



**Geological Survey of Brazil:
40 years producing and providing data and geological
information**

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Abstract:

Since the beginning of its operation in 1969, the Companhia de Pesquisa de Recursos Minerais (CPRM) began, gradually, to monopolize the work of geological mapping in the country. Relevant activity from 70s and 80s includes the Geological Map of Brazil (1:1,000,000), published between 1974 and 1979, and the integration of information with the implementation of the Geological Map of Brazil and adjacent ocean areas, including mineral deposits, at the scale 1:2,500,000 (1981). The resumption of basic geological surveys from 1986 took place with the implementation of the Program Basic Geological Surveys of Brazil. In the 90s geological maps have been produced normally in digital media, although the databases are stored in the structure of mainframe, in use since the 70s. In 2000, the Company initiated a vigorous program of modernization in the area of information technology, to present their products through the mapping technology of Geographical Information Systems and relational databases. Today, using the most modern features, the Geological Survey of Brazil has the mission of "Produce and divulge the basic geological and hydrological knowledge required for sustainable development in Brazil", so that everyone can have access to these products through online services.

I. Introduction

Mineral, water and energy resources combined with technology are the foundation for social building and maintenance which reflects on the welfare and quality of life of its citizens and its environment. However, these resources are finite and over time are becoming more scarce, making their viability and proper management key to the future and to sustained economic growth.

The concept of sustainable development, understood as "a model for development which allows meeting the needs of the present without compromising the ability of future generations to meet their own needs" (UNITED NATIONS, 1987), checkmates current practices and proposes new rationality. It demands new modes of natural resources exploitation, new investment criteria, a different technical-scientific standard and a different basis for human, community, organization and nation relations.

It is clear that knowledge is a major variable and that education and culture are explicitly determining parameters for the development of a nation (CRUZ, 2002). Therefore, it is worthwhile reflecting on the influence and transverseness of Geological knowledge (produced/stored) on society as a whole. Not only on knowledge but also on the great volume of information and data generated by researchers and professionals.

It is in that sense, that we, as information professionals should reflect on the role and influence of Geoscientific information. Furthermore, we should critically analyse the products/services offered as well as the tools and techniques for storage, organization and availability of this information. As information, especially environmental information constitutes a key element for a model of sustainable development, we need to consider the basic principles of efficacy, diversity and decentralization (ALBAGLI, 1995).

Geoscientific information is an indispensable input and constitutes a significant part of environmental information as it reduces uncertainty allowing for greater understanding of the planetary environmental complex. In other words, it is directly related to the knowledge of planet functioning and contributes to sustainable activity management (CORDANI, 2002).

The challenges of sustainability with regards to Geology and the contribution that geoscientific information may provide lie especially in securing sustained natural resource supply, in the mitigation of the effects of geologic risks, in minimizing and guiding adaptation to the effects of global and environmental changes, and in the preservation of geological environments. Nevertheless, in order for the contributions to be effective it is necessary to guarantee the availability and diffusion of geoscientific information. In accordance with that, *Companhia de Pesquisa de Recursos Minerais - CPRM/SGB* (Mineral Resources Research Company) has demonstrated the capacity to adapt to the new expectations beginning with its mission which used to be simply technical to now being “a generator and disseminator of basic geological and water knowledge necessary for the sustainable development of Brazil” (CPRM, 2009).

II. Background in Brief

Geological activities in Brazil date back to the XIX century beginning with scientific and naturalist expeditions performed by Europeans and Americans. Thereafter, it established itself with the setting up of governmental research and educational institutions. According to Campos, Cordani and Kellner (1997), the activities and works carried out by geoscientists have always been directly related to both governmental and political actions in the sector of minerals and energy.

The first recorded initiative was the constitution of the *Comissão Geológica do Império do Brasil* (Geological Commission of Brazil) in 1875 (closed in 1878), which had as its objectives “to perform preparatory studies for mapping a geological chart of the Empire; guide these studies in order to learn about the geological structure of the country, its paleontology, mineral wealth and how to exploit them; complementing these works with the analysis of the rocks, minerals, terrains and waters which could be used; and finally, study the archeology and ethnology of the existing tribes, collecting and classifying samples which would conveniently illustrate them” (BERTOLDO, 2006; LEINZ, 1994; NAGAMINI, 2004).

