alterations to water quality and quantity and waterborne diseases. Similar impacts have been found in Seridó Potiguar (Rio Grande do Norte, RN): there, although desertification caused by the region's climate had already existed, it has been exacerbated by mining activities.

In the state of Ceará, in the municipalities of Nova Olinda, Santana do Cariri, Crato and Barbalha, the APL was identified as the main industrial responsible for several negative environmental impacts, such as the accumulation of tonnes of waste on the riverbanks and in front of the APLs (SDE-CE, 2013).

Other noteworthy situations in the north-east region are the cases of abandoned mines and processing plants. The factors leading to the abandonment of small or informal mining

operations are: the lack of resources to acquire the equipment and machinery needed to mine further underground; the lack of a consumer market; and the depletion of minerals at more superficial levels, which generates the need for more advanced technologies (DNPM, 2009). However, there are cases where big mines are also abandoned, such as the ones in Boquira (BA) and the processing plant in Santo Amaro (BA), where the deserted mine and plant have left enormous liabilities, namely large amounts of toxic and hazardous waste. Part of the population of these municipalities, including former employees of the mining company, as well as the soil, sediments and the biota were contaminated by waste from the mines. Another important case is the closure of the asbestos mine in Bom Jesus da Serra and Simões Filho, Bahia, which left a trail of socio-environmental degradation. In addition to the open crater full of contaminated water, the local population suffers from illnesses caused by prolonged exposure to asbestos, such as cancer.

One of the case studies that do not involve mines directly is focused on the coal-fired thermal electric station in the municipality of São Gonçalo do Amarante (Ceará, CE). The use of coal as fuel impacts both human health and the environment, as it pollutes the atmosphere in the surrounding communities (RIGOTTO, 2009). References to negative environmental impacts caused by the release of sewage and industrial waste into the environment and engagement in subsistence activities were also found in the case studies conducted in Mossoró, Areia Branca, Grossos, Felipe Guerra, Apodi and Pau dos Ferros in the state of Rio Grande do Norte. What is more, these cases reveal that there is a lack of urban infrastructure to support industrial operations. Another notable case is the

atmospheric pollution in Simões Filho, where the production of manganese ferroalloys has direct impacts on the environment.

Illegal mining on indigenous land was found in the municipality of Centro do Guilherme (Maranhão, MA). The indigenous reserve is targeted by gold miners and groups involved in the illegal logging of native wood, while vegetable and/or animal species in the area are becoming extinct. In the state of Piauí, in the municipalities of Castelo do Piauí and Juazeiro do Piauí, the illegal extraction of ornamental stones has generated several negative socio-environmental impacts. Thus, the accumulation of waste released randomly into the environment proves to be a chronic problem in mining when it is carried out without adequate monitoring and supervision. This is the case of Pindobaçu and Campo Formoso, Bahia, where emerald mining has generated numerous negative environmental impacts.

Pressure exerted by local communities can force changes to be made to the original plans to reduce their negative impacts on the environment. This is the case of the industrial hub in São Luiz (MA) where there were plans to build three mineral processing and two pig iron plants. Pressure from social groups and organisations opposed to the venture's installation resulted in the investment being transferred to another location. In the case of Santa Quitéria (CE), as uranium-phosphate mining would obviously generate radioactive uranium waste, the plans for the mine were altered.

In Juazeiro (BA), deficiencies in infrastructure do not prevent the prospects of new mineral explorations in the locality. Negative impacts such as river sedimentation and inadequate waste disposal can generate losses in other economic sectors,

such as agriculture and animal rising. Seismic shocks generated by the rock explosion, compromising existing buildings and the atmospheric pollution, due to the dust from the mining activity, also worry residents.

These issues demonstrate the need for mining companies to incorporate principles of social responsibility into their activities. In addition to the spread of best practices, transparency is required when communicating the risks to the local community. The delivery of economic rewards, education and jobs to the population must be accompanied by professional training so that present and future generations can enjoy the benefits of the best practices. Therefore, there is a pressing need to develop socio-environmental technology that seeks to go beyond mitigating negative environmental impacts and to guarantee the population's well-being.

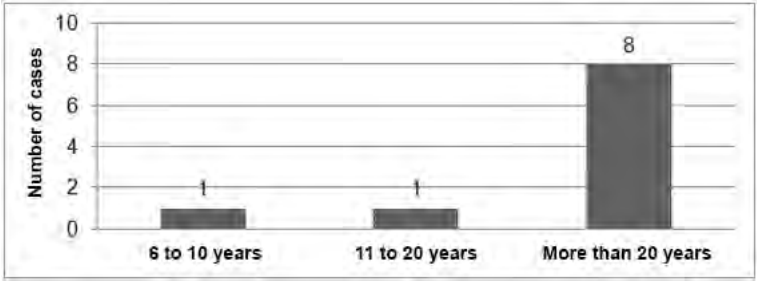
## 3.1 |The Profile of Mining in the State of Bahia

Bahia ranks fifth on the list of the country's largest producers of mineral goods. Thanks to the geological diversity of its territory, approximately 40 mineral substances can be mined there, namely, gold, aluminium and copper. It is also important to highlight that it leads the country in the production of uranium, chrome, magnesite and talc (SDE-BA, 2018).

Bahia has 367 producers, from which the ten largest correspond to 76% of the State's production. In 2017, the mining sector employed 15,4 thousand workers, whose production reached R$ 2,6 millions in ICMS, Imposto sobre a Circulação de Mercadorias e Serviços (ICMS stands for the Tribute over the Circulation of Goods and Services) (SDE-BA, 2018).

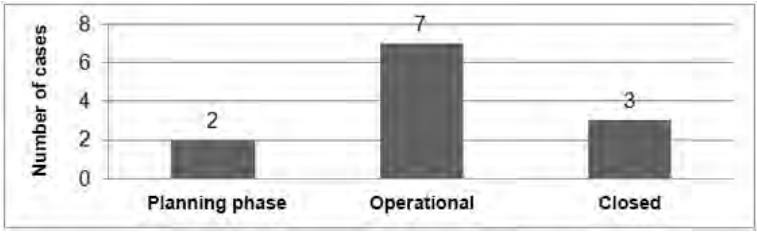
Furthermore, it still has a state-level public enterprise dedicated to research on and the development of processes for Bahia's mining sector: Companhia Baiana de Pesquisa Mineral (CBPM, Mineral Research Company of Bahia) (CBPM, 2018).

Among the 21 reports in this chapter that discuss mining in the state of Bahia, the date they began operations was found for 10 of them. The majority of the mining operations studied have been operational for over two decades (see graph 13).



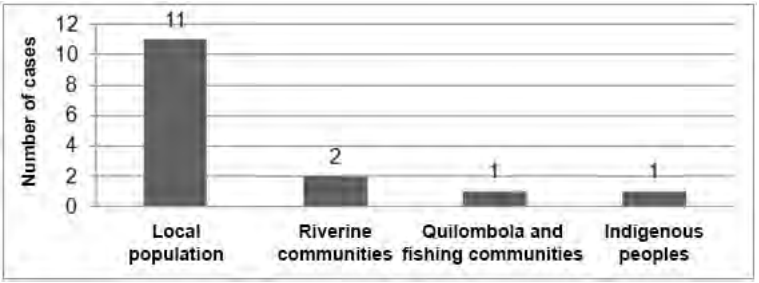

**Graph 13**. Years of operation of mining ventures in the state of Bahia.

Even though most of the case studies examine operations of the mining sector that are still active or in the planning phase, three reports focus on mines that have been closed (see graph 14).



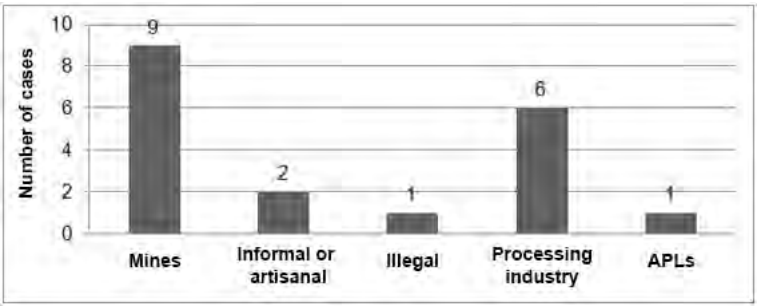

**Graph 14**. Status of operations of the mining sector in Bahia.

As for the residents negatively affected by mining activities in Bahia, the local urban population was identified as the main group affected, followed by riverine, quilombola and fishing communities and indigenous peoples (graph 15).



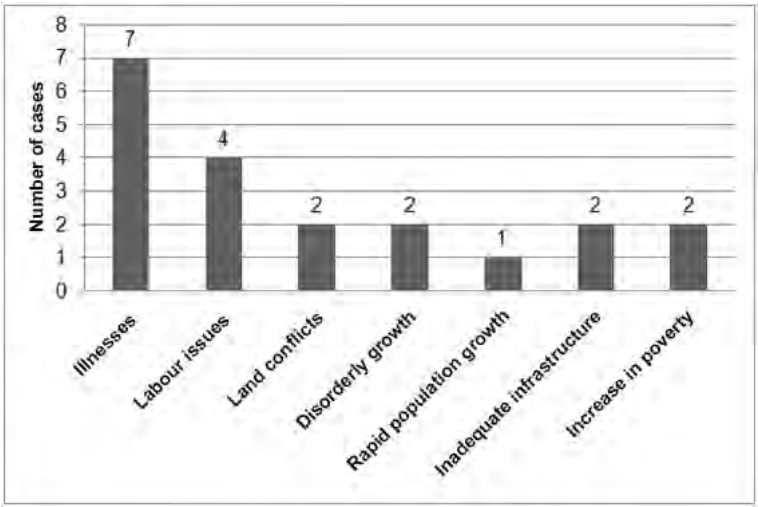

**Graph 15**. Populations affected by mining in the case studies on the state of Bahia.

The extractive and processing industries were the main objects of study in the cases analysed Bahia. However, there were also case studies done on illegal mining activities, informal or artisanal mining and Local Production Arrangements (APLs). Graph 16 illustrates the distribution of cases by activity.



