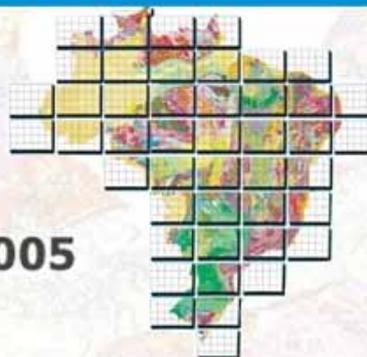


CARTA GEOLÓGICA DO BRASIL AO MILIONÉSIMO



XI Congresso Brasileiro de Mineração – EXPOSIBRAM'2005

20-SETEMBRO-2005 - TERÇA-FEIRA

Auditório I

20h00 - Ato de Lançamento da CARTA GEOLÓGICA DO BRASIL AO MILIONÉSIMO pelo Excelentíssimo Senhor Ministro de Estado de Minas e Energia, Doutor **SILAS RONDEAU CAVALCANTE SILVA**, durante a sessão de abertura oficial do XI Congresso Brasileiro de Mineração - EXPOSIBRAM'2005.

21-SETEMBRO-2005 - QUARTA-FEIRA

Auditório I

12h25 às 12h50 - APRESENTAÇÃO DA CARTA GEOLÓGICA DO BRASIL AO MILIONÉSIMO (Serviço Geológico do Brasil - CPRM)

PROGRAMAÇÃO:

Vídeo - Retomada dos Levantamentos Geológicos Básicos

Descerramento de placa alusiva ao lançamento da CARTA GEOLÓGICA DO BRASIL AO MILIONÉSIMO

Palavras do Secretário de Geologia, Mineração e Transformação Mineral, Prof. Cláudio Scliar

Palavras do Diretor-Presidente do Serviço Geológico do Brasil - CPRM, Dr. Agamenon Dantas

21-SETEMBRO-2005 - QUARTA-FEIRA

Pavilhão Geologia e Mineração (estande da CPRM)

19h00 - Lançamento da publicação GEOLOGIA, TECTÔNICA E RECURSOS MINERAIS DO BRASIL - Texto, Mapas e SIG (livro e DVD)

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Secretaria de Geologia,
Mineração e Transformação Mineral

Ministério de
Minas e Energia



GEOLOGICAL INTEGRATION OF BRAZIL AT 1:1 MILLION SCALE: THE LARGEST BRAZILIAN GEOSCIENCE PROJECT IN GIS

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INTRODUCTION

The Geological Map of Brazil, 1:1 million scale, prepared by the Geological Survey of Brazil–CPRM, is composed by a mosaic of 46 articulated map sheets (Figure 1), with dimensions of 6° longitude and 4° latitude, following the articulation of the International Chart of the World on the Millionth Scale. These map sheets constitute a repository of digital geological information, associated to several related databases that together make up the GEOBANK System. This system is a collection of bases of geological data organized in themes according to a relational model, built on Oracle 9IAs platform (a Web version), using standard libraries and client-server architecture, accessible for consultation and data edition through the Internet by means of selective passwords. The Geographic Information System named *GIS do Brasil* operates the great volume of information contained in the data bank and several geological map sheets, 1:1 million scale. The geological cartographic informations were obtained essentially by compilation, critical analysis, integration and interpretation of the available data (3,328 bibliographic references are listed), in addition to fieldwork, interpretation of satellite images, sampling, as well as isotopic and geochronological analyses. GEOBANK data were obtained by restructuring and re-feeding bases which already existed at Geological Survey of Brazil – CPRM, and by organizing new bases as well. This information represents the state of the art of the Geology of Brazil at the end of 2003, in the perspective of CPRM, within the special consistency limits defined by the 1:1million scale. These data banks resulted in the largest geoscience project in GIS environment ever realized in Brazil.