A few years later, regional initiatives are recorded such as the Geological and Geographical Commission for the Province (*Comissão Geographica e Geológica da Província*), and the Geographical Exploitation State Commission (*Comissão Estadual de Exploração Geographica*).

The Geological and Geographical Commission for the Province was established in 1886, in São Paulo, and had as its objective to “obtain ‘detailed and precise’ information on the geography, relief, geological structure, communication network, mineral wealth and soil types”. (NAGAMINI, 2004; BERTOLDO, 2006).

In 1891, the *Comissão Estadual de Exploração Geographica* was established with the objectives of proceeding with the mapping of the General State Chart for the State of Minas Gerais

(*Carta Geral do Estado*), as well as with the studies on the waterways and climate aspects of the state of Minas Gerais. (AMADO, 2009).

In the beginning of the XX century national initiatives were readopted. In 1904, the Commission for the Study of the Coal Mines of Brazil (*Comissão de Estudos das Minas de Carvão de Pedra do Brasil*) was constituted, headed by the North American Geologist Israel Charles White.

In 1907 the Geological and Mining Services of Brazil (*Serviço Geológico e Mineralógico do Brasil - SGMB*) was established in connection with the then Ministry of Agriculture, Means of Transportation and Public Works, with the objective of scientifically studying the geological structure, mineralogy, mineral means and resources of the Republican territory, the basis for the organization of projects on the means of communications and other public works, in particular those for the prevention of the effects of droughts (NAGAMINI, 2004; BERTOLDO, 2006).

In 1934, the National Department for Mineral Production (*Departamento Nacional da Produção Mineral – DNPM*), was established in connection with the then Ministry of Agriculture. The DNPM has as its purpose to promote the planning and harboring of mineral exploitation, superintending geological, mineral and mineral technology research as well as ensuring the control and monitoring the performance of mining activities nationwide (DNPM, 1997).

However, there were no nationally trained technicians or specialists in a significant number to meet the demand of market needs. With the objective of addressing this deficiency and as an initiative from the Ministry of Culture and Education, in 1956, a campaign for training Geologists took place (*Campanha para a Formação de Geólogos - CAGE*) (GOMES, 2007).

In parallel to the initiative of the CAGE, *Petrobrás (Petróleo Brasileiro S/A)* as well as many other companies, had an immediate need of geologists. So, in 1969, the CPRM was established, known as the *Companhia de Pesquisa de Recursos Minerais*, “which had the triple function of being a service for the bodies in charge of studying the country’s natural resources; of a financier for the mineral resource research private mining companies; and, lastly, as a research company, operating at its own risk and in the licitation to eventually interested private entities” (DIAS LEITE, 1974 apud BERTOLDO, 2006).

Some other regional initiatives also took place during this period, in particular those established in the 70’s. Those still existing include the *Companhia Baiana de Pesquisa Mineral (CPBM)*, *Companhia de Desenvolvimento de Minas Gerais (CODEMIG)*, *Minérios do Paraná (MINEROPAR)*, and the *Departamento de Recursos Minerais do Estado do Rio de Janeiro (DRM-RJ)* (BERTOLDO, 2006).

III. CPRM/SGB

Established in 1969, CPRM, initially had as its objective to stimulate the finding of, and intensify the use of, mineral and water resources in Brazil, providing technical support for the administrative bodies of the Ministry of Mining and Energy, encouraging and cooperating with the private sector initiative in every area of its presence, provided the hiring comprised the company degree of specialization and characterized as supplementary activity to that of the private sector initiative (HENIE, 2001).

It occupied an important place in the economic-historical arena, and still has as its priority the search for mineral wealth to replace import and also attract foreign capital for the investment. It led to the discovery of new deposits of minerals and to the knowledge of the Brazilian subsoil, key to the beginning of a national and foreign capital mining industry (DANTAS, 2007).

