INDUSTRIAL MINERALS AND CERAMIC RAW MATERIALS IN BRAZIL

Marsis Cabral Junior, [1] **Gilson Ezequiel Ferreira,** [2]
Edson Farias Mello, [3] **José Mário Coelho** [3], **José Francisco Marciano Motta** [1]

[1] Instituto de Pesquisas Tecnológicas do Estado de São Paulo – IPT.
[2] Centro de Tecnologia Mineral.
[3] Department of Geology – UFRJ.
jfmotta@ipt.br

ABSTRACT

Brazilian occurrences of industrial minerals are expressive and comprise a large variety of substances and typological classes of mineralization of igneous, metamorphic and sedimentary nature, which are hosted in terrains of different ages, from the Archean to the Holocene.

This diversity enables mining of about 50 varieties of industrial minerals. Official figures indicate that the value of the annual production is U$ 3,400 m., with a ROM of 400 million tpa, which means 24% of the total Brazilian mineral production income (US$ 14,100 m.).

About 80% (US$ 2,700 m.) of the total value of Brazilian industrial minerals production refers to five groups of raw materials, used mainly in construction and agriculture: aggregates (US$ 1,412 m.), limestone (US$ 625 m.), ceramic clays (US$ 292 m.), dimension stones (US$ 200 m.) and phosphate (US$ 186 m.). Another 25% of the production is distributed through 45 classes of mineral goods, which are consumed by a wide series of economic segments, mainly by ceramic, glass, agriculture, metallurgy, foundry, paper, paints and chemistry sectors.

This paper gives further information on the ceramic industrial minerals, such as common and plastic clays, kaolin, feldspar and others and discusses the availability of these minerals and necessities for domestic and foreign markets.

In the Brazilian sector of industrial minerals, facing challenges of technological and managerial modernization, important opportunities of production increase and diversification are identified. Amongst those ceramic raw materials, mineral fillers, aggregates and dimension stones are outstanding. Positive expectations are supported by geological potential and favourable perspectives of domestic and international consumer markets expansion.

1. INTRODUCTION

Brazil, with an extension of 8,5 million km^2 and a great diversity of geological terrains, has an expressive mineral wealth, which is demonstrated by the production of more than 80 types of mineral substances: 24 metallic minerals, 50 non-metallics, 3 energetics and a large variety of gemstones.

Official data indicate that the Brazilian mineral production reached, in 1996, the amount of U$ 14,100 m. Industrial minerals have contributed with US$ 3,400 m., which means 24% of the total financial results. The energetic minerals have participated with US$ 6,400 m. (46%), whereas metallics contributed with US$ 3,900 m. (28%). The remaining production consists of US$ 292 m. (2%) in mineral water and US$ 51 m. (0.4%) in gemstones and diamonds.

It is worth to add that there is a great parcel of informal mineral production in Brazil, especially in the sectors of construction materials, gold and gemstones, which could be estimated in around US$ 2,000 m./year.

In terms of inner market, it is verified that the non-metallic industry has expanded substantially along the last three decades. In this period, intensification of urban occupation, progressive increase in the number of infrastructure works and diversification and development of national industries caused an increased demand of such mineral commodities that could be compared in some regions to the consumption scale of developed countries.

On the other hand, national producers, especially those of medium and small mining enterprises, did not follow technological and managerial updating required to the production system optimization – exploration, mining and ore-dressing. In times, as a consequence, unfavourable differences in terms of quality, constant supplying and prices of raw material has occurred when compared to major international producers, and has affected both, the development of their commercialization and the conquest of new emergent markets.

Even so, the size of the domestic market and the development of new important deposits, some of them of world class, keep Brazil as the greatest industrial minerals producer in Latin America. In this sense, the Country is gradually amplifying its participation in the world mining scene, with an outstanding level in reserves and production of substances like kaolin, common clays, graphite, asbestos, magnesite, vermiculite, talc and dimension stones.