PRODUCTS

The products available in 41 CD-ROMs containing 46 geological map sheets, were generated using referred data bank system -GEOBANK-, which allows mathematical modeling, interactions and updates in an user-friendly environment. The following products may be accessed in GIS environment: 1) Lithostratigraphic Units and Structures; 2) Mineral resources; 3) Landsat-TM and ETM+ Satellite images, resolution 100 m (Geotiff); 4) Integration of Landsat-TM, ETM+ and JERS1-SAR satellites images, for the Amazonia map sheets; 5) Digital Elevation Model, 100 m resolution (grid ArcInfo); 6) Digital Elevation Model, 500 m resolution (Geotiff image and zipped grid); 7) Geotiff image of Aeromagnetometry, total field; 9) Geotiff image of Aerogamaspectrometry, total counting; 10) Geotiff image of Gravimetry, Free Air anomaly; 11) Geological and physiographical data of the adjoining ocean floor; 12) Paleontological sites and Geochronological dating; 13) Geochemistry of active stream sediments and rocks; 14) Digital cartographic base; 15) Altimetry data and bench marks; 16) Bathymetry; 17) Main sources of cartographical geological data used in the compilation of the map; 19) Nature Reserves, Nature Parks and Indian Reservation.

The different map sheets, available for printing, are represented in the Lambert Conic Conformal cartographic projection system, whose parameters are specifically indicated in each map sheet. They are organized in geodesic values (geographic) and datum SAD69, in the Geographical Information System.

Additional information includes, among others, a map of structural provinces, a list of selected mineral resources, a list of macrofossils, geochronological dating and main sources used in the compilation of the geological cartography.

ARCEXIBE PROGRAM

This program was created by the CPRM staff especially for this project to allow the user to execute geoprocessing tasks, to handle files with several compositions and researches. It is free of charge and without any additional needs. This software enables the user to modify working directories of the CDs, attach new files and data, thus creating specific projects. The only requirement is to simply copy the CD content to the hard drive. The program ArcExibe is a set of routines developed in object Pascal, compiled in Delphi environment, which uses free libraries Map Objects LT ESRI and functions from the program Exibe of the system Geoexp. The environment is user friendly, easy and portable enough. The user is able to read, exhibit shape files (format ESRI ArcView), as well as georeferenced images tiff, bmp and jpeg.

CARTOGRAPHIC BASE

The cartographic base of Brazil used for the project was primarily prepared and published in analog version by the Brazilian Institute of Geography and Statistics – IBGE, according to the International Chart of the World on the Millionth Scale. Digital cartographic bases of the 1:1 million map sheets were prepared conjunctly by the IBGE, CPRM and the the National Agency of Electric Energy–ANEEL. Afterwards, hydrographic simplifications, adaptations and modifications were undertaken by CPRM and Geoambiente Sensoriamento Remoto S/C Ltda, according to images from LANDSAT 5, LANDSAT 7 and JERS 1, compatible with the limits of the 1:1 million scale cartographic accuracy, as well as insertion of new data from the Digital Cartographic Base of Brazil, 1:1 million, published in 2003 by IBGE. For geometrical correction of the images, a simple polynomial model was used plus an average of 240 control points by Landsat image, with average error of 248.13 m collected from common points among images, hydrographic vectors and road system from the Digital Maps of Brazil, 1:1 Million. Overall 382 Landsat images cover Brazil. In some areas, as for example in the Amazon region, much less than 240 points were used. However, in the Southeast, much more than 240 points were collected.

LITHOSTRATIGRAPHIC AND STRUCTURAL DATABASES

These bases comprise data and information generated through field mapping and applied geologic studies in several scales undertaken by CPRM since 1970, as well as public domain bibliographic references developed by teaching and researching institutions. The Geological Map of Brazil, 1: 2.5 million scale (Bizzi et al. 2001), published by CPRM, was the basis for the preliminary version of the 1:1 million map sheets. The first version presented only as plt and pdf files (version 1.0, 2003), was then reviewed, updated and new data bases were incorporated to obtain the final product (version GIS, 2004). An important amount of the data used in the compilation were generated after 1988, through the Basic Geological Surveying Program of Brazil (PLGB) in CPRM, at 1:250 000 and 1:100 000 scales, which improved the accuracy of the cartographic positioning of the geological data for the 1:1 million scale. In the legend of the printing map sheets, stratigraphic units are represented by a colored box with the code of the corresponding lithostratigraphic unit in the map, which is accompanied by a brief description. Shape files of Lithostratigraphy and Structures contain information on age, lithotypes, metamorphism, magmatism, sedimentation, type and attitude of the structures. About 3.200 different lithostratigraphic units were incorporated in the GIS of the Geological Map of Brazil. Beyond that large number of lithostratigraphic units, the location of about 1.200 kimberlites and rocks akin was also included in the GIS, supplied almost entirely by DeBeers do Brasil Ltda. The publication of such volume of information represents a remarkable achievement for the Brazilian Geology.