CPRM/SGB gradually began to monopolize the works of geological mapping in the country, taking over the activities carried out by other public bodies. The objectives for the works carried out at the time were to map geologically unknown areas on a recognition scale (1:250.000) and, in larger scale those areas with a probability of mineral concentration. The important projects include:

- Systematic Geological Mapping Project of Brazil (*Projeto Mapeamento Geológico Sistemático do Brasil*) at a scale of 1:250.000 (DNPM-CPRM collaboration)
- Aerogeophysical Mappings (Brazil-Germany collaboration)
- Discovery of deposits:
 - Phosphate - Patos de Minas (MG)
 - Kaolin - Rio Capim (PA)
- Building and inauguration of the plant *Usina Patos de Minas* (MG)
- Building and inauguration of *CETEM* for the *DNPM*
- Pluriannual Program for the study of Brazilian coal
- Operation and maintenance of the national hydrometeorological network
- Project for Analytical References on Brazilian Geology (*Projeto Bibliografia Analítica da Geologia do Brasil*)

As of 1978, with a drastic cut in investments, geological mapping was practically paralyzed, and only resumed as of 1986 with the implementation of Basic Geological Mapping Program in Brazil (*Programa Levantamentos Geológicos Básicos do Brasil - PLGB*).

In the 1990s, following a hectic period in which its extinction was discussed, *CPRM* becomes a government controlled company in 1994 and in 1995, its statute is approved describing functions of a Geological Service for Brazil. In 1996, *CPRM/SGB* is consolidated as a Center for the distribution of basic information, resulting in the commitment set forth in its mission to “Guarantee basic water and geological information for the social and economic development of the Country” (HENIE, 2001).

Already in this decade geological maps began to be produced in digital media with data banks stored in the structure of the mainframe (used by *CPRM* since the 70s). However, an enormous amount of data, information and knowledge, resulting from the intense activities of the previous three decades were scattered. The majority of which was found in analog files, which besides not being relational, were difficult to integrate and lacked consistency.

In 2000, the whole IT area began to be modernized. Maps and cartographic products began to be presented via the Geographic Information System (*Sistema de Informações Geográficas - SIG*) and the relational data banks (BERTOLD, 2006). The project *Projeto GIS do Brasil*, launched in that year, constituted a technological milestone, because it represented the migration of digital paradigms into the XXI century (DANTAS, 2007). And with the objective of supplying the need for a data structure to support the project, *Projeto GIS do Brasil*, in 2000, the idea of a corporate data bank came into being which lead to the elaboration of the *GEOBANK*.

From this period onwards, leveraged by its internal transformations and modernization, *CPRM/SGB* begins a new phase in its history, establishing a position both in the national scenario, as an information and national geoscientific knowledge production and disseminator model, and in the international scenario as the Geological Service of Brazil. When Brazil hosted the 31st International Geology Conference in 2000, the main event organizer was *CPRM/SGB*. In the new phase, with new objectives outlined (such as the search for strategic and social use materials), new programs and important projects are initiated.

A further fact to be noted is the Technical Cooperation Collaboration agreement executed between by and between *CPRM/SGB* and the National Agency of Oil (*Agência Nacional de Petróleo*). *CPRM/SGB* begins to manage and operate the Oil Production and Exploitation Data Bank (*Banco de Dados de Exploração e Produção de Petróleo - BDEP*), established on May 29, 2000, with the objective of organizing, managing, maintaining and making available the technical data generated by the activities of oil exploitation and production in Brazil.

In 2004 part of the governmental *royalties* with their origin in the production of oil and natural gas were now transferred to *CPRM/SGB* in order to promote geological knowledge on the Brazilian territory. In the same year, the technical-scientific cooperation agreement was signed between *CPRM/SGB*, and *DNPM*, and the Japan International Cooperation Agency (Jica) for installing, operating and maintaining the National Center for Training on Mining Pollution Control.