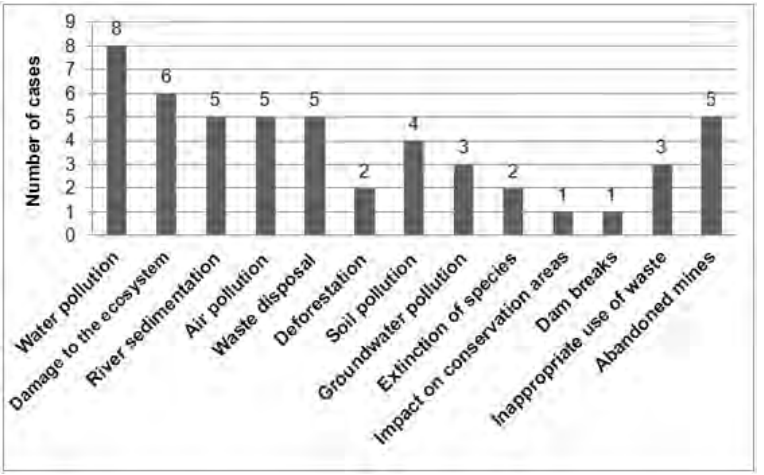

**Graph 16**. Classification of different productive activities related to mineral resources in the state of Bahia.

The main negative impacts of mining-related activities in Bahia that affect local communities are illnesses and work-related issues. The other half of the cases mention issues such as land conflicts, the increase in poverty among the population and problems linked to unplanned urban development, such as, for example, disorderly growth, rapid population growth and a lack of infrastructure (see graph 17).



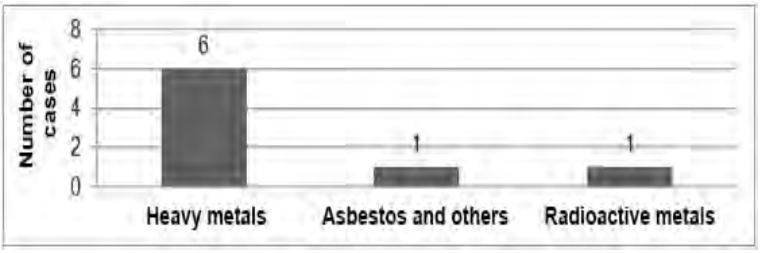

**Graph 17**. Negative impacts of mining in the state of Bahia.

In relation to the environment and mining in the state of Bahia, a range of negative impacts were found, which raises questions on the sustainability of these operations. Some important challenges must be overcome to mitigate or put an end to problems such water, air and soil pollution and river sedimentation and to ensure that mine closures are carried out in accordance with the law to avoid damage to local ecosystems. Graph 18 below presents a detailed overview of this situation.




**Graph 18**. Negative environmental impacts of mining identified in the case studies on Bahia.

One factor aggravating the environmental problems caused by mining in Bahia is the release of waste containing substances that are extremely hazardous to health into the environment. The most serious case was the presence of heavy metals identified in several case studies (see graph 19).




**Graph 19**. Types of contaminants from mining in the state of Bahia.

With the goal of linking mining in Bahia and economic development centred on the sustainability of these operations, the Public Prosecutor's Office was called on to intervene four times. However, only one case ended with the signing of a conduct adjustment agreement (TAC).

Mining plays a very important role in the state of Bahia's economy. Therefore, the expansion of this sector must also be guided by earlier experiences so as to reconcile sustainable development with the viability of this important economic sector.

## 4 | NORTH REGION SOCIOECONOMIC DEVELOPMENT CHALLENGES AND MINING IN THE NORTH OF BRAZIL

The north is the largest region in Brazil. It includes the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins. With an area of 3,853,677 km², 45% of the national territory, and is about the same size as the European part of Russia. However, the region's population was estimated at 17,9 millions in 2016, which makes it the least densely populated area of the country, with 4,7 inhabitants/km² (IBGE, 2018d).

The sociocultural diversity in the region is very distinct, as it is home to 39% of Brazil's indigenous population, who live in "Terras Indígenas" (TIs, or indigenous reserves), special territories recognized by the Federal Constitution of 1988 (Brazil, 1988). This percentage represents 342.836 individuals with languages, traditions and cultures that are different from one another and from the non-indigenous way of life (IBGE, 2018d).

Even though the indigenous people's ownership and use of the rivers, lakes and land is guaranteed, they are prohibited from exploiting water resources to generate energy and the mineral reserves on their land. The National Congress must hear the affected communities before it can authorize mining projects and hydroelectric dams in ITs; when it does, it must guarantee the indigenous people a share of the profits in accordance with the law (BRAZIL, 1988).

The media often reports on artisanal mining activities in ITs or nearby areas. It is also known that some indigenous communities are interested in legalizing mining activities on their land. There are still numerous applications for prospecting and mining permits in ITs that have been submitted to the

Departamento Nacional de Produção Mineral (DNPM, National Department for Mineral Production), which were frozen but are not extinct. Often, the conflicts between mining corporations, artisanal miners, and indigenous people end without reaching consensus and even in death in the most extreme cases of violence.

Eight of the 11 case studies that report on indigenous communities being affected by activities linked to mining are located in the northern region. Amazonas, Pará, Rondônia and Roraima are the states mentioned in the summaries on the conflicts or pressure on indigenous peoples related to the extraction of gold, iron, nickel, and diamonds.

Of the 105 case studies carried out throughout Brazil, the region merits special attention as 40% of the socioeconomic impacts listed in this book are concentrated there. This number indicates that in both large- and small-scale mining in the north, challenges remain in reconciling the development of mining with human development, which involves improvements to infrastructure, professional training and the reduction of economic and educational disparities among its inhabitants.

The north was the only region where incidents were registered in all sub-items of the socioeconomic impacts category. These situations range from harm to the population's health to working conditions analogous to slavery. Land issues, increased violence, and disorderly population growth were also identified.

In the north, approximately 20% of the people are not originally from the state in which they reside (IBGE, 2018b). In municipalities where artisanal or large mining operations exist, it is common to find a growing number of migrants who have left the countryside or their hometown in search of better

job opportunities and a life where they have access to basic public services such as health and education. Parauapebas (PA) is probably the best example of this situation, in which popular struggles are often demobilized when they come up against the rigidity of public authorities and the power that capital exerts in these societies (VERDE, FERNANDES, 2009).

Of the 450 municipalities in the north, the majority are linked to mining activities and the population does not exceed 50,000 inhabitants (IBGE, 2013a). In mining municipalities, the economy is not diversified and highly dependent on the mining industry. Most of the ventures listed in the case studies in this chapter have been operational for more than two decades, and are mines, steel mills, and other mining and metallurgy industries.

In 2015, the mining industry (excluding oil and natural gas) employed 177,827 workers in the entire country. The municipality of Parauapebas is the first in this ranking, employing alone 10,987 workers related to mineral activities, which corresponds to 15,6% of all royalties collected through the Compensação Financeira pela Exploração Mineral (CFEM, Financial Compensation for Mineral Exploration) (DNPM, 2018b).

In relation to environmental issues, the pollution of water resources tops the list of negative environmental impact confirmed in this chapter. This point deserves special attention, especially since the majority of the region is located in the basin of the Amazon River– the largest river in the world, both in terms of water volume and extension. Another major negative

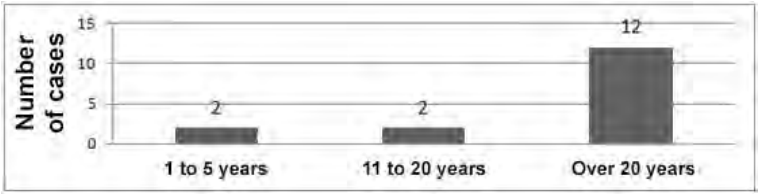
impact is deforestation, which is intensifying environmental degradation, and has repercussions not only on local ecosystems, but also on human life.

Despite the importance of its mineral reserves (primarily kaolin, tin, iron, manganese, graphite, aluminium, copper, nickel, and gold), the number of mining companies responsible for production in the north is small. In fact, it is the region with the lowest number in the country: 515 (IBRAM, 2018).

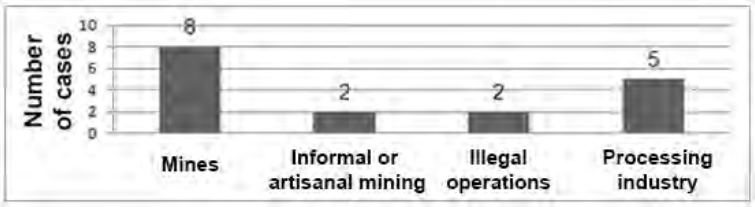
## 4.1 | Mining in Pará: an outstanding performance

The state of Pará deserves a special place in research on mining in the north of the country. Its economy is based mainly on mineral extractivism (especially iron, bauxite, manganese, limestone, gold, and tin), followed by vegetable extractivism, agriculture and livestock (PARÁ, 2013).

