GEOCHEMISTRY-GEOPHYSICS DATA INTEGRATION FOR MINERAL EXPLORATION IN BRAZIL

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• Introduction

• Geological data base

• Geophysical data base

• Geochemistry data base

• Data integration: examples

• Conclusions
Brazil’s mining potential is significant. To date, about less than 30% of its immense territory is known through geological surveys in an appropriate scale for this activity (IBRAM, 2010).

Geologic, geophysical, and geochemical public data bases have been improved continously in the recent years.

The integrated use of this information can lead to new mineral prospects and targets.
With the development of the Program Geology of Brazil, early in this century, the Brazilian Geological Survey (CPRM) received new means to improve the geological knowledge of the country.

The aim of PGB is to cover all the country with geological maps in the 1:250,000 and 1:100,000 scales.
Location of geological mapping projects in the scale of 1:250,000 under development in 2010 by CPRM
Location of geological mapping projects in the scale of 1:100,000 under development in 2010 by CPRM
Location of geological mapping projects in the scale of 1:250.000 under development in 2010 by Universities in association with CPRM
The main public geochemistry data base available in Brazil is with CPRM. The Database of Geochemical Projects (GEOQ) was created from the geochemical data of the Projects developed since 1972 by the Geological Survey of Brazil - CPRM. It intends to supply the users with all data produced by the geochemical surveys carried on in Brazil in order to help mineral exploration and geologic mapping.
The projects have been assembled in four maps as following: Regional Geochemical Surveys - Maps 1 and 2; Special and Detailed Projects - Map 3; and Projects without geochemical activities - Map 4.
Geochemistry projects from regional surveys conducted since 1972 for the Mineral Production Department (DNPM) and regional geochemistry studies from the Program of Basic Geological Surveys (PLGB), conducted by CPRM.
Regional Geochemistry Prospecting 2

Regional geochemistry projects from the Program of Basic Geological Surveys (PLGB), conducted by CPRM to the DNPM and CPRM.
Detail Geochemistry Prospectsing

Special projects and detail geochemistry surveys conducted to CPRM, National Commission on Nuclear Energy (CNEN), National Copper Reservation and Associates (RENCA), and Executive Group of the Lower Amazon River (GEBAM).
Geochemistry data base

Data from other Projects

Geochemical data from projects without specific geochemistry activity conducted by CPRM to CNEN and local state governments.
The CPRM database comprises 373 parameters (location, coordinates, field and analytical data, etc.) covering 330 projects. Stream sediments, pan concentrates, soils and rocks are the main sample classes. Water, vegetation, pebbles and marine sediments are in minor amount. Atomic absorption, x-ray fluorescence, inductively coupled plasma, emission spectrometry and mineralogy determinations are the principal analyses.
Stream sediment samples in CPRM projects (Lins, C. A. C. 2005)
Paterson, Grant & Watson Limited (PGW), in collaboration with Companhia de Pesquisa de Recursos Minerais (CPRM), have recompiled part of existing Brazilian geochemical data into a single unified digital database.
Data
262 Project Areas consisting of 284,475 samples and over 3 million measurements
Elements Sampled: Au, Cu, Pb, Zn, Ag, Co, Cr, Ni, Fe, Mn, As, Sb, Bi, Sn, and Mo
Sample Types: soils, stream sediments, rocks, pan concentrates, and pebbles
Analytical Techniques: fire assay, emission spectrometry, and atomic absorption
Geochemistry data base

Products
Each edited dataset have been transformed from the current IBM-CPRM computer database to a new unified database (i.e. Geosoft OASIS Chimera™ and Microsoft Access™). The data structure is the same for all surveys and will be accessible by all major current GIS/geochemical software packages.
Final Products consist of the complete database for Brazil, a set of sample location maps, and a complete Technical Report with Documentation and Digital Survey Atlas.
Partial products available on a survey or area basis.
Geochemistry data base