In a context of a high geological potential, an expanding domestic consumption market and a mineral industry with segments presenting technological gaps, this paper intends to characterize the geo-economic profile of present situation of industrial minerals in Brazil and to discuss the major challenges, trends and perspectives of this mineral sector.

2. GEOLOGY OF INDUSTRIAL MINERAL DEPOSITS IN BRAZIL: A PANORAMIC VIEW

Brazilian geologic setting is characterized by a complex geological history, registered in rocks from Archean to Recent.

The Precambrian (earlier than 550 m.y.) represents wide area of the territory, and are formed by a cratonic mosaic constituted by ancient Archean shields (granulite and amphibolite metamorphic rocks, and granitoides), surrounded by mobile belts (sedimentary and volcanic sequences, locally metamorphosed and intruded by granitic bodies of varied nature).

The Phanerozoic was a period of relative tectonic stability, prevailing extensional events, where volcanic and sedimentary episodes concentrated in three intracratonic syneclises (Paraná, Amazon and Parnaiba basins), including the rifting processes, which lead to the rupture of the Gondwana Super-Continent and the formation of the South Atlantic Ocean, involving generation of the marginal basins and interior rifts.

During the Cenozoic the present relief framework was set, modelled by successive planation surfaces and associated sedimentary deposits.

In view of this great profusion of geologic environments, industrial mineral occurrences are expressive, comprising a great variety of substances and typological classes of mineralization.

In a synthetic view on the main types of deposits could be shown that in the Precambrian basement there are hydrothermal barite deposits; metasomatic-metamorphic ores of talc, magnesite, asbestos, graphite and fluorspar; sedimentary phosphate mineralizations (fosforite); and feldspar and quartz in pegmatites, the main source for premium feldspar. Inserted in igneous and metamorphic granitoid massifs, additional supplying of feldspar and most crushed stones quarries are established. In metasedimentary areas, limestones, dolomites, calcite, phyllites and agalmotolites are mined. A series of metasediments (marbles, metaconglomerates, quartzites, slates and related rocks) and a great variety of granitoid types are exploited for dimension stones.

More recent igneous ore deposits associated to Mesozoic Atlantic rifting, correspond to primary phosphates and carbonates occurrences, both related to alkaline intrusives, hydrothermal vein mineralizations of fluorspar, and basic rocks mined for crushed stones, especially in the Southern and Southeastern regions of Brazil.

Within inland Phanerozoic sedimentary basins, production of silica sands, sands for construction, limestone for agriculture soil correction, bentonites, as well as broad belts of Permo-Carboniferous pelitic rocks supplying raw material to the important ceramic production poles, in the Southern and Southeastern regions.

Paleozoic and Mesozoic evaporitic salt deposits are associated with the same interior sedimentary basins (Na and K salts and gypsum). In the Atlantic Continental Margin, rift basins also host expressive evaporitic mineralizations (Na, K, Mg salts and gypsum) and barytes deposits.

Important series of industrial mineral occurrences are related to the morpho-climatic conditions of the Cenozoic, which were favourable to the concentration of residual and alluvial deposits. In Tertiary laterized sedimentary layers of the Amazon region, world class kaolin and bauxite deposits take place. Associated to weathered residual covers phosphate, kaolin, bauxite, fire clays and vermiculite are found. In the Quaternary alluvial plains along the main rivers, sand, gravels, clays (plastic, fire and common types) and more locally peat, are mined. Also, associated with quaternary coastal sands occur the main production of heavy minerals, including zircon for ceramics as well titanium dioxide.

Besides those already discovered mineral resources, the nature and extension of geologic terrains in Brazil, where huge areas are not yet well explored, indicate a remarkable potential for finding new industrial minerals deposits. The search to turn this geological favourability in reality, through systematic surveys (prospection and exploration), will give new ore deposits that certainly will increase availability of raw material to domestic and international promising markets.