MINERAL RESOURCES DATABASE

This database was built from files containing information compiled from several databases of CPRM (which also include public domain data) and National Department of Mineral Production–DNPM. More than 28,000 mineral deposits are registered and represent 166 different mineral commodities grouped according to the following classification: ferrous metals, non-ferrous metals and semi-metals, precious metals, gems, rocks and industrial minerals, energetic minerals, rocks, civil construction

materials and minerals for agriculture. It also includes information about mineral typology and metallogeny, according to the Metallogenic Classificatory System of CPRM. The databank presented here still is object of consistency. It is estimated that approximately 4% of the records may contain errors with respect to location, status, toponimy, or mineral classification. The data and information found in the tables of mineral resources attached to shape files, represent a consultation to GEOBANK databank, which is continuously fed and made spatially consistent. In this stage of the setting up of the databank certain parameters were prioritized, such as the updating and spatial consistency of the principal mines in Brazil, represented in the 1:1 Million scale map sheets. Selected and non-selected mineral resources can be distinguished in this global databank. The selected mineral resources correspond to about 10% average, of the total mineral resources registered in the country and among them, deposits, occurrences, active and inactive mines. Information of concession areas of gas and oil were obtained from the databank of the Brazilian National Petroleum Agency.

GEOPHYSICS

The Aeromagnetometric Map of Brazil (Reduced Total Field from International Geomagnetic Reference Field –IGRF with shading effect) was generated from aerogeophysics data gathered from several sources, mainly from the Geological Survey of Brazil– CPRM, the National Department of Mineral Production – DNPM and the Brazilian National Petroleum Agency – ANP. Files in format Geotiff were exported using the same software.

The Aerogamaspectrometric Map of Total Count of Brazil (with shading effect) was generated from aerogeophysic project data gathered from several sources, mainly from the the Brazilian Nuclear Enterprises – NUCLEBRAS, the Nuclear Energy Commission – CNEN, the Geological Survey of Brazil – CPRM and the National Department of Mineral Production – DNPM. Details of both aerogamaspectrometric and aeromagnetometric projects can be found in the CPRM homepage (www.cprm.gov.br). The projects were processed separately and integrated afterwards, using the software OASIS Montaj, Geosoft. The illumination inclination is 45° and the declination is 0°.

The Free-air Anomalies Gravimetric Map covering Brazil was generated from data derived from satellite available for download from the site <http://topex.ucsd.edu>. The grid spacing used for integrating the data is 3,000 m, using the minimum curvature method of the software OASIS Montaj, Geosoft. Files in Geotiff format were exported using the same software.

DIGITAL ELEVATION MODEL

The Digital Elevation Model was generated from the vectorization of constant altimetry of map sheets 1:1 million of the Brazilian Institute of Geography and Statistics – IBGE, in the grid ArcInfo format. The elevation digital model may be visualized overall, map of Brazil (resolution 500 m) or each map sheet individually, 1:1 million map (resolution 100 m).

LANDSAT SATELLITE IMAGES AND INTEGRATION OF LANDSAT IMAGES

A mosaic of images with resolution of 500 m obtained by the Landsat Satellite, from the sensors TM and ETM+, geotiff format covering the entire country are inserted in the CD-ROM. These images may also be visualized individually for each map sheet (resolution 100 m) in the 1:1 million map, in jpeg and geotiff formats. These mosaics were produced by the remote sensing team of the Geoambiente Sensoriamento Remoto S/C Ltd. Each map sheet of the Amazon region is an integration of the Landsat images (3, 4 and 5 bands) and JERS 1-SAR (Japanese Earth Resources Satellite–Synthetic Aperture Radar) presented in jpg and Geotiff formats. The JERS1-SAR images were used by courtesy of “Global Rain Forest Mapping (GRFM) Project © Japan National Space Development Agency-NASDA/MITI” (www.nasda.go.jp). This integration was executed by the Geoambiente Sensoriamento Remoto S/C Ltd.