During the four decades of presence its activities have spread nationwide by its 13 regional units, divided into 8 bureaus, 3 residencies and 2 offices. Besides incorporating new technologies, today, more than ever, it is believed that the geological knowledge of our soil and subsoil, and of the processes in place, is important in both economic and social development. Research and knowledge is discussed among State actions, contributing to the improvement of life quality for the population.

V. Services/On line Products

All of these changes and modernization were also seen at the 12 libraries that comprise the *SGB* Network. Today, they operate as an *on line* cooperative catalog, further qualifying the services already offered. These services are not limited to the technical body of the company but reach the whole society. Much more than a deposit for the technical-scientific memory, the *SGB* Network libraries represent a place of connection, building bridges between internal and external users, research and teaching institutions and the society.

Regarding the information services provided on the net (www.cprm.gov.br), the guiding principle was to promote and make available data, information and geoscientific knowledge. Following site update, the number of visits went from 715,000 in 2006, to 1,120,000 in 2007, corresponding to 2 TB of information provided to users.

Presently, any and every user, besides consulting the *on line* *SGB* Library Network catalog, will have access to the following products/services (*CPRM*, 2009):

a) Digital Preservation of the *SGB* Library Network Archives (*Projeto de Preservação Digital do Acervo da Rede de Bibliotecas do SGB*)

With the objective of promoting and publicizing access to the institutional collections, *CPRM/SGB* provides free access to its expressive geoscientific information and data deposit possible via the Digital Preservation Project. Among the available collections, the Geological Analytical References of Brazil (*Bibliografia Analítica da Geologia do Brasil*) and the *CPRM* Collection are of major importance.

The Geological Analytical References of Brazil (*Bibliografia Analítica da Geologia do Brasil*) had as an objective the recovery of the archives lost in a fire, in 1973, at the main geological and mineral matter library existing in South America. In 1982 the first five volumes of the References were published. The Project was concluded in 1985 (last volume date of publication) and it is important to point out that the Geological Analytical References of Brazil, besides listing the references, also includes document finding (depository libraries) and have had their summaries prepared by field specialists.

b) Virtual Shelf

The Virtual Shelf aims at concentrating and making available free access to its published products. Assuming "Free Access" as academic or scientific literature freely available on the Internet, allowing any user to read, download, copy, distribute, print, research or link the full document text, therefore with the aim of obtaining the most profit possible for science and society.

c) Virtual Map Library

Virtual Map Library is a real time catalog that allows access to 530 georeferenced maps, which are a part of the institutional reports generated in the period of 1970-1980. Aiming to preserve the institutional memory this initiative also has the objective of intensifying the diffusion of geoscientific knowledge (comprising the same principles as those mentioned above in the Virtual Shelf).

d) Scientific Production

Scientific Production is a space destined for both publicizing and making available technical-scientific texts produced by *CPRM/SGB* technicians. It lists articles in periodicals, articles of scientific events, lectures monograph, thesis and dissertation presentations.

e) School Channel

The School Channel has the objective of stimulating and harboring knowledge on Geoscience, with the use of selected texts and the aim of contributing as a didactic basis of resources for school research.

f) GeoBank

Geobank is a geological data bank, designed and developed on an Oracle® platform and based on the technology of the Geographic Information System (*Sistema de Informações Geográficas - SIG*). It is a powerful instrument of governmental action for the users of geoscientific information, which contains mixed object-relational type data, under its conception it is destined to attend spatial research in a dynamic way.

It has its origin in the GIS Project of Brazil. This project gathered a collection of geological maps at several scales, existing at *CPRM* until 2002, standardizing information and coding and making uniform lithostratigraphic units, initially at a scale of 1:2.500.000 and then at a scale of 1:1.000.000.