3. PROFILE OF BRAZILIAN PRODUCTION

The geographical distribution and the profile of the industrial minerals production in Brazil basically reflect the different levels of social-economic development and territorial occupation, as well as the geological aptitude of the Brazilian terrains.

Being so, the mining of substances with low unit value, such as aggregates, common clays, carbonatic rocks, phyllite and silica sands, is concentrated close to the great urban and industrial centres located in Southern and Southeastern regions (Table 1). Other industrial minerals with higher value have their production linked to more qualified deposits, and, in several cases, more restricted occurrences, inserted in specific geologic sites. Some special examples are world class mines of the Amazon region (kaolin and bauxite), asbestos in Goias, graphite in Minas Gerais, magnesite in Bahia and silvinite (potassium) in Sergipe.

Table 2 shows the relation of twenty main classes of industrial minerals produced in Brazil, their value and bulk output in 1996, the geological framework, major industrial consumers and characteristic size of mine in operation.

From this assembly of substances, which include more than 98% of the total value of Brazilian production, 80% (US$ 2,700 m.) refers to six groups of industrial minerals with preponderant use, directly or indirectly, in agriculture and construction: crushed stone and sand as aggregates, limestone for cement, lime and soil correction, clays for ceramic use, dimension stones and phosphatic rocks for fertilizers.

The remaining 20% of the production is distributed through more than 30 minerals, which are consumed by a wide series of economic segments, amongst them ceramic, agricultural, glass, siderurgy, foundry, paper, paints, and chemical are preponderant.

Despite Brazil having considerable reserves of the major part of non-metallic minerals required by its domestic market, it is not reflected in its trade balance, which was a great deal affected by the increase in imports along the years 90. Being so, the trade deficit of US$ 338 m. in 1992, went up to US$ 813 m. in 1998, and from six principal raw materials (potash, phosphate, sulfur, bentonite, diatomite and vermiculite) imported in the beginning of the decade, it jumped to fourteen in 98, including new items, such as barite, feldspar, cement, lime, fluorspar, lithium, quartz and talc, becoming self-sufficient in vermiculite [2]

Regions→ ↓Concentration	1. Southeastern	2. Northeastern	3. Southern	4. Mid-west	5. Northern	Five Regions of Brazil
100-90 %	silica sand, fire clay, graphite, phosphate rock	barite, diatomite, magnesite, salt, potash, gypsum	fluorspar	asbestos		
89-70 %	sand and gravel, common and plastic clays, carbonate rock, phyllite, crushed and dimension stones	bentonite				
69-50 %		vermiculite			kaolin, bauxite	
49-25 %	kaolin, feldspar, talc, agalmatolite/ pyrophyllite, bauxite	feldspar	talc	vermiculite		

Table 1. Regional concentration of Brazilian industrial minerals production - Source: Brazil 1995, Brazil 1999; modified.

4. PERSPECTIVES AND TENDENCIES

Production and consumption of industrial minerals in Brazil had a gradual growing in the decade of 90, despite the macro-economic conditions existing in the Country. Mainly due to the effects of the globalization, a recessive framework in the last years is being presented. In the period 1990 – 1995 an accumulated growth of 33.6% for industrial minerals occurred, for instance, the 9.6% of metallics increased.

The great mineral potential of Brazil with the presence of world class ore deposits, the size of the domestic market and the favourable perspectives of its growing, as well as the potential for export of manufactured goods, are attracting more and more international groups to act in the extractive segments (aggregates, industrial sand, kaolin, feldspar, dimension stones) and of industrial minerals transformation (calcium carbonate, cement, glass, ceramic segments - tiles, bricks, sanitary ware, ceramic body preparation centres, frits and enamels).

While raw materials addressed to construction use and related transformation industries have needs matched principally by domestic production, agrominerals – sulfur, phosphate and potassium - do not. These are responsible for the increasing deficit of Brazilian commercial balance in the sector of industrial minerals. Perspectives of an increasing agricultural production with dependence on import of these commodities will prevail at least for a short term, especially if it is kept in mind limitations of sulfur and potassium in Brazilian underground. In the case of phosphate, despite available reserves and geological potential, low price international offers will continue inhibiting the expansion of domestic production.