ADJOINING OCEAN FLOOR

Bathymetry data were obtained from the Brazilian National Petroleum Agency–ANP databank. Brazilian Petroleum S.A.-PETROBRAS granted the information of the isopachs and structural framework of sedimentary basins offshore. The structural framework maps were given as figures,

which were georeferenced and coordinates changed according to the projections parameters adopted in this work. Location errors due to data manipulation are compatible with the work scale. Additional data were compiled from the Geological Map of Brazil, 1:2,5 Million scale (Bizzi et al. 2001). The printing files of some map sheets contain the oceanic islands and archipelagos and islands of the Brazilian continental platform, represented in larger scales insets.

GEOCHEMISTRY

The chemical elements of active stream sediments with more accurate analytical results and more requests by the academic and business areas were also incorporated in the GIS. This selection resulted in more than 150,000 samples, which were analyzed by optical spectrography emission for 20 trace elements (Ag, B, Ba, Be, Co, Cr, Cu, La, Mn, Mo, Nb, Ni, Pb, Sc, Sn, Sr, V, W, Y and Zr). The elements Ag, Au, Co, Cr, Ni and Pb were also analyzed using atomic absorption, while F was analyzed by specific ion electrode. In addition to analytical data, the database contains location and data pertinent to the environment of each sampling local. The vast majority of the analysis was conducted at Laboratory of Mineral Analysis (LAMIN) in CPRM. The analyses were carried out more than 20 years ago by geochemical surveys of CPRM; therefore the lower detection limit of each element is compatible with the standards then. The hydrographic network, 1:1 million scale, was the vector chosen for the works of spatial consistency.

Data related to the geochemistry of rocks are being organized in a specific database. The data presented that correspond to one map sheet (Tapajós–SB. 21), is the first step in the formation of such database. The results represent major, minor and trace elements (including rare earth elements), respectively. The results are associated with sampling point, rock classification and stratigraphic unit.

PALEONTOLOGICAL DATABASE

Paleontological information consists of data referent to fossil taxonomy (macro and microfossil) at specific, generic and supra generic level. Fossil locations are indicated by decimal geographical coordinates and UTM, towns and states, including the form of occurrence. Chronostratigraphic information is referred according to the data obtained from the original source of fossil description, moreover maintaining the lithostratigraphic unit mentioned by the author. The paleontological data presented in the 1:1 million map sheets, includes more than 2, 000 fossils distributed in 480 sites.

GEOCHRONOLOGICAL DATABASE

This database presents the results of about 550 radiometric dating produced by the CPRM between 1996 and 2002. The national geochronology bank, still under construction, is presented here as a first effort, and should be consolidate until the end of 2005, when it is expected to include all geochronological data of Brazil.

TECTONIC MAP

The tectonic map found attached on the left margin of the printing file of the geological map is presented in the same format of the 1:1 million map sheets. The tectonic map was obtained by generalizing, updating and restructuring of the data available in the Tectonic Map of Brazil published by CPRM, scale of 1:2,5 million (Bizzi et al. 2001).

REFERENCES

- Bizzi, L.A., Schobbenhaus, C., Gonçalves, J.H., Baars, F.J., Delgado, I.M., Abram, M.B., Leão Neto, R., Matos, G.M.M., Santos, J.O.S. 2001. Geologia, Tectônica e Recursos Minerais do Brasil: Sistema de Informações Geográficas-SIG e Mapas na Escala 1:2.500.000. Brasília: CPRM, 4 CD-ROM. ISBN: 85-7499-006-X.
- Schobbenhaus, C., Gonçalves, J.H., Santos, J.O.S., Abram, M.B., Leão Neto, R., Matos, G.M.M., Vidotti, R.M., Ramos, M.A.B., Jesus, J.D.A. 2004. Carta Geológica do Brasil ao Milionésimo, Sistema de Informações Geográficas – SIG e 46 folhas na escala 1:1.000.000. Brasília: CPRM, 41 CD-ROM. ISBN: 85-7499-099-4