Mining operations are concentrated in the southeastern part of Pará state. Parauapebas and Canaã dos Carajás are the main mineral production cities and the city of Marabá stand out for their industrial mineral processing districts (PARÁ, 2013). Most of these undertakings have been operating for more than 20 years (graph 20). It is also important to mention that, in some cases, mining and other forms of illegal logging coexist with formal activities (graph 21).




**Graph 20**. The number of years that mining ventures have been in operation in the state of Pará.




**Graph 21**. Classifications of productive activities included in the case studies on mineral resources in the state of Pará.

It is no coincidence that, in 2012, the municipalities of Parauapebas and Canaã dos Carajás had the highest Gross Domestic Product (GDP) per capita in Pará, next to the state capital, Belém (figure 1). (IBGE, 2018b).

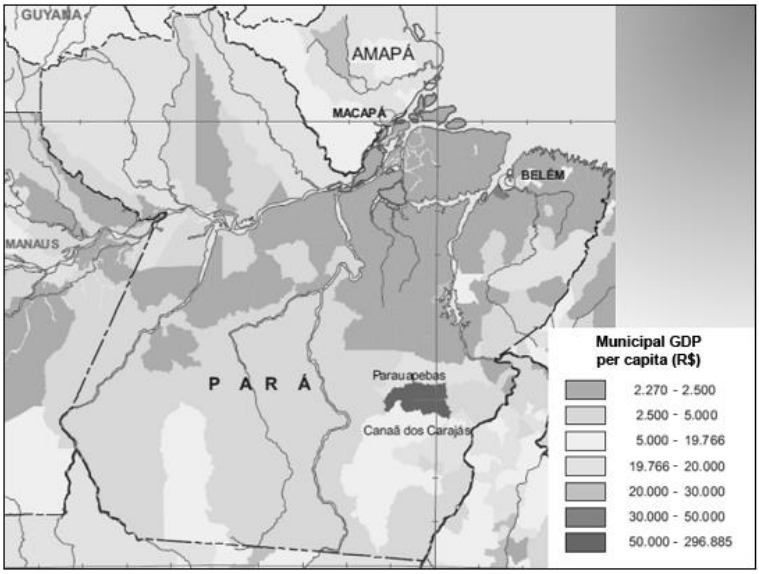


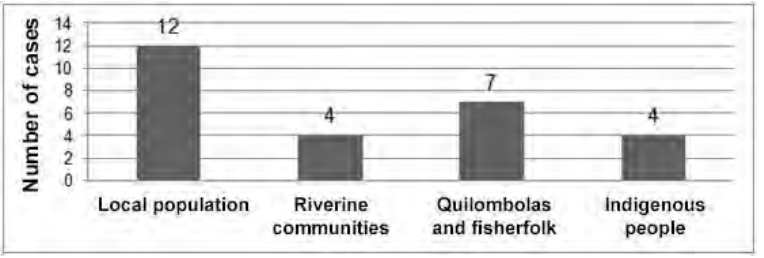

**Figure 1**. Distribution of GDP per capita per municipality in Pará (Adapted from IBGE, 2012).

Although the mining and processing industries' role in driving up economic indicators is notorious, it is important to note that the statistics on certain aspects evolve at a much slower rate. The 2010 demographic census noted, for example, that the richest 20% of the population of Parauapebas concentrates approximately 60% of the income at the expense of the poorest 20%, who receive only 3.5% of the income in the municipality. Altogether, 15% of Parauapebians are either on the poverty line or below the extreme poverty line (PNUD, 2013a).

The biggest mineral deposit in the world is in Parauapebas, and the exploitation of these resources is its main source of wealth (PARAUAPEBAS, 2013). However, public authorities must still overcome several barriers to make progress on socioeconomic development. Of the total population, 36% does not have access to drinking water and 54% does not have access to adequate sanitation services (PNUD, 2013a).

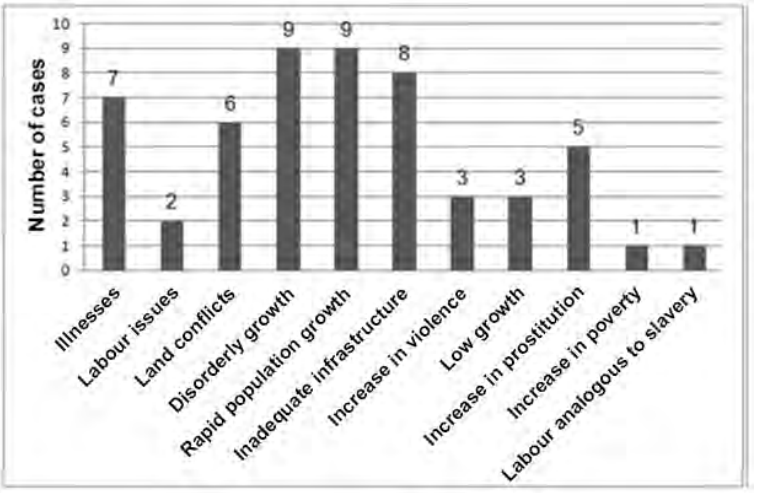
When we compare the Human Development Index (HDI) for Pará to that of other states, we find that mining contributes little to social advances in the state. Due to its low HDI (0.646), it comes in second last in the national ranking. Minas Gerais, on the other hand, which is also a mining state, is 9th on the HDI ranking. In 2011, Minas Gerais raised more funds through the CFEM than Pará: 51% of the national total (PNUD, 2013b).

Some of the people affected by the ventures in Pará are local population resident in urban areas or in the center of mining municipalities. But there are also others communities affected, like quilombola, fisherfolk, riverine and indigenous peoples (graph 22).




**Graph 22**. Types of population affected by mining in the case studies in the state of Pará.

These populations suffer mainly from the problems arising from the way mining operations are set up, which is still far from being as inclusive as it could be. This is where disorderly growth, rapid population growth, inadequate infrastructure, impoverishment, etc. emerge (graph 23).




**Graph 23**. Negative impacts of mining in the state of Pará.

The area of the Amazon region under pressure, known as the Arch of Deforestation, covers almost half of the state of Pará (figure 2). In this region, there is a concentration of not only agribusiness, but also old and new mining and metallurgical projects and demands from new hydroelectric plants. The research done for this chapter confirmed the damage that water pollution, inadequate waste disposal and other impacts caused by mining have done to the local ecosystem (graph 24).

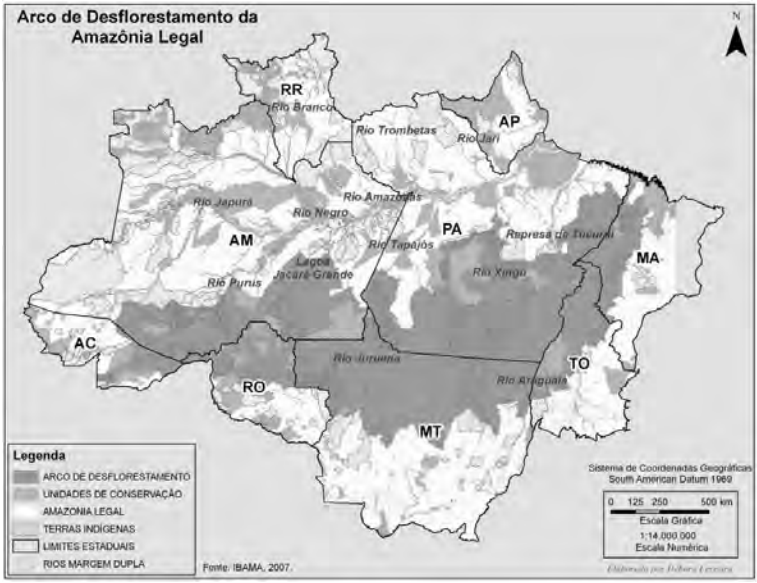
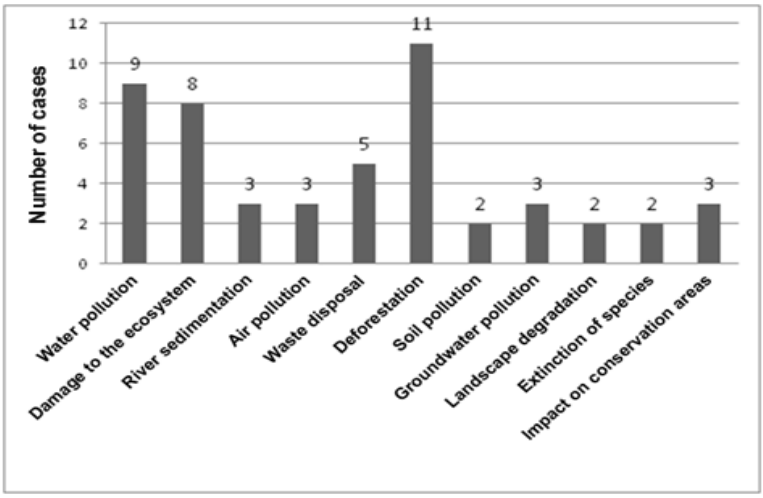
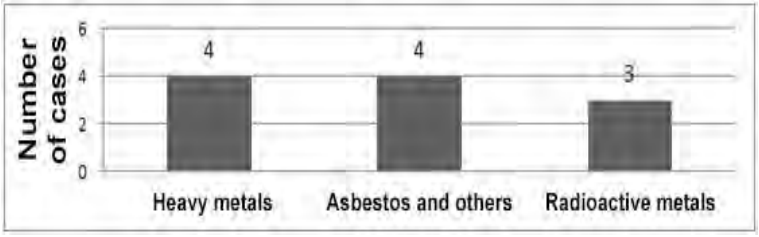