The offer of other industrial minerals, including some of those that have been presenting deficit in the commercial balance, could be supplied through investments in proper technologies of mineral research and production aiming higher quality, lower cost and logistic bettering.

As examples of new business opportunities for enterprises, mining of alternative potassium salts (carnalite), smectitic clays and peats for environmental uses, and wollastonite reserves can be mentioned, besides the systematic exploration of favourable prospects for ball clays, diatomite, phosphorites, and feldspar rocks.

Dimension stones, kaolin, graphite and asbestos, all in already developed world class deposits, shall continue to be the chief export commodities in short to medium terms. It should be highlighted the great potential for an output expansion of Amazonian kaolins as well as dimension stones as function of the rich variety of lithological types of granitic rocks.

In relation to raw materials for glass and ceramics manufacturing, a great expansion of these industries is in general expected, as well as its spreading through the Country, in order to supply increasing domestic market, and the continuous growth of exports. Those factors will cause a regionalization of industrial minerals offer, including the production of new raw materials, such as flux substances.

MINERAL	VALUE US$ m.	BULK 1,000 t	GEOLOGIC SETTING (major producer states)	USES (production characteristics)
Crushed Stones	838,786	61,452	Metamorphic and igneous rocks from Precambrian basement, and Phanerozoic basic and alkaline rocks. (SP, RJ, MG, RS, BA)	Construction material (A, B)
Carbonatic Rocks	624,639	78,261	Carbonatic sequences from Precambrian basement, Paleozoic and Mesozoic basins and shell accumulations in Recent. (MG, SP, PR, RS)	Cement, Lime, Agriculture, Siderurgy, Ceramic, Paints, Plastics, Carpets (A, B)
Sand and Gravel	573,203	99,474	Coarse sequences in alluvial and coastal sediments in Quaternary, Tertiary and Paleozoic basins; and weathered horizons from quartz-rich Precambrian rocks, such as granites and gneiss. (SP, RJ, MG, RS, PR)	Construction material (B)
Common and Plastic Clays	292,417	37,066	Pelitic units from Phanerozoic basins, Quaternary alluvial sediments and some weathered horizons of feldspathic or pelitic rocks. (SP, RJ, MG, RS, PR)	Ceramic and Cement (B)
Dimension Stones	200,686	818* (*m^3)	Igneous and metamorphic rocks such as granite, gneiss, migmatites and marble. (ES, MG, BA, CE)	Construction material (B, C)
Phosphatic Rocks	186,499	24,455	Mesozoic alkaline complexes and platformal marine sediments from Precambrian sequences (fosforites). (MG, GO, SP)	Fertilizer and Phosphoric acid (A, B, C)
Asbestos	127,915	4,008	Precambrian mafic-ultramafic complexes. (GO)	Fibrous cement and Friction materials (A)
Kaolin	125,155	2,197	Cenozoic continental sediments and weathered horizons of feldspathic rocks such as pegmatite and granite. (AP, SP, MG)	Paper, Ceramic, Paints, Rubber, Pharmaceutics (A, B)
Salt (Rock and Solar)	69,619	5,384	Artificial solar precipitation and Mesozoic evaporitic sediments from marginal basins (RN, BA)	Chemical ind., Food ind., Leather ind. (B)
Refractory Bauxite	68,146	1,279	Weathered caps on Tertiary pelitic rocks, Mesozoic alkaline massifs, and Precambrian granitoides rocks. (PA, MG)	Ceramics (refractories, abrasives) and Chemical ind (Al sulfate) (B)
Potash	59,198	1,410	Mesozoic evaporitic sediments from marginal basins. (SE)	Fertilizers (A, C)
Silica Sand	49,642	3,893	Mesozoic eolian-fluvial sediments of Paraná basin, Cenozoic continental and coastal sediments, and Precambrian quartzites. (SP, SC, MG)	Ceramics, Glass, Siderurgy, Chemical ind. (Na silicate) (A, B)
Magnesite	45,504	1,270	Precambrian metassedimentary carbonatic covers. (BA)	Refractories, Chemical ind. (B)
Graphite	29,026	843	Precambrian metamorphic units. (MG, BA)	Foundries, Paints, Refractories, Lubricants, Batteries, Pencils (B)
Talc	28,236	452	Metamorphic (Mg/Ca) carbonatic units from Precambrian. (BA, MG, PR, SP)	Ceramic, Paint, Insecticide carrier (B)
Fluorspar	18,652	142	Hydrothermal veins deposits across alkali rock complexes, Precambrian granites, and stratabound deposits in Precambrian metamorphic carbonatic units. (SC, PR)	Hydrogenic fluoride, Siderurgy, Foundries, Paints, Glass (B)
Gypsum	17,675	1,126	Chemical sediments in marine evaporitic environments from Mesozoic and Paleozoic cratonic and marginal basins. (PE, CE)	Construction material and Cement (B)
Bentonite and Filler's Earth	14,169	169	Pelitic sedimentary lenses associated to volcanic rocks and pelitic lacustrine sediments related to Tertiary continental rift. (PB, SP)	Foundries, Iron ore pelletizing, Oil bleaching, Drilling mud (B, C)
Phyllite	13,902	1,143	Precambrian metamorphic sedimentary sequences. (SP, MS, MG)	Ceramic, Construction, Carrier in insecticide and animal feeding (B)
Fire Clay	10,645	430	Cenozoic alluvial sediments, and weathered horizons over Mesozoic alkaline massifs and Precambrian granitic rocks. (MG, SP)	Ceramic (refractories and abrasives) (B)
Subtotal	US$ 3,393,714		**Key: Brazil's regions and states: Northern Region**: PA– Pará, AP– Amapá; **Northeastern**: BA– Bahia, SE– Sergipe, RN– R. Grande do Norte, CE– Ceará; **Southeastern**: SP– São Paulo, MG– Minas Gerais, RJ- Rio de Janeiro, ES– Espirito Santo; **MidWest**: GO– Goiás; **Southern**: PR- Paraná, SC- Santa Catarina, RS – Rio Grande do Sul**; Production characteristics: A-** Large size mining**; B-** small/medium size mining**; C-** additional importation is needed to supply domestic market	
Total of Brazil's IM production	US$ 3,448,329			