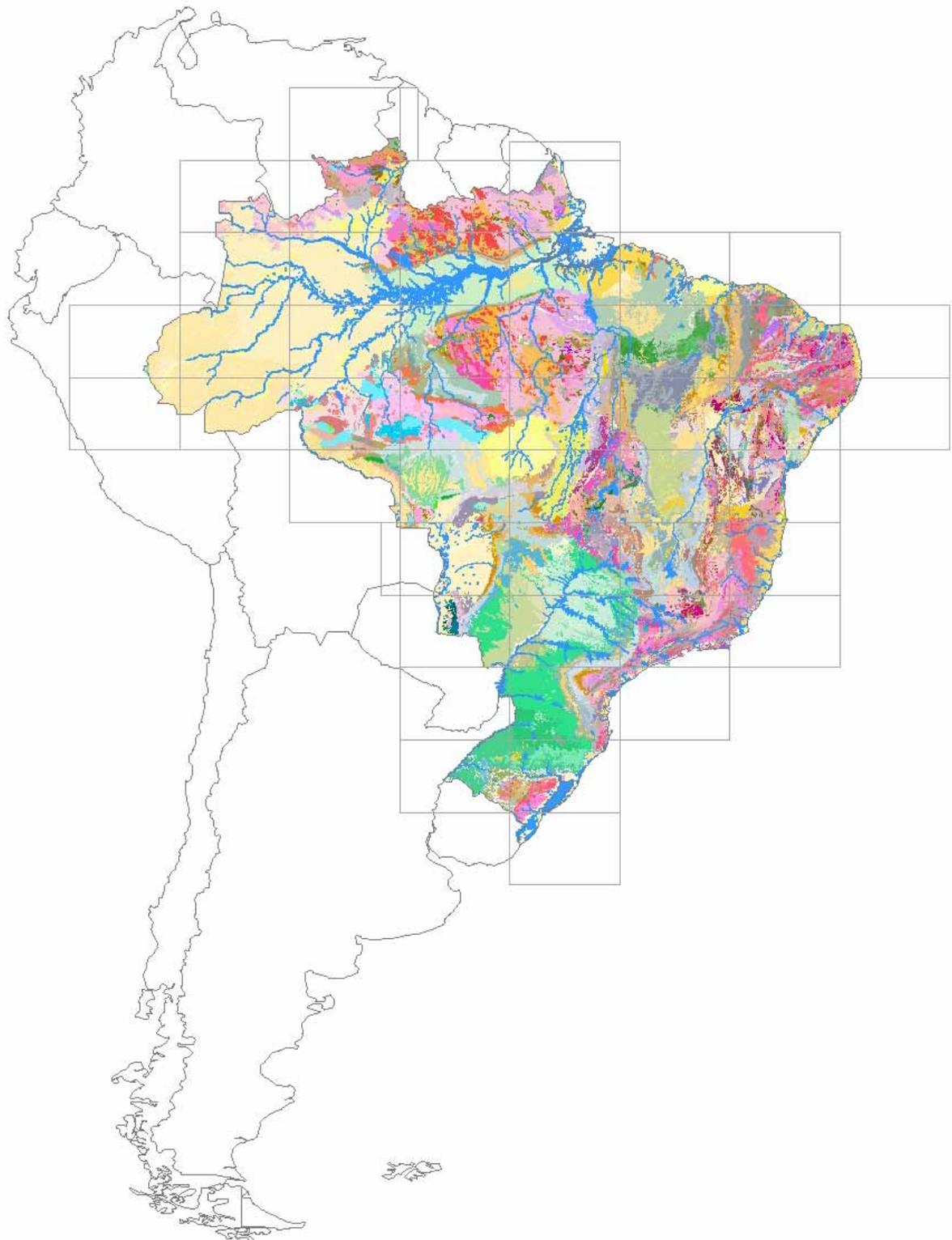


Figure 1 – Geological Map of Brazil, showing articulation of 46 sheets, 1:1 million scale.

RESENHA SOBRE A CARTA GEOLÓGICA DO BRASIL AO MILIONÉSIMO EM SIG DA CPRM **Álvaro Penteado Crósta**

O lançamento pela CPRM da coleção de CDs contendo a Carta Geológica do Brasil ao Milionésimo a CPRM estabelece um marco histórico na disponibilização de informações sobre a geologia do território brasileiro.

