

# The Environmental Impact of Mining in the State of São Paulo

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The same geologic process from which mineral deposits originate determines their location in the earth's crust. The abundance or scarcity of elements that compose this crust determines the frequency of occurrence of the various types of mineral deposits. It is from these peculiarities that the term absolute location is associated, which expresses the boundaries for selection of areas that could generate less environmental impact in situating mining undertakings. Often the locales for their occurrence are environmentally sensitive and important for the preservation of biodiversity, water resources, the landscape or the many natural resources of great environmental importance. For these reasons, beside the frequent need for numerous extensive excavations for removal of the desired mineral, which results in large volumes of scrap, mining is linked to significant negative impact to the environment.

Practically speaking, all mining activity implies suppression of vegetation or prevention of its regeneration. In many situations, the surface soil with greatest fertility is also removed, and the remaining soils are exposed to erosion processes that can silt up of bodies of water in the surrounding area. The ebbing of waters in rivers and reservoirs downstream from the same basin can be harmful due to the turbidity provoked by the fine sediment in suspension, as much by the pollution caused by substances leached and dragged or contained in the effluents throughout the mining areas, such as oils, grease and heavy metals. These latter can also reach underground waters. Water-flow regimens and aquifers can be modified when these resources are used in mining (hydraulicking) and for improvement, beyond lowering the water table. Lowering of the river runoffs from mining in the riverbed could provoke instability of its banks, causing the suppression of riparian vegetation, besides making possible the unseating of bridges with eventual breaks. Frequently, mining provokes air pollution from suspended particles from the activity, from improvements and transportation, or by gases released by the burning of fuel. Other impacts on the environment are associated with noise, acoustical pressure and vibrations in the soil associated with the operation of equipment and explosives.

All of the previously referred to impacts can be detrimental for the equilibrium of ecosystems, such as the reduction or destruction of habitat, chasing off of animal life, death of species of animals and ground and water vegetation, eventually including putting species under risk of extinction, interruption of genetic flow, and movement of biota, among others. In relation to the anthropic environment, mining could cause not only environmental discomfort but also impact on health due to sound pollution, pollution of the air, water and from the soil. Disfiguring of the landscape is another aspect generated by mining whose impact is dependent on the volume of excavation and from visibility due to its location.

The photo below illustrates environmental degradation generated by mining in the region of Guararema,SP.



Courtesy of the Authors

*Environmental degradation generated by mining in the region of Guararema (SP).*

## Mining in São Paulo State

In spite of the first discoveries of Brazilian mineral resources at the end of the 16th century having occurred in the territory of São Paulo State, the economy of the State was initially notable for its agricultural activity, followed by industrial development and the acceleration of urban growth. These characteristics, associated with the potential of the geological lands, determined, definitively, the present profile of the State's mineral industry, notoriously directed to internal consumption to supply its industries from the ceramic, steel, cement, and glass sectors, among others, including agriculture and, intensively, civil construction.

Table 1 – Mineral substances produced in São Paulo State – base year 2005

Mineral substance	Annual value R\$ x 103	%	Quantity t x 10 <sup>3</sup>
Sand	846,293.0	40.81	75,420.4
Crushed rock	548,317.4	26.44	49,286.9
Mineral water	262,593.8	12.66	2,108.0
Limestone	151,542.4	7.31	9,755.4
Industrial sand	105,821.8	5.10	3,604.3
Phosphate	71,252.8	3.44	200.5
Kaolin	21,965.6	1.06	139.4
Common Clay	15,946.1	0.77	4,661.5
Phyllite	12,251.3	0.59	243.7
Feldspar	6,534.6	0.32	33.6
Plastic Clay	6,506.7	0.31	125.8
Bentonite and bleach clay	6,394.7	0.31	45.2
Dolomite	5,900.0	0.28	198.5
Ornamental Stone	5,686.5	0.27	269.1
Metallurgical bauxite	1,851.2	0.09	131.8
Talc	1,515.6	0.07	56.3
Industrial quartzite	834.4	0.04	21.9
Refractory clay	761.6	0.04	65.5
Refractory bauxite	574.3	0.03	18.8
Iron	572.9	0.03	74.7
Peat	527.4	0.03	9.4
Copper	14.5	0.01	0.183
Manganese	11.6	-	0.118
Calcite	4.7	-	0.686
Total	2,073,807.4	100.00	146,472.7

Source: Cabral Junior et al. (2008).

The great majority of São Paulo municipalities count on some mineral production, whether regulated or not, and the geological characteristics of the territory of São Paulo State associated with the demands resulting from urban

and industrial growth have facilitated the centering of mining activity in specific zones, promoting the formation of regional production centers with densification of areas impacted by mineral extraction, such as the Metropolitan Region of São Paulo (RMSP), the Sorocaba-Itu-Campinas belt, the Valley of Paraíba, Valley of Ribeira and municipalities adjacent to Itapeva, Apiaí and Capão Bonito.