Currently, Geobank and its new collection depend on aggregate technology for the availability and storage of vector data associating graphic entities to the Oracle set of tables, with real time interactions and thematic maps. The Web Map Geobank allows data banks to be consulted and the plotting of maps. Regarding its coverage, Geobank contemplates data from the whole Brazilian territory, in reference to planimetric bases, satellite images, lithostratigraphic units, mineral resources, geochemistry, structures, geochronology, paleontology, geological upwelling, petrographic descriptions and geophysical data. It is therefore a powerful tool for the scientific community users, mining companies, professionals and researches who work in the field of planning, urban, territorial and environmental management.

g) SIAGAS

Established in 1997, the Underground Waters Information System (*Sistema de Informações de Águas Subterrâneas - SIAGAS*), has as its objective to store, systemize and make available data and georeferenced information; initially to support the elaboration of hydrogeological maps inserted in the Program of Basic Geological Mapping (*Programa Levantamentos Geológicos Básicos*) and, later, to meet user demands in the sense of instituting the National Register on Wells (*Cadastro Nacional de Poços*) meeting the requirements of the Water Resource and correlated areas.

Most of its data was obtained from information cards on the wells supplied by several public and private national Institutions, managers and users of underground water and more recently is being enriched with updated data obtained through the register of sources of supply of underground waters.

h) Geodiversity Map

This is a synthesis of the great geosystems which compose the national territory, evidencing its limitations and potentials, based on the lithological constitution analysis of the geological supra and infra-structure.

i) Hydrogeological Domain/Subdomain Maps

Presents the great Hydrogeological Domain/Subdomain Maps (group of geological units with hydrogeological affinities, based mainly on lithological characteristics of the rocks) into which the national territory has been divided, considering its potentials and limitations to what regards the occurrence of underground water. Within the concept adopted, the geological units of the country have been concentrated in seven great hydrogeological domains: Cenozoic Formations; Sedimentary Basins; Porous/Fissure; Metasediments/Metavulcanics; Volcanic; Crystalline and Carbonates/ Metacarbonates.

j) Brazilian Geological Chart to the Million

The Brazilian Geological Chart to the Million (*Carta Geológica do Brasil ao Milionésimo*) is one of the largest products in the field of Geoscience in Brazil, being unique as it unites the knowledge of a whole century of geological mapping in the country and of five decades of academic research.

Available in formats such as JPG (image) or PDF (Adobe Acrobat Reader® document) the Brazilian Geological Chart to the Million contains, in addition to geological information, several thematic folders, standard cartographic information (key, mosaic, etc.) and a data base organized in the Geographic Information System (*Sistema de Informações Geográficas - SIG*), containing an enormous amount of invaluable geological information.

k) Medical Geology

Operating on a multi-institutional and interdisciplinary level and presenting multiuse results, the National Program for Environmental Geochemistry and Medical Geology (*Programa Nacional de Geoquímica Ambiental e Geologia Médica - PGAGEM*) has been elaborated by researchers from CPRM/SGB, and from a number of Universities and Institutes.

Among its objectives it is worthy to mention the execution of environmental geochemical mapping projects in partnership with the other institutions which constitute it, with the goal of supplying support to public health nationwide, by means of water, soil and sediment sampling from river and lake banks, analyzed for the identification of essential elements and compounds and/or that are harmful to the ingestion of humans and/or animals.

l) Paleo Base

The Paleontology Data Base (Paleo Base) gathers data referring to the occurrence of fossils (macrofossils, microfossils and palynomorphs), their taxonomy, paleoecology and biostratigraphy. Additional information is also supplied with a high degree of precision regarding the lithology and geochronology of sediments that possess them, collection sites and reference sources. The registered fossils have their origin in projects carried out by CPRM/SGB, from collections that belong to the DNPM/Museum of Earth Sciences (*Museu de Ciências da Terra*), and to the National Museum and Institute of Geoscience (*Museu Nacional e Instituto de Geociências*), both at the Federal University of Rio de Janeiro (*Universidade Federal do Rio de Janeiro - UFRJ*).

m) Hydrogeological Research on the Semi-arid Northeast (*Pesquisa Hidrogeológica do Semi-árido nordestino*)

The aim of this research is to obtain a general understanding of the hydrogeological behavior of the studied water reserves and of quality distribution of its waters resulted in the elaboration of seasonal potentiometric maps and special and time related zoning on the quality of the water for the various studied water reserves and risk of contamination maps. Another aspect which deserves mention is the question of capacitation and scientific output which was widely developed throughout the project by means of young researcher program reports, Master dissertations, Doctorate theses and works already published in technical-scientific, national and international events.