**Figure 2**. Arch of deforestation in the Legal Amazon area (IBAMA, 2007 apud FERREIRA, 2010).



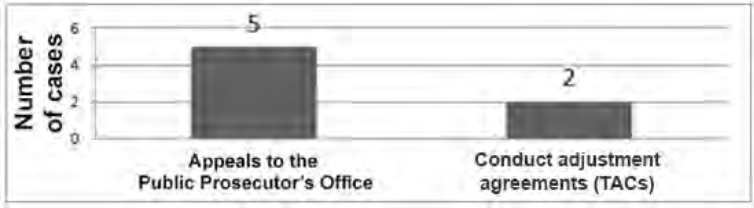

**Graph 24**. Environmental impacts from mining listed in the case studies from Pará.

In the case studies on Pará, there was mention of the naturally occurrence of heavy metals in ore, radioactive metals, and other potentially contaminating substances. This is a subject that merits further study, as the biome of the region is very sensitive and rich due to its great biodiversity, and due to concerns for the health of its resident population, especially the riverside communities (graph 25).




**Graph 25**. Types of pollution from mining in the state of Pará.

The Public Prosecutor's Office (PPO) had to be called on five times to force the miners to adopt good management and sustainability practices. Conduct adjustment agreements (Termo de Ajustamento de Conduta or TAC in Portuguese) – a document used by the PPO to adjust practices that do not comply with the law – have been signed twice, as shown in graph 26 below.




**Graph 26**. Case studies on conflicts resulting from mining in the state of Pará.

It should be highlighted that in relation to mining in the north of Brazil, important challenges remain for this sector, in which there has been a boom in investments in recent years. The governance of regional development seeks to drive mining in a way that advances in parallel to the demands of the local community.

Mining operations are capable of bringing benefits to the population in the municipalities where they exist. Doing so, however, depends on the government's commitment to the diversification of the economy and the construction of the infrastructure necessary to provide efficient transport modes, education, technological training, and health and sanitation services. These premises are capable of not only generating positive repercussions on and accelerating human development, but also minimizing the negative social and environmental impacts of mining.

## 5 | SOUTH-EAST REGION THE IMPORTANCE OF MINING IN THE SOUTH-EAST REGION

According to the Departamento Nacional de Produção Mineral (DNPM, National Department for Mineral Production), there are 8,870 mining companies in the country. In the south-east region, this number reaches 3,609, which is close to 40% of the total (IBRAM, 2018).

In 2018, Brazil has a population of 207 million inhabitants. With a population of approximately 85 million (IBGE, 2018), the main minerals in the region include iron ore, gold, manganese and bauxite in the Iron Belt; niobium and phosphate in Araxá; gems in Governador Valadares; and graphite in Salto da Divisa – all in the state of Minas Gerais. Aggregates are also mined in the states of São Paulo and Rio de Janeiro, and ornamental stones in the state of Espírito Santo (IBRAM, 2018).

The south-east region has been receiving waves of immigrants from other regions and abroad since the 18th century. It was the mining industry that began attracting people to the area.

Thirty-four of the case studies presented in this book were conducted in this region. Minas Gerais is the state with the highest number of cases (20), followed by Rio de Janeiro (9), São Paulo (4) and Espírito Santo (1).

Minas Gerais leads mining in Brazil. With mining activities in over 250 municipalities and more than 300 mines in operation, the state is home to 40 of the 100 biggest mines in Brazil. Furthermore, of all the Brazilian municipalities in which the largest mining operations are located, seven are in Minas Gerais; in which Itabira is the biggest in the country. The state

accounts for approximately 53% of the metallic minerals produced in Brazil and 29% of all minerals, and more than 160 million tonnes of iron ore per year (IBRAM, 2018).

The majority of the operations in the south-east region identified in this study are active, whereas 16% have ceased operations. Another 16% are still in the project phase and only 3% are currently paralysed due to social opposition. Over half of the mining ventures extend over more than one municipality, sometimes within the same state, but not always. Virtually all these operations have been established by mining companies and mineral processing corporations (such as cement kilns, steel and iron plants and mines) and many have been operational for over 20 years.

As for the population involved in mining operations in the region, the majority of the municipalities that host mining ventures are classified by the IBGE[4] as small (54%), followed by large (29%) and medium-sized ones (10%). Furthermore, in this region, mining operations involve people living in urban areas, as well as traditional (quilombola, artisanal fishing, forest products collectors, etc.) and riverine communities.

Based on the analysis of the case studies, we were able to identify the main negative socioeconomic and environmental impacts caused by inadequate mining practices that have affected the local communities. The main socioeconomic issue raised was harm to the population's health (respiratory, skin, heart and other diseases). After that, the most common complaints appear to be of equal importance and one can say

[4] The IBGE classifies municipalities with up to 50,000 inhabitants as small; those with 50,000 to 100,000 as medium-sized; and the ones with over 100,000 inhabitants as large.

that they are correlated: here, uncontrolled growth and, consequently, the rapid increase in the population stand out. As a result, the existing infrastructure is insufficient to respond to the demands of a growing number of people. Other problems found were labour-related and land issues, the increase in violence and the use of child labour.

The principal negative environmental impacts observed in the region were water and air pollution and harm to local ecosystems. In second place, we found river sedimentation, inadequate disposal of waste and soil contamination. Groundwater pollution, impacts on landscape and the extinction of vegetal and animal species were also common. Reports of deforestation, dam breaks, operations in environmental protection areas, inadequate use of waste and the illegal extraction of native wood were less frequent.

Finally, problems of contamination caused by the release of hazardous substances into the environment appeared in the cases. Most reports are related to the contamination of heavy metals. In second place, we find cases of contamination of "natural" hazardous substances, such as asbestos, and contamination from substances used or released during industrial processes (cyanide, ammonia, nitrates, etc.) and/or during the amalgamation process (mercury). There are also reports of contamination of radioactive materials.

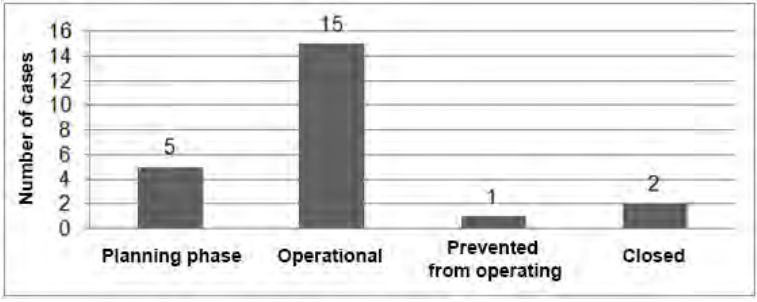
In over half of the cases studied, the Public Prosecutor's Office actively intervened. In some, reports on the socioeconomic or environmental problems caused by mining operations led to the signing of conduct adjustment agreements (TACs for their acronym in Portuguese) in which the parties involved committed to adapt their practices in order to meet legal requirements.

In light of the above, it is clear that there is still much to do to achieve sustainable development and contribute to the well-being of and improve to the quality of life of the communities living near mining operations.

## 5.1 |The Thriving Mining Sector in Minas Gerais

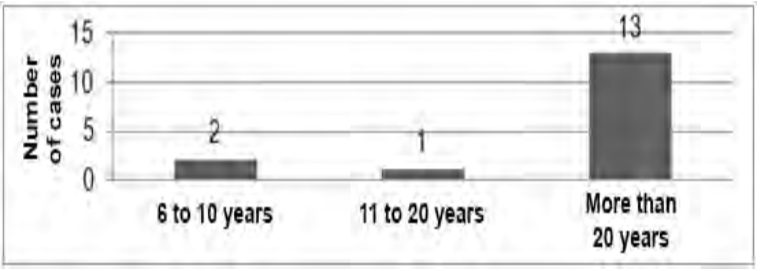
Mining in the state of Minas Gerais has great historical importance due to its contribution to the culture, history, geography and economy of the country. The production of mineral goods in Minas is growing and there is evidence that major deposits of iron ore, gold, diamonds, phosphate, zinc, aluminium, limestone and ornamental stones exist in the state. The state accounts for approximately 30% of the national production of metallic and non-metallic minerals, putting it in the lead of the production of these substances in Brazil

According to the case studies, the majority of mining operations in Minas Gerais today are active. There are new projects in the pipeline for the mining sector, which are likely to be added to the ones that are currently operational (see graph 27).