According to Cabral Junior et al. (2008), in specific regions the agglomeration of mining companies came to constitute local productive arrangements based on minerals, such as the innumerable agglomerations of ceramic-miners that involve the production of clay and the manufacture of red ceramic products and facings. One of these agglomerates extends along the Paulista Periphery Depression constituting a continuous strip from the Itapeva region to São João da Boa Vista. Another agglomeration is sited in western São Paulo State along with the margins of the rivers Paran, Tiet and Paranapanema.

With rare exceptions, So Paulo State's industrial mining shows technological deficiencies, especially when dealing with small companies that correspond to the larger that are the great majority in the State's productive sector. The greater part of mineral companies resents investments in geologic survey of the ore beds and in the technological character of the ores, in planning of the operations, improvement and environmental recovery of the field, among other factors.

Lack of planning on the part of the public powers and scarcities referred to here have generated conflicts from this activity with other uses for the soil, in many cases with discomfort and risks to the surrounding communities. Besides this, lack of control and satisfactory environmental recovery in the mined areas has caused a series of other undesirable impacts on the environment.

And aggravating this problem, there is significant illegal activity in the sector. According to a statement in the 7/12/2005 edition of the newspaper *Folha de S.Paulo* by Enzo Lus Nico Jnior, Chief of the 2<sup>nd</sup> So Paulo district of the National Department of Mineral Production, there were at that time nearly 2500 authorized mining fields in So Paulo State and indication of nearly three thousand clandestine mining companies.

### **Prevention and Mitigation of the Impacts**

As an instrument foreseen by the National Environment Policy, the prevention and the mitigation of the impacts of mining on the So Paulo State environment have been effected through environmental license, based on undertaking of planning expressed in the documents entitled Report on Environmental Control (RCA), Environmental Control Plan (PCA), Preliminary Environmental Report (RAP), Environmental Impact Study (EIA) and Environmental Impact Report (RIMA), to be presented according to the criteria established by the Secretary of the Environment in Resolution n.51 of 12 December 2006.

The requirements of RAP or EIA/RIMA are applied to new undertakings every time the environmental agency considers there will be significant environmental impact or when the extraction area is greater than 20 ha<sup>2</sup> or the total volume of material to be extracted, including ore and sterile ground, surpasses 5,000,000 m<sup>3</sup>.

There will also be this requirement when suppression of natural vegetation is above 5 ha<sup>2</sup>, when there will be intervene in the sources or flows of water within the public storage sources, to the area that will be inserted in the Damping Zone of Whole Protection Conservation Units within the terms of Federal law n.9.985/00 or if there is extraction of carbonate rocks in regions with evidence of karst phenomena.

For mining operational at the date of publication of Regulation of Law n.997/76, Resolution SMA n.51/06 establishes the obligation of the explorer to request a License for Operation, presenting a Degraded Area Recovery Plan (PRAD). In the cases of deactivated explorations, which were not the object of environmental licensing, the responsible party was required to present a revegetation project for approval by DEPRN (now CETESB) and to make recovery of the degraded area possible.

Another instrument of the National Environment Policy employed by São Paulo State refers to the “Program of Mineral Resources and the Environment” that has been developed by the Geologic Institute (IG), connected with the Ministry of the Environment, aimed at a definition of environmental mining zoning and elaboration of regional directing mining plans.

The first work concluded by the IG in 1997 was directed toward the Vale do Paraíba with the “Paraíba do Sul Project – Sand Potential,” between Jacaré and Roseira. The objective of the project was to subsidize the establishment of technical norms and environmental licensing proceedings and the environmental zoning of sand mining, by means of the definition of its own areas for mineral exploration. In this study, a synthesis of previous work relative to mineral exploration and to integrated planning was conducted owing to economic and environmental development of the region, complemented by a collection of municipal legislation relative to the activity of exploration of mineral resources and soil usage. The definition and the delimiting of the potential sand zone were based on establishing of construction limits for eminently sandy areas or of the winding belt belonging to the “Winding Holocene Water System” of the Paraíba do Sul River.

Based on this study of the IG, the Ministry of the Environment established environmental zoning for mining of sand in the lowlands of the Paraíba do Sul River, in the subsection within the municipals of Jacaré, São José dos Campos, Caçapava, Taubaté, Tremembé and Pindamonhangaba, as disposed in Resolution SMA n.28/99. In this subsection, new undertakings were allocated by EIA/RIMA for its licensing, according to Resolution SMA n.03/99, allowing sand extraction within the mining zone limits, respecting protection

zones, that aim to preserve the ecosystem formed by the Paraíba do Sul River, the remaining vegetation and especially that associated with abandoned windings, as well as lowland conservation zones, which sought to protect and conserve the flood plain, in this manner insuring soil permeability and non-contamination of the waters through use compatible use with its ecological function. The recovery zone applies to exploratory activity or previously exhausted areas, with the defined areas considered priorities for environmental recovery with the objective of making them compatible with urban, livestock raising or preservation uses, according to their specific location.