n) Geology on the Legal Continental Shelf of Brazil

This presents a synthesis on the information regarding the Geology on the Legal Continental Shelf of Brazil (*Geologia da Plataforma Continental Jurídica Brasileira - PCJB*) and adjacent ocean areas in the environment of the Geographic Information System (*Sistema de Informação Geográfica - SIG*). It contains the available information about the PCJB, in an integrated form and correlated to an ample variety of geological, tectonic and mineral resource information in one only georeferenced environment, in addition to a map on the Mineral Potential of the PCJB at a scale of 1:2.500.000.

The collection used was compiled from data available in Brazil and at international agencies on various degrees of knowledge and formats, which were submitted to generalization, filtering and digital fusion procedures with adaptations regarding representation at a scale of 1:2.500.000.

o) South America Geological Map

The South America Geological Map (*Mapa Geológico da América do Sul*) represents a synthesis of the South Americas and of the adjacent ocean area's geology at a scale of 1:5.000.000. This map represents a very consistent summary on the geological information generated in the last 30 years, especially by geological and mining South American services, and allows a quick vision and diagnosis of geological issues.

Geological representations come from published or non-published maps, usually at a small scale as well as from contributions given directly to the coordinators. The main sources of information were compiled until 1998. After that, some areas were updated by means of new collaborator contributions, including added information on the adjacent ocean area.

p) RADAM D Project

The RADAM-D Project (*Projeto RADAM-D*) consists of the performance of a process which allows the preservation of information from original films and diafilms regarding the RADAM and RADAMBRASIL projects, by their digitalization. On execution the following activities may be distinguished: existing material inventory; schematization of the spatial distribution of tracks imaged; high resolution scanner digitalization of images; treatment and edition of imaged tracks and publicizing.

The Amazon Radar Project (*Projeto Radar na Amazônia - RADAM*), was created in October, 1970, and its priority was to collect data on mineral resources, soils, vegetation, use of the land and cartography of the Amazon and in adjacent areas of the Northeastern region. In July, 1975, the radar mapping was expanded to the remainder of the national territory, with the aim of an integrated mapping of the natural resources and was then named the RADAMBRASIL Project (*Projeto RADAMBRASIL*).

As end radar products for the RADAM and RADAMBRASIL projects, 550 semi-controlled mosaics were made available to the public at a scale of 1:250.000 nationwide, which were edited on common and photographic paper, and organized according to the References of Map Indexing (*Mapa Índice de Referência - MIR*) from the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística (IBGE)*).

q) Flood Alert System

The Flood Alert System (*Sistema de Alerta de Cheias*) was a measure adopted to minimize losses incurred due to floods in hydrographic basins. The system consists of a collection and analysis of data from various entities, the elaboration and hydrological forecast and the transmission of information to the Civil Defense Force, Fire Brigade, Military Police and Town-halls.

VI. Conclusion

Amplification of geological knowledge gained leverage with the restructuring of the Mineral Resource Research Company (*Companhia de Pesquisa de Recursos Minerais - CPRM*) which, when submitted to a thorough strategic review and institutional reorganization process, was transformed into the current Geological Service of Brazil (*Serviço Geológico do Brasil - SGB*), an entity exclusively dedicated to generating and disseminating basic geological information and knowledge of the country.

By its history and actions, *CPRM/SGB* has been providing invaluable services, meeting growing demands in regards to the characterization of knowledge about the physical environment of Brazil and demonstrates the capacity of adapting to a new time, in which currently, the expectations face the economic, social and environment fields.

In its mission statement ("Generate and disseminate basic geological and water knowledge necessary for the sustainable development of Brazil"), one clearly notice that its mission is no longer simply technical but becomes a provider of information and knowledge in the field of

geoscience focused on meeting the demands for multidisciplinary products and services of interest to a larger community: the Brazilian Society.

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