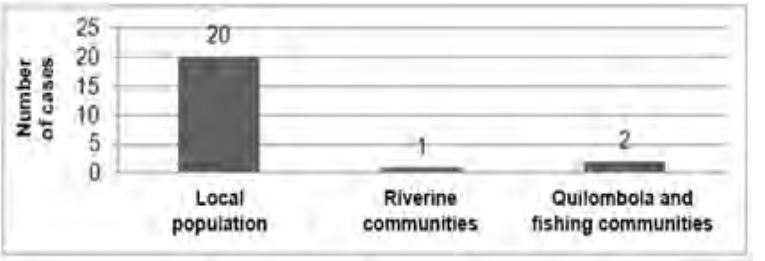

**Graph 27**. Status of the operations of the mining sector in the state of Minas Gerais.

The mining ventures referred to in the case studies date back at least five years. The majority have been operating for over 20 years. Minas Gerais has a long-standing mining tradition (graph 28).




**Graph 28**. Years of operation of mining ventures in the state of Minas Gerais.

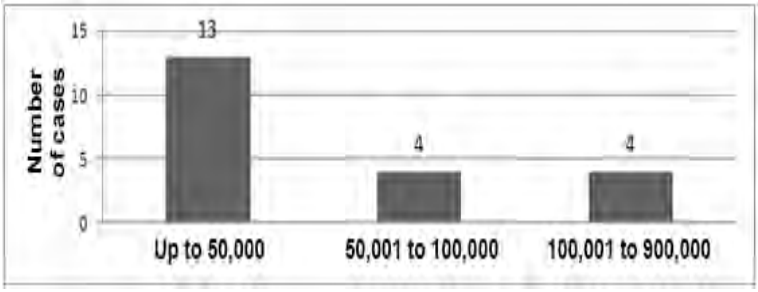
The exploitation of mineral resources has mainly affected local populations in urban areas, although impacts on riverine, fishing and quilombola communities were also found (graph 29).



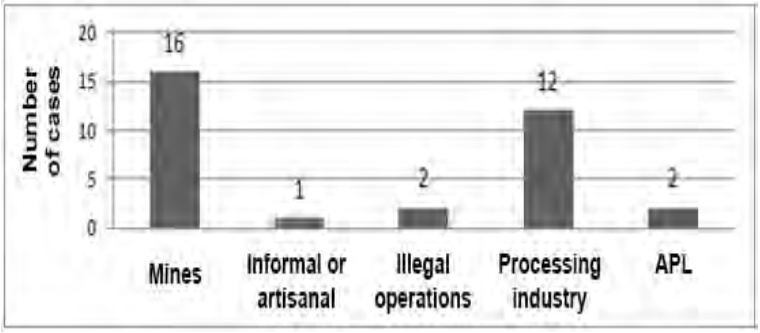

**Graph 29**. Population affected by mining in the case studies conducted in the state of Minas Gerais.

Most the mining cities that were the object of study for this chapter are small in size. The remaining cities studied are divided up between medium-sized and big cities, as illustrated in Graph 30.

The Graph 31 below presents an overview of the main productive activities of the mining sector in Minas Gerais, in which mines and mineral processing stand out.




**Graph 30**. Number of inhabitants of the municipalities hosting mining operations in Minas Gerais.




**Graph 31**. Classification of the different productive activities in the mining sector in the state of Minas Gerais.

Figure 3 illustrates the spatial distribution of mineral resources in not only the state of Minas Gerais, but also the entire south-east region. The main mineral mined in Minas Gerais is iron ore (MINAS, 2013). Vale (the former Companhia Vale do Rio Doce) is the main corporation involved in the production of iron ore in the state.

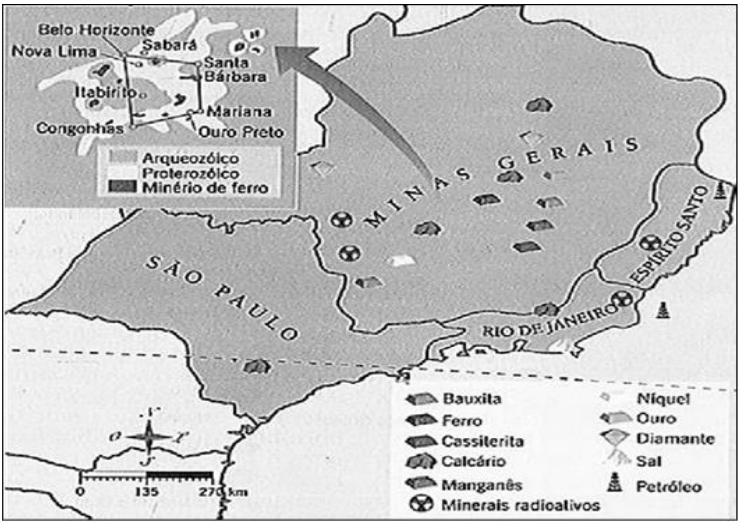



**Figure 3**. Geographic location of the main mineral resources and the Iron Belt in the state of Minas Gerais (and other states in the south-east region) (FONTANAILLES, 2011).

Vale is present in the municipality of Mariana, in the Iron Belt, and the mining complexes in Itabira and in central and western Minas. Approximately US$1.1 billion were invested in Brucutu alone, which is the largest iron ore mine and processing complex in the world in terms of its initial productive capacity (30 million tonnes of iron ore/year). This facility has the potential to employ up to 2,500 workers. Brucutu is located 93 km from the state capital, Belo Horizonte, in the municipality of São Gonçalo do Rio Abaixo (MINAS, 2013; VALE, 2009).

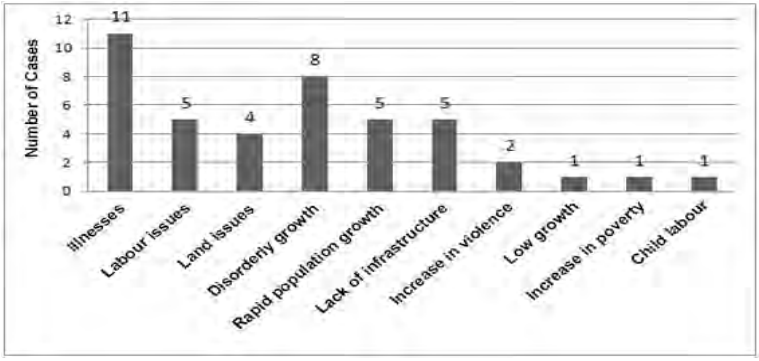
Mining and metallurgy (iron and metallurgy of zinc, niobium and aluminium, foundry and ferroalloy) are the main components in the chain of production in Minas Gerais (MINAS, 2013).

The state is the largest employer in the mining sector (53,791 workers in 2011) and has a considerable lead on other states. São Paulo, the second largest employer, did not surpass the 19,000 employees mark in 2011 (DNPM, 2012).

A severe event occurred in 2015 with the iron mining dam rupture from Samarco in Mariana-MG, causing serious human, social and environmental impacts. These impacts persist until today.

However, the case studies in Minas Gerais revealed various problems caused by the extraction and/or processing of mineral resources. Graph 32 below presents an overview of the negative impacts identified.

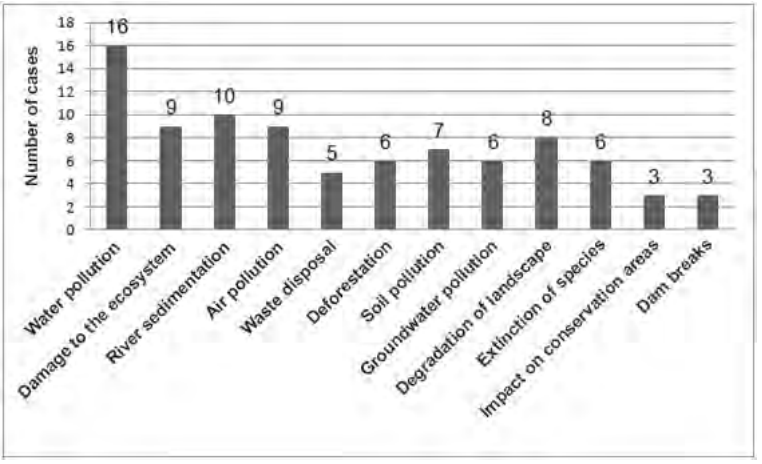
Health problems were the negative impacts that appeared repeatedly in the case reports. Disorderly growth comes in next, which is commonly linked to inadequate urban infrastructure, rapid population growth (often caused by migratory flows) and land issues. Labour-related problems and the increase in violence were identified as some of the most evident social problems.




**Graph 32**. Negative impacts associated with mining in the state of Minas Gerais.

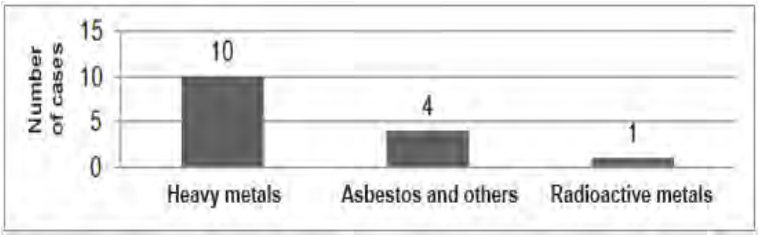
The negative environmental impacts in Minas Gerais are relatively complex due to the number of issues raised in the reports. Problems related to water resources are the most common ones (such as the pollution of rivers and groundwater and river sedimentation). Air pollution is another aspect that raises questions on the sustainability of the operations studied (graph 7).