Courtesy of the Authors

*Sand mining in the Paraíba do Sul River (SP) lowlands.*

According to Reis et al. (2006), in work conducted with the purpose of investigating the consequences of large scale sand extraction in the water climatology balance of the Vale do Paraíba, in São Paulo State the area of artificial lakes originating from the extraction of sand evolved from 591.4 ha in 1993 to 1,726.5 ha in 2003. In that year water loss to the atmosphere by evaporation from diggings was 19,157,022 m<sup>3</sup>/year which would be sufficient to supply a city with 326,318 residents. Another aspect observed by Reis (2009) referred to observation of the advance of excavations beyond the mining zone limits in the municipality of Tremembé.

In evaluations of the environmental recovery from sand mining in the lowlands of the Paraíba do Sul in the portion between Jacaré and Pindamonhangaba, the Minister of the Environment concluded that vegetative recovery was qualified as bad or ordinary in the majority of explorations (São Paulo, 2008). The questions pertaining to the quality of the water and sediments in the holes, to eutrophication processes and to possibilities for future uses were not evaluated.

According to Resolution SMA n.42/96, which governs environmental licensing of sand mining extraction undertakings in the Paraíba do Sul River Water Basin, recovery measures in the degraded area bound to stabilization of the physical environment and regeneration of vegetation of the margins of the holes, and in areas not considered in present legislation as permanent preservation, depending on the intended future use of the soil, will be usable, without distinction, for both foreign and native species planting, or in other alternatives, pending approval of the project by SMA after complying with requirements for protection of the soil and water resources.

In evaluations of the recovery of areas degraded by mining in the São Paulo Metropolitan Region (RSMP), Bitar et al. (2000) concluded that there was an obvious dissociation between the measures employed and those recommended in recovery plans that were elaborated by mining companies. The largest part of the recovery work practiced in active mines in the RSMP had an incipient character, especially based on execution of measures restricted to re-vegetation, aiming, particularly to attenuate the visual impact generated. Deactivated mines favored chaotic occupation, and the remaining holes, entirely or partially inundated, would be permanently subject to untidy depositing of residues, which can generate soil as well as surface or underground water contamination, putting at risk human health from the surrounding area.

Other environmental liabilities associated with soil and surface or subterranean water pollution by substances hazardous to human health were studied by Bernardino et al. (2004), who observed that, while mining and metallurgy activities had ceased in 1996, the populations of Alto Vale do Ribeira still are affected by various sources of environmental contamination, particularly of lead and arsenic, typically originating from extractive activity, improvement and mineral refining. Metal emissions into the atmosphere and subsequent depositing of particles were responsible for soil contamination in areas inhabited by these populations. Silting processes also transported these contaminants to sediments of the rivers of the region, which wound up in the estuary of the Ribeira de Iguape River.

## **Perspectives**

If we consider the history of mining in São Paulo State and the actions of the public sector in the sense of stanching and reversing the degradation

generated by this activity, there will be no short term development of this activity that will both assure future supply of raw mineral material and guarantee the quality of environmental conditions.

To the weight of the contribution represented by market forces and some voluntary initiatives by companies, there were the demands imposed by legislation that really brought about the advance of environmental management (Centro de Tecnologia Mineral, 2007). Even so, there has been a long road to travel that is necessarily in the direction of promoting of activities and projects in the sector directed to technological planning, ordering and improvement of mining activity in the State, besides the improvement of implements and oversight for licensing and inspection.

With increasing frequency, mining has come to be developed in environmentally sensitive locations important for the preservation of biodiversity, of water resources, of the landscape, or of the many natural resources, demonstrating technical mistakes in having been previously considered an activity with low environmental impact. The rebound has been that, in the case of mineral exploration in an area of permanent preservation, the framing it as an environmentally low impact activity is out of the question.

Extraction of sand from the river bed, of sand or clay in lowland areas or on the banks of waterways or lakes, of varied rocks used in civil construction on the tops of hills or steep slopes reaching fountains, waterways and native vegetation, are common in São Paulo State, and the great majority of explorations have obtained operating licenses without presenting EIA/RIMA documents. Extraction of sand by water jets in the soil (hydraulic mining) is also common and, similarly, the majority of explorations do not have EIA/RIMA.