Table 2. Brazilian Industrial Minerals Production (official values in 1996)
Source: IPT 1991, Frederico and Gurmendi 1995, Sintoni and Tanno 1997, DNPM 1997.

Other important aspect is related to the contained demand of industrial minerals for construction, linked to the housing deficit and to the needs for recovering and enlarging infrastructural systems. At the same time when an important increase in the above mentioned production of raw materials - aggregates, clays and carbonatic rocks - is expected, it is foreseen that a reshaping of the productive sector will happen and productive poles will migrate towards the interior of the country.

REFERENCES

[1] Brasil. Ministério de Minas e Energia – DNPM. 1997. Anuário Mineral Brasileiro, Brasília. Mining annual directory – www.dnpm.org.br.

[2] Brasil. Ministério de Minas e Energia – DNPM. 1998. Sumário Mineral, Brasília.

[3] Frederico, F. L. M. and Gurmendi, A. C. (coords.) 1995. Economia Mineral do Brasil, Departamento Nacional da Produção Mineral - DNPM, 280 p, Brasília, DF, Brasil.

[4] Instituto de Pesquisas Tecnológicas do Estado de São Paulo - IPT. 1991. Mercado produtor mineral do Estado de São Paulo. Publicação IPT, n. 1822. São Paulo, Brasil.

[5] Sintoni, A. and Tanno, L.C. 1997. Minerais industriais e de uso social: panorama do mercado consumidor no Brasil. Brasil Mineral, 147: 34-39.