Damage to local ecosystems, the loss of species and drastic changes to landscape are some of the main negative consequences that the mining sector's operations can cause and that must be mitigated or resolved definitively. Irregular waste disposal, deforestation and soil contamination are other impacts found in Minas Gerais (graph 33).



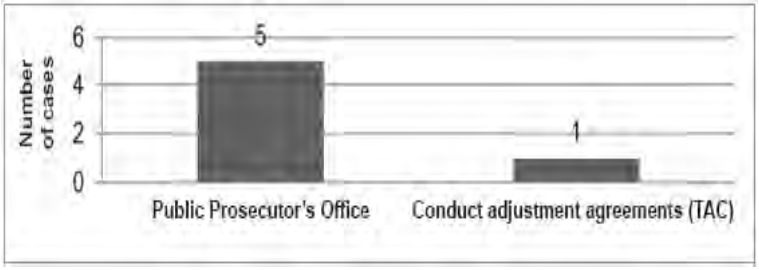

**Graph 33**. Negative environmental impacts of mining listed in the case studieson the state of Minas Gerais.

Heavy metals were the contaminants mentioned the most in the case studies on mining activities in the state of Minas Gerais. The other third of contaminants cited are radioactive metals and various substances, such as asbestos (graph 34).




**Graph 34**. Case studies on the impacts caused by contamination of hazardous substances as a result of mining in the state of Minas Gerais.

In the attempt to remedy the negative impacts caused by mining on the environment and society in Minas Gerais, the Public Prosecutor's Office has been called on to intervene. In five cases, these interventions led to the signing of a conduct adjustment agreement (graph 35).




**Graph 35**. Case studies on conflicts resulting from mining operations: recourse to the Public Prosecutor's Office and TACs in the state of Minas Gerais.

## 6 | SOUTH FROM COAL TO PRECIOUS STONES: THE SOUTHERN REGION

With an area of 576,774,310 km2, the southern region is the smallest in the country: it occupies close to 7% of the Brazilian territory. Formed by the states of Paraná, Santa Catarina and Rio Grande do Sul, it has a population of 29 million people, according to IBGE estimates for 2013 (IBGE, 2013).

Even though it is the smallest region in Brazil, according to the Departamento Nacional de Produção Mineral (DNPM, National Department for Mineral Production), close to 25% (2.065) of mining companies in the country have operations there. Thus, it ranks second, behind the south-east region. Of the 233,466 jobs in the mining industry, the region accounted for 7% (IBRAM, 2018).

In the South, there are mineral deposits of amethyst, aggregates, gold and kaolin in Rio Grande do Sul; coal (mainly in Criciúma) and kaolin in Santa Catarina; and talc (in Ponta Grossa), kaolin and gold in Paraná (IBRAM, 2012).

Rio Grande do Sul is the second largest producer of precious stones in Brazil, coming in behind Minas Gerais. The areas that produce the most gem stones are: the Médio Alto Uruguai region, close to the border of the state of Santa Catarina, where deposits of amethyst are found, and the Lajeado – Soledade – Salto do Jacuí region in the centre of the state, which is rich in agate (BRANCO; GIL, 2002). The extraction of these stones has become a tourist attraction: tours that explore the chain of production of the gemstones, especially amethyst, have been set up, which lead tourists through visits to the mine, the different extraction phases, to the polishing and sale of the stones (SETUR, 2013).

The state of Rio Grande do Sul is home to close to 90% of the country's coal reserves, while Santa Catarina and Paraná have close to 10% and 0.5%, respectively. Even though Brazil's reserves are in 10th place on the global ranking, they correspond to less than 1% of the world's total reserves (ANEEL, 2009). The largest coal deposits are in Rio Grande do Sul (RS) and Santa Catarina (SC). The deposit in Candiota (RS) contains38% of all coal in the country (ANEEL, 2009; IBRAM, 2018).

In this book, there are 10 reports on the south region: five in Paraná, four in Rio Grande do Sul and one in Santa Catarina. Four of them discuss coal, two are on lead and the other four are on gold, copper, gemstones and phosphate rock.

One can say that environmental issues, which were previously ignored, are starting to be taken seriously. An indication of this are the two reports on mining ventures that have been prevented from being set up in the region by popular protest and legal actions drawing attention to environmental issues. In the municipality of Anitápolis (SC), a preliminary environmental permit (Licença Ambiental Prévia or LAP in Portuguese) issued for the installation of a phosphate mine was suspended by a federal court injunction. In Mauá da Serra (PR), the courts suspended the operating permit of a lead recycling plant because of flaws in its environmental protection plans.

In the majority of the other case studies, the mining ventures in question have been operating for over 20 years and are described as processing industries, such as steel plants and thermal power plants, among others. They are also established in more than one municipality.

The population that coexists with the mining operations studied in this chapter live in small municipalities. The main socioeconomic impacts identified in the region include harm to people's health. This is the case of the municipality of Candiota (RS), where residents are exposed to residue from coal burned by the thermal power plants. Another negative impact is the growing poverty among the population, as was the case in the municipality of Caçapava do Sul (RS) due to the closing of the mine. As a result of the closure, people moved out of the area. Land issues were also mentioned.

It is worth recalling that coal is one of the most aggressive ways of producing energy for the environment. Even if its extraction and use generate economic benefits, the production, mining and burning processes have important socioenvironmental impacts (ANEEL, 2009).

One of the environmental issues raised was inadequate waste disposal, which leads to the contamination of water sources. This was the case in São Martinho da Serra (RS), where researchers found that informal mining was having direct impacts on the quality of the water in the Ibicuí Mirim river basin. Soil pollution is another problem: for example, mercury contamination from informal or artisanal gold mining operations in Lavras do Sul (RS). River sedimentation is also an issue in the region due to the construction of tailings dams. Furthermore, there are reports of atmospheric pollution caused by an old lead plant in Adrianópolis (PR), as well as problems linked to abandoned mines and dam breaks.

Also in relation to the environment, there were nine reports of contamination from toxic substances. Of the nine, six were due to heavy metals. One case involved mercury from informal or

artisanal gold mining in Lavras do Sul (RS), and another three were on arsenic in Vale do Ribeira (PR/SP), Figueira (PR) and the region of the Complexo Estuarino da Baía de Paranaguá (Paranaguá Estuarine Complex, PR).

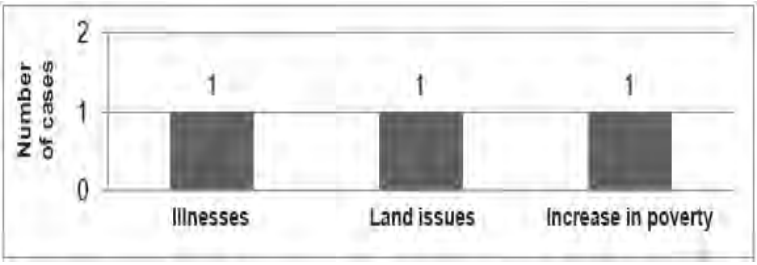
## 6.1 | Mining in Rio Grande do Sul

The state of Rio Grande do Sul has the fourth highest gross domestic product (GDP) in the country

(R$ 296 billion 2012), placing behind São Paulo, Rio de Janeiro and Minas Gerais. Most of the state's economic strength comes from the services and industrial sectors (RIO, 2013). The state still has control over the state mining enterprise, the Companhia Riograndense de Mineração (CRM), which owns three billion tonnes of coal with mining potential and the main destination of the coal mined is the coal-fired power stations (CRM, 2013).

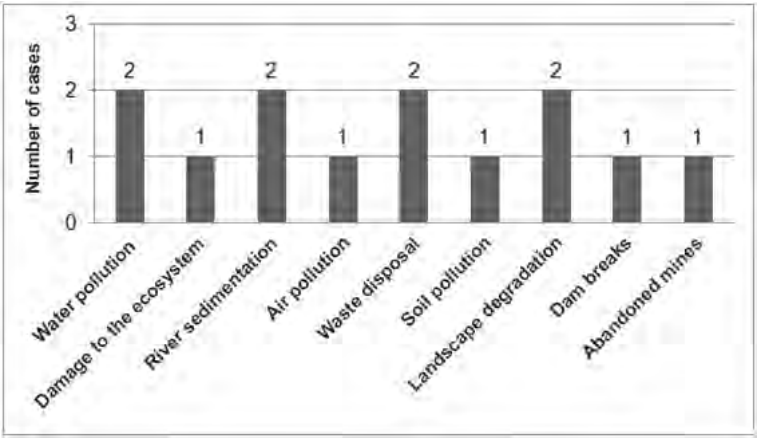
All the mining operations in the case studies conducted in this state have been operating for over 20 years, except one. Mining ventures that exploit coal, gold, copper and gem stones are discussed in this chapter. Productive activities include mines, informal mining operations, local productive arrangements (APLs), the processing industry and thermal power stations.

The affected peoples live in the urban centres of the municipalities where the operations are situated and neighbouring cities. With regards to the demographics of these localities, none of the cases were carried out in cities with more than 50,000 inhabitants. The negative impacts noted were land issues and the increase in poverty among the population (see graph 36).