Alguns talvez recebam esse lançamento como mais um conjunto de mapas, produzido por um órgão público e contendo o conhecimento atualizado sobre a geologia do Brasil. Outros, todavia, irão perceber que se trata de muito mais do que isto.

Membros do primeiro grupo não irão, porém, se decepcionar. Ao colocarem um dos CDs da coleção em seu computador, poderão visualizar ou imprimir cada uma das folhas ao milionésimo. O menu de acesso é simples e intuitivo e traz uma série de informações sobre o projeto, o mapa geológico propriamente dito e um conjunto de mapas temáticos do Brasil, representado por mosaicos de imagens de sensoriamento remoto, modelo digital de elevação e dados geofísicos. O mapa encontra-se disponível nos formatos JPG (imagem) ou PDF (documento do Adobe Acrobat Reader©) e contém, além das informações geológicas, vários encartes temáticos, além das informações cartográficas padrão (legenda, articulação das folhas, etc.).

Já aqueles que não se contentarem com um documento cartográfico “estático” terão diante de si algo de valor consideravelmente maior: uma base de dados organizadas em SIG (sistema de informações geográficas), contendo uma enorme quantidade de informações geológicas, de valor inestimável.

Essa quantidade bem como a diversidade de informações que a CPRM conseguiu reunir nesses CDs é simplesmente espantosa. Além daqueles dados que normalmente compõem um mapa geológico (unidades litoestratigráficas, estruturas, etc., das áreas continental e oceânica), a base de dados inclui também imagens dos satélites Landsat 5 e 7 e JERS-1/SAR, modelos digitais de elevação, imagens geofísicas (magnetometria, gamaespectrometria e gravimetria), ocorrências minerais, sítios fossilíferos, datações geocronológicas, análises geoquímicas, batimetria oceânica e referências bibliográficas.

Em contraposição aos documentos cartográficos “estáticos” (impressos), a organização das folhas da Carta ao Milionésimo em uma base SIG permite não apenas a visualização desse imenso conjunto de dados, mas também a sua análise integrada e sua modelagem. Permite ainda que, no futuro, esses dados sejam modificados, complementados e/ou atualizados, gerando novos mapas e imprimindo assim um caráter dinâmico à cartografia geológica do nosso território.

Talvez alguns de nós, membros da comunidade geocientífica, se sintam desencorajados em fazer uso pleno desse grande potencial, por não ter acesso fácil a aplicativos de software de SIG (geralmente de alto custo). Para estes, a boa notícia é que a CPRM também pensou nisso e incluiu em cada CD-ROM cópia de um aplicativo gratuito de SIG desenvolvido pela própria empresa. Trata-se do programa ArcExibe, de manuseio muito simples e com uma interface bastante amigável. Mais um ponto para a CPRM!

A coleção de 46 mapas ao milionésimo abrangendo todo o território nacional foi reunida em 41 CDs. Cada um vem em uma capa dura, de design atrativo, acompanhado de livreto explicativo (em português e inglês), com informações sobre a instalação e o uso dos CDs e seu conteúdo. A coleção completa foi reunida numa prática caixa de papelão dura, com o mesmo design das capas, garantindo assim uma boa figura em qualquer biblioteca.

Em conclusão, trata-se de uma iniciativa louvável da CPRM, que com este lançamento dá seqüência à disponibilização em 2002 do mapa geológico Brasil na escala de 1:2.500.000, também em SIG. Trata-se certamente do maior conjunto de informações sobre a geologia do Brasil colocado à disposição da sociedade em todos os tempos.

Deve ser destacado o caráter possivelmente inédito de tal iniciativa em nível mundial. Não há registro de qualquer outro país que tenha disponibilizado, de uma só vez, informações dessa completude, em formato digital e organizada numa base SIG, acompanhada de software gratuito.

Está de parabéns a CPRM e todo o seu corpo técnico por esta coleção, que passa a constituir documentação de referencia indispensável para profissionais e empresas da área de geologia, mineração, petróleo e meio ambiente, bem como para atividades de ensino relacionadas à geologia do Brasil.

Álvaro Penteado Crósta

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