In spite of being required since 1989 Recovery Plans for Degraded Areas (PRAD) are relatively recent in mining undertakings and there has been an obvious dissociation between measures in practice and those defined in these plans. The greater part of recovery work in areas degraded by mining that have been registered in São Paulo State have an incipient character and, in particular, are based on the execution of limited measures of regeneration, aiming to attenuate the visual impact generated.

Excavation planning and employment of equipment can reduce impact during the operation of the activity, although it is not possible to restore the original conditions of the area, to restrict future use of the area, and altering its primitive environmental functions. These facts owe especially to the shortage of the volume of non-commercialized or scrap materials resulting from the excavations that could fill in the holes resulting from the excavations and recompose the topography of the terrain.

The majority of the open mining holes in lowlands for sand or clay extraction results in lakes that, in spite of being destined for fish farming or recreational fishing in the majority of recovery plans, frequently end up abandoned or in a process of eutrophication. Generally these conditions are

repeated along the same lowland, creating a densification of lakes and significantly altering the original environment due to the cumulative impact.

On the other hand, extraction of sand from the river channel has caused lowering of its bed and imbalance from the middle, provoking undermining and erosion of the banks. The necessary interventions to artificially aid in restraint of these processes have an impact and are onerous to the extent that, in general, these areas remain abandoned to the mercy of natural forces until a new balance is established.

Large excavations from pits of stone or from sand extraction by hydraulicking close to urban centers, have been filled in with inert residue from civil construction waste, whose adequacy has been contested due to the total lack of quality control of these residues, which might contain non-inert and eventually dangerous substances that can pollute surface and underground waters and put human health at risk.

In many circumstances, the front of the mining excavation proceeds overmuch, giving rise to holes limited by high, steep slopes for which reduction of the incline becomes problematic, or infeasible once this measure implies numerous additional excavation that expands the degraded area, and, eventually reaches forested areas or lands beyond the limit allowed for excavation.

Such conditions could have origin in deficiency of either the recovery plan or from lack of systematic inspection for verification of compliance with the chronograms established in the projects. Delay in implementing recovery measures for the final phase of the mining, close to its exhaustion, implies significant increase in costs precisely in the income reduction phase, resulting in either abandonment or only partial fulfillment of obligations.

As commented previously, the geologic characteristics of São Paulo State that are associated with the demands derived from urban and industrial growth have propelled a centering of mining activity in specific zones, promoting the formation of regional productive poles with resulting increased density of areas impacted by mineral extraction. In the attempt to resolve this question, the Geologic Institute has been developing the “Program of Mineral Resources and the Environment” aiming toward a definition of environmental mining zoning and elaboration of regional mining directive’s plans and to integrate the activity with sustainable development.

Examples of zoning approved by the Ministry of the Environment such as the Paraíba do Sul River Basin, where licensing of new undertakings is exempted from EIA/RIMA, based on Resolution SMA n.03/99, have, however, created apprehension in relation to the effects over the environment from the increase in the number of mining holes throughout the lowland of this still unevaluated waterway bed.

From the way that the works were developed, problems can be verified related to the extraction of sand in the Vale do Paraíba do Sul that are related to the absence of effective studies about the characteristics of ecosystems

(composition, structure, dynamic), their functional and fragile aspects, which could really provide the basis for an assessment of the consequences of the mining activity over the environments reached.

In the face of this context, environmental zoning for sand mining from the Paraíba do Sul River Basin cannot be equated with EIA/RIMA, keeping in view the proximity and detailing of the studies and surveys that have been conducted, as has been cited, have not adequately diagnosed ecosystems, have not evaluated environmental liabilities and the impact of present and future undertakings on the environment.

For the reasons cited, it could be concluded that licensing mining activity, in the manner that has been conducted in São Paulo State, has not satisfactorily reached the objectives of the National Policy for the Environment. In the same way, the order imposed by the Federal Constitution by which those who want to exploit mineral resources are obligated to restore the degraded environment, according to the technical solution required by the responsible public agency, is not being addressed satisfactorily.

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*ABSTRACT* – Generally, mining causes significant impact on the environment, since this activity often involves suppression of vegetation, soil exposure and erosion resulting in important changes in the quantity and quality of surface and ground-waters and in air pollution, among other negative effects. The prevention and mitigation of these impacts in the State of Sao Paulo are done through the environmental licensing. Another means of environmental management includes programs like mining and environmental zoning and regional mining director plans. But there is clear dissociation between the actions effectively taken and those recommended in the projects, limiting the recovery of degraded areas by measures that only attenuate the visual impact. This paper presents considerations on the subject and challenge of the industry to adapt to the Federal Constitution and the National Policy on Environment.

*KEYWORDS*: Mining, Environmental impact, Management, Rehabilitation of degraded areas.

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