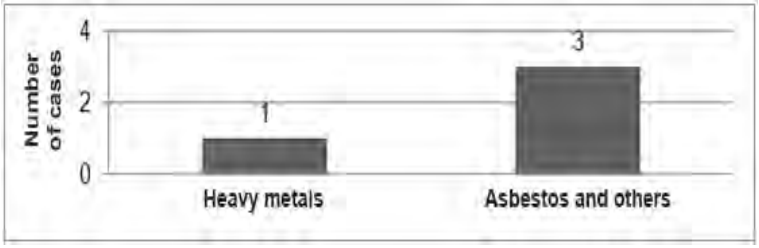

**Graph 36**. Negative impacts associated with mining in the state of Rio Grande do Sul.

Frequently reported environmental problems are linked to water resources (pollution and the sedimentation of rivers), waste disposal and degradation of the landscape. Abandoned mines, dam breaks and soil and air pollution were also identified (see graph 37 below).




**Graph 37**. Negative environmental impacts of mining identified in the case studies on Rio Grande do Sul.

As for pollution-related problems, graph 38 identifies asbestos and other substances that are intrinsic to the geology of the areas exploited by the mining industry in Rio Grande do Sul as the contaminants present in most cases. It is therefore urgent that mining technology and best management practices be adopted to resolve the situation in exploited areas that have suffered from contamination.




**Graph 38**. Case studies on the impacts generated by the contamination of hazardous substances resulting from mining.

Of all the reports on Rio Grande do Sul, it was noted that the Public Prosecutor's Office was called on to intervene only twice. However, neither of the cases ended with the signing of a conduct adjustment agreement (Termo de Ajustamento de Conduta or TAC in Portuguese).

## BIBLIOGRAPHIC REFERENCES

AMARAL, J.E.; KREBS, A.S.; PAZZETTO, M.B. Mapeamento de bocas de minas abandonadas na região Carbonífera de Santa Catarina. In: CPRM, Serviço Geológico do Brasil. 44º Congresso Brasileiro de Geologia, 26-31 Oct. 2008. Available at: <http://www.cprm.gov.br/publique/media/evento_0537.pdf>. Accessed on: 2 Aug. 2013.

ANEEL, Agência Nacional de Energia Elétrica. Atlas de energia elétrica do Brasil. Carvão mineral. 2009. Available at: <http://www.aneel.gov.br/arquivos/PDF/atlaspar3cap9.pdf>. Accessed on: 8 Oct. 2013.

BRANCO, P.M.; GIL. C.A.A. Mapa gemológico do estado do Rio Grande do Sul. Porto Alegre: CPRM, 2002. Available at: <http://www.cprm.gov.br/arquivos/pdf/recmin/pedrainforme5.pdf>. Accessed on: 8 Oct. 2013.

BRASIL. Constituição da República Federativa do Brasil de 1988: Capítulo VIII, Artigo 231. Brasília, 5 de outubro de 1988. Available at: <http://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm>. Accessed on: 03 Oct. 2013.

BRAZIL. Resolução Conama n. 001, 23 January 1986. Dispõe sobre critérios básicos e diretrizes gerais para a avaliação de impacto ambiental. Diário Oficial [da] República Federativa do Brasil, Brasília, DF, 17 Feb. 1986. Available at: <http://www.mma.gov.br/port/conama/legiabre.cfm?codlegi=23>. Accessed on: 24 Jul. 2013.

BRAZIL. Resolução Conama n. 237, 19 December 1997. Regulamenta os aspectos de licenciamento ambiental estabelecidos na Política Nacional do Meio Ambiente. Diário Oficial [da] República Federativa do Brasil, Brasília, DF, 22 Dec. 1997. Available at: <http://www.mma.gov.br/port/conama/legiabre.cfm?codlegi=237>. Accessed on: 24 Jul. 2013.

CBPM, Companhia Baiana de Pesquisa Mineral. Institucional. 2018. Available at: <http://www.cbpm.ba.gov.br/modules/conteudo/conteudo.php?conteudo=6>. Accessed on: 8 Aug. 2018.

CORUMBÁ, Prefeitura. Dados econômicos. 2013. Available at: <http://www.corumba.ms.gov.br/site/corumba/2/dados-economicos/11/>. Accessed on: 21 Oct. 2013.

CRM, Companhia Riograndense de Mineração. 2013. Available at: <http://www.crm.rs.gov.br/conteudo/909/?Historico#.UmgNOfnryWY>. Accessed on: 22 Oct. 2013.

DNPM - Departamento Nacional de Produção Mineral. Maiores arrecadadores CFEM. [online]. 2018b. Available at: <https://sistemas.dnpm.gov.br/arrecadacao/extra/Relatorios/cfem/maiores_arrecadadores.aspx>. Accessed on: 8 Jul. 2018.

DNPM - Departamento Nacional de Produção Mineral. SMB - Sumário Mineral Brasileiro 2016. 131 p. 2018a. [ISSN 0101 2053]. Available at: <http://www.anm.gov.br/dnpm/publicacoes/serie-estatisticas-e-economia-mineral/sumario-mineral/sumario-mineral-brasileiro-2016>. Accessed on: 8 Jul. 2018.

DNPM, Departamento Nacional de Produção Mineral. Mineração no semiárido brasileiro. Brasília: DNPM. 2009. Available at: <http://www.dnpm.gov.br/mostra_arquivo.asp?IDBancoArquivoArquivo=3194>. Accessed on: 23 Jul. 2013.

DNPM, Departamento Nacional de Produção Mineral. Sumário mineral 2012. v. 32. Brasília, 2012. p. 19-24. Available at: <https://sistemas.dnpm.gov.br/publicacao/mostra_imagem.asp?IDBancoArquivoArquivo=7366>. Accessed on: 30 Sep. 2013.

EJATLAS. EJAtlas: Environmental Justice Atlas – mapping environmental justice. [online]. Available at: <http://ejatlas.org/>. Accessed on: 30 Jan. 2018.

ENRIQUÉZ, M.A.R.S.; FERNANDES, F.R.C.; ALAMINO, R.C.J.A mineração das grandes minas e as dimensões da sustentabilidade. In: FERNANDES, F.R.C.; ENRIQUÉZ, M.A.R.S.; ALAMINO, R.C.J. (Eds.). Recursos minerais e sustentabilidade territorial. v. 1, Grandes minas. Rio de Janeiro: CETEM/MCTIC, 2011. Available at: <http://www.cetem.gov.br/publicacao/livros/Vol1_GRANDES_MINAS_TOTAL.pdf>. Accessed on: 30 Sep. 2013.

FERNANDES, F.R.C.; LIMA, M.H.R.; TEIXEIRA, N.S. A Grande Mina e a Comunidade: Estudo de caso da Grande Mina de Ouro de Crixás em Goiás. Rio de Janeiro: CETEM/MCT, 2007b. 96p. Available at: <http://mineralis.cetem.gov.br/handle/cetem/242>. Accessed on: 8 Aug. 2018.

FERNANDES, F.R.C.; LIMA, M.H.R.; TEIXEIRA, N.S. Grandes Minas e Comunidades: algumas questões conceituais. Rio de Janeiro: CETEM/MCT, 2007a. 58p. Available at: <http://mineralis.cetem.gov.br/handle/cetem/243>. Accessed on: 8 Aug. 2018.

FERREIRA, D. Arco de desflorestamento da Amazônia. [online]. 22 Oct. 2010. Available at: <http://mapeandonarede.blogspot.com.br/2010/10/arco-de-desflorestamento-da-amazonia.html>. Accessed on 18 Oct. 2013.

FIOCRUZ; FASE. Mapa de conflitos envolvendo injustiça ambiental e saúde no Brasil. (online). Available at: <https://www.conflitoambiental.icict.fiocruz.br/>. Accessed on: 30 Jan. 2018.

FONTANAILLES, G. Estrutura geológica brasileira. 8 Nov. 2011. Available at: <http://geografalando.blogspot.com.br/2011/11/aula-estrutura-gelogica-brasileira.html>. Accessed on: 4 Nov. 2013.

GESTA - Grupo de Estudos em Temáticas Ambientais. Obsertavório de Conflitos Ambientais - Mapa de conflitos ambientais de Minas Gerais. (online). Available at: <http://conflitosambientaismg.lcc.ufmg.br/>. Accessed on: 30 Jan. 2018.

IBGE - Instituto Brasileiro de Geografia e Estatítisca. Marabá-PA. [online]. 2018a. Available at: <https://cidades.ibge.gov.br/brasil/pa/maraba/panorama>. Accessed on: 7 Jul. 2018.

IBGE - Instituto Brasileiro de Geografia e Estatítisca. Pará. [online]. 2018b. Available at: <https://cidades.ibge.gov.br/brasil/pa/panorama>. Accessed on: 7 Jul. 2018.

IBGE - Instituto Brasileiro de Geografia e Estatítisca. Parauapebas-PA. [online]. 2018c. Available at: <https://cidades.ibge.gov.br/brasil/pa/parauapebas/panorama>. Accessed on: 7 Jul. 2018.

IBGE - Instituto Brasileiro de Geografia e Estatítisca. População. [online]. 2018d. Available at: <https://www.ibge.gov.br/estatisticas-novoportal/sociais/populacao.html>. Accessed on: 7 jul. 2018.

IBGE, Instituto Brasileiro de Geografia e Estatística, Diretoria de Pesquisas, Coordenação de População e Indicadores Sociais. NOTA: Estimativas da população residente com data de referência 1 de julho de 2013. Available at: <http://www.ibge.gov.br/home/estatistica/populacao/estimativa2013/estimativa_dou.shtm>. Accessed on: 10 Sep. 2013.

IBGE, Instituto Brasileiro de Geografia e Estatística. Contas Nacionais número 39. Produto Interno Bruto dos municípios 2010. Rio de Janeiro: 2012, pp. 34. Available at: <http://biblioteca.ibge.gov.br/visualizacao/livros/liv62930.pdf>. Accessed on: 15 Oct. 2013.

IBGE, Instituto Brasileiro de Geografia e Estatística. Perfil dos Estados. [online]. 2013a. Available at: <http://www.ibge.com.br/estadosat/>. Accessed on: 30 Sep. 2013.

IBGE, Instituto Brasileiro de Geografia e Estatística. Sistema IBGE de Recuperação Automática – SIDRA. 2013b. Available at: <http://www.sidra.ibge.gov.br/>. Accessed on: 30 Sep. 2013.

IBRAM, Instituto Brasileiro de Mineração. Informações da economia mineral brasileira. 2018. Available at: <http://www.ibram.org.br/sites/1300/1382/00005836.pdf>. Accessed on: 3 Aug. 2018.

IBRAM, Instituto Brasileiro de Mineração. Informações e análises da economia mineral brasileira. 7ª edição, Brasília/DF: 2012. Available at: <http://www.ibram.org.br/sites/1300/1382/00002806.pdf>. Accessed on: 30 Sep. 2013.

IBRAM, Instituto Brasileiro de Mineração. Informações da Economia Mineral. Belo Horizonte: IBRAM, 2018.

MINAS Gerais, Governo do estado. Mineração: O maior e mais tradicional estado minerador do Brasil. 2013. Available at: <http://www.exportaminas.mg.gov.br/madeinminas/mineracao.aspx#>. Accessed on: 4 Nov. 2013.

MINÉRIO & MINERALES. 200 maiores minas brasileiras. São Paulo: Lithos Ed. Ltda., 2017. Available at: <http://www.revistaminerios.com.br>. Accessed on: 8 Aug. 2018.

OCMAL - Observatorio de Conflictos Mineros de América Latina. (online). Available at: <https://www.ocmal.org/>. Accessed on: 29 Jan. 2018.

PAIVA, C.T. Proposta de metodologia para análise de passivos ambientais da atividade minerária. Ministério de Minas e Energia - MME. 2006. Available at: <http://www.mma.gov.br/port/conama/reuniao/dir934/RelatConsultoriaApresentaoMME_PassivosAmbientais.pdf>. Accessed on: 24 Jul. 2013.

PAIXÃO, M.R.; QUEIROZ, R.M. Impactos ambientais e danos humanos causados pela extração de amianto no município de Poções - BA. A legislação brasileira e o controle da exploração de amianto. Webartigos.com, 10 Sept. 2009. Available at: <http://www.webartigos.com/articles/24591/1/IMPACTOS-AMBIENTAIS-E-DANOS-HUMANOS-CAUSADOS-PELA-EXTRACAO-DE-AMIANTO-NO-MUNICIPIO-DE-POCOES---BA-/pagina1.html>. Accessed on: 2 Aug. 2013.

PARÁ, Governo do Estado. Conheça o nosso Pará, Economia. 2013. Available at: <http://pa.gov.br/O_Para/economia.asp>. Accessed on: 15 Oct. 2013.

PARAUAPEBAS, Prefeitura. Economia. [online]. S.d. Available at: <http://www.parauapebas.pa.gov.br/paraupebas/economia>. 2013. Accessed on: 15 Oct. 2013.

PINHEIRO, J.C.F. A importância econômica da mineração no Brasil. Apresentação Rede Nacional de Informações sobre o Investimento - Renai, ago. 2011. Available at: <http://www.mdic.gov.br/sistemasweb/renai/public/arquivo/arq1314392332.pdf>. Accessed on: 10 Aug. 2013.

PLATAFORMA DHESCA. Mina de urânio pode transformar Caetité em cidade fantasma. Plataforma Dhesca Brasil/Plataforma Interamericana de Direitos Humanos, Democracia e Desenvolvimento (PIDHDD). Available at: <http://www.dhescbrasil.org.br/index.php?option=comcontent&view=article&id=346:mina-de-uranio-pode-transformar-caetite-em-cidade-fantasma&catid=149:noticias-biblioteca&Itemid=189>. Accessed on: 8 Aug. 2018.

PNUD, Programa das Nações Unidas para o Desenvolvimento. Acompanhamento municipal dos objetivos de desenvolvimento do milênio, Parauapebas – PA. Available at: <http://www.portalodm.com.br/relatorios/1-acabar-com-a-fome-e-a-miseria/pa/parauapebas>. Accessed on: 15 Oct. 2013.

PNUD, Programa das Nações Unidas para o Desenvolvimento. Atlas do desenvolvimento humano no Brasil 2013. Ranking IDHM Unidades da Federação 2010. Available at: <http://www.pnud.org.br/atlas/ranking/Ranking-IDHM-UF-2010.aspx>. Accessed on: 15 Oct. 2013.

PORTO, M.F.; PACHECO, T.; LEROY, J.P. Injustiça Ambiental e Saúde no Brasil: o mapa de conflitos, Cooperação Fiocruz - Fundação Oswaldo Cruz e pela Fase - Federação de Órgãos para Assistência Social e Educacional Editora Fiocruz, 2013.

RIGOTTO, R.M. Inserção da saúde nos estudos de impacto ambiental: o caso de uma termelétrica a carvão mineral no Ceará. Ciência & Saúde Coletiva, v. 14, n. 6, Rio de Janeiro, dez. 2009. Available at: <http://www.scielosp.org/scielo.php?pid=S1413-81232009000600012&script=sci_arttext&tlng=pt>. Accessed on: 21 Jul. 2013.

RIO GRANDE DO SUL, Governo do Estado. Economia. 2013. Available at: <http://www.estado.rs.gov.br/o-estado/Economia/109>. Accessed on: 22 Oct. 2013.

SANCHEZ, L.E. Comunidades podem defender seus direitos durante licenciamento ambiental. Site Mobilizadores, 16 Sep. 2010. Available at: <http://www.mobilizadores.org.br/coep/Publico/consultarConteudoGrupo.aspx?TP=V&CODIGO=C20109121570821&GRUPO_ID=15>. Accessed on: 2 Aug. 2013.

SDE-BA, Secretaria de Desenvolvimento Econômico do Estado da Bahia. (online). 2018. Available at: <http://www.sde.ba.gov.br/Pagina.aspx?pagina=mineracao>. 2013. Accessed on: 8 Aug. 2018.

SDE-CE, Secretaria do Desenvolvimento Econômico do Estado do Ceará. Arranjo Produtivo Local de pedras ornamentais em Nova Olinda e Santana do Cariri. 2018. Available at: <https://cearatransparente.ce.gov.br/>. Accessed on: 9 Aug. 2018.

SETUR, Secretaria do Turismo do Rio Grande do Sul. Rotas e roteiros: rota das águas e pedras preciosas. 2013. Available at: <http://www.setur.rs.gov.br/portal/index.php?q=destino&cod=4&opt=&id=55&bd=&fg=3>. Accessed on: 8 Oct. 2013.

SOUZA, K.V.; TEIXEIRA, N.S.; LIMA, M.H.M.R.; BEZERRA, M.S. Os Arranjos Produtivos Locais (APLs) de base mineral e a sustentabilidade.In: FERNANDES, F.R.C.; ENRIQUEZ, M.A.R.S.; ALAMINO, R.C.J. (Eds.). Recursos Minerais e Sustentabilidade Territorial v. 2, p. 69-88. Rio de Janeiro: CETEM/MCTI, 2011. Available at: <http://www.cetem.gov.br/publicacao/livros/Vol_2_APL_TOTAL.pdf>. Accessed on: 20 Jul. 2013.

TONIDANDEL, R.P. Aspectos legais e ambientais do fechamento de mina no estado de Minas Gerais. Thesis (Masters in Geography). 2011, 146 f. Instituto de Geociências da Universidade Federal de Minas Gerais. Belo Horizonte (MG), Feb. 2011. Available at: <http://www.bibliotecadigital.ufmg.br/dspace/bitstream/1843/MPBB-8LMGN5/1/rodrigo_tonidandel.pdf>. Accessed on: 2 Aug. 2013.

VALE. Brucutu: a maior mina de minério de ferro do mundo em capacidade inicial de produção. Sala de Imprensa, 5 out. 2009. Available at: <http://201.59.137.230/pt/versao_impressao/prt_detail.asp?tipo=2&id=16586>. Accessed on: 4 Nov. 2013.

VERDE, R.B.R.V.; FERNANDES, F.R.C. Panorama socioespacial de Parauapebas (PA) após a implantação da Mina de Ferro Carajás. Anais da XVII Jornada de Iniciação Científica do Centro de Tecnologia Mineral. p. 171-177. Rio de Janeiro, 2009. Available at: <http://www.cetem.gov.br/publicacao/serieanaisXVIIjic2009/RodrigoBragadaRochaVilla_Verde.pdf>. Accessed on: 3 Oct. 2013.

WWF, World Wildlife Fundation. Cerrado. 2013. Available at: <http://www.wwf.org.br/natureza_brasileira/areas_prioritarias/cerrado/> Accessed on: 21 Oct. 2013.

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