Copper geochemical anomalies

Paterson, Grant & Watson Limited (PGW), 2012


Special reference to international cooperations: with Canada (PGBC, 1970) and Germany (CGBA, 1971).
As grandes “crises do petróleo” de 1978 e 1982, trouxeram restrições orçamentárias para o DNPM e para a CNEN, que contratavam a CPRM para seus levantamentos. Como consequência houve a suspensão da grande maioria dos trabalhos planejados para as décadas de 80 e 90 nos dois Planos Decenais de Mineração e no Programa Levantamentos Geológicos Básicos do DNPM. A retomada dos aerolevantamentos geofísicos ocorre no início do presente século.
Airborne geophysics production by DNPM and CPRM from 1953 to 2006. Incluídos aqui os aerolevantamentos feitos pela CODEMIG no início de 2000.
Airborne geophysics production by CNEN and NUCLEBRAS from 1959 to 1982
Airborne geophysics production by CNP and PETROBRAS from 1952 to 1996
Airborne geophysics production by private companies and through cooperation between CPRM and states MG, BA and GO from 1955 to 2007.
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Geophysical data base
Residual magnetic field
(Bizzi et al 2003)
EXAMPLES
The State of Goiás is an important polymetallic province. The province has close to 2,000 mineral occurrences. Some of those have been changed to active mines.

The State of Goiás has a geological setting favorable to the exploration of several minerals. Presently, the exploration activity in the state is quite intense.
Bases de dados

- Bases de dados
- Geologia
- Geofísica aérea
- Geoquímica
UnB/ IG – LGA

Data bases: geology

Geologic map 1:500,000

Geologic map 1:250,000

Geologic map 1:100,000
Recent airborne geophysics coverage
Brazil-Canada Geophysical Program complementary geochemistry survey.

Stream sediment
13104 samples
27 elements
Obs.: Not all samples analysed for all elements
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Bases de dados: geofísica

Goiás examples:
Gold in Mara Rosa Arc

Gold occurrences are recorded south of the study area. To the south lies the occurrence Adventino structurally controlled by NS shear zone and hosted in chlorite schist. These rocks, interpreted as the product of hydrothermal alteration, are associated with meta-andesite, carbonaceous schist with disseminated sulphides and massive sulfide layers. Potential for gold also occurs in Neoproterozoic units north of this region. There is a possibility volcanogenic mineralization in Mara Rosa Sequence. Additionally, remobilization and deposition of gold may have occurred along the extensive shear zones and subordinate systems.
The area is located in the northern segment of the Brasília Belt. The Mara Rosa magmatic arc consists of extensive outcrops of gray gneisses, with composition ranging from predominantly dioritic to tonalitic, and can present granodioritic and granitic compositions. The orthogneisses are associated to supracrustal rocks consisting of schists and amphibolites and rocks of chemical origin, such as banded iron formations and gondites. The mafic metavolcanic rocks represent calc-alkaline signature, which is associated tholeiitic series. Abundant late intrusions of granitic rocks and gabbro-diorite cut orthogneisses and supracrustal rocks.
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Airborne magnetometry

Magnetic field analytic signal amplitude

Geologia local
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Airborne magnetometry

Magnetic field analytic signal inclination
UnB/ IG – LGA

Airborne magnetometry

Magnetic domains and lineaments

<table>
<thead>
<tr>
<th>Dominios Magnéticos Interpretados</th>
<th>Amplitude relativa para as assinaturas magnéticas</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Muito Alto</td>
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<tr>
<td>2</td>
<td>Alto</td>
</tr>
<tr>
<td>3</td>
<td>Médio</td>
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<tr>
<td>4</td>
<td>Baixo</td>
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<tr>
<td>5</td>
<td>Muito Baixo</td>
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Airborne gamma-ray spectrometry

Potassium content distribution over the area

K (%)  K_{anomalous} (%)
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Geofísica aérea: Gama

Radioelements in magmatic rocks

RGB composition

Geology
The 59 samples of stream sediment geochemistry are distributed uniformly over the area. Samples were collected from drainages that are oriented, in the region, mainly in the directions NW-SE and NS.
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Geochemistry

Copper

Lead

Zinc
- The presence of granitic intrusive rocks and shear zones may be exerting strong control on the spatial distribution of some elements.

- High contents of REE and others in the northwestern portion of the area are clearly associated with the presence of granites.

- The presence of these elements, in combination with regions with anomalous values of potassium concentration, suggest the occurrence of hydrothermal alteration in the northwestern region.

- The differential enrichment observed, especially in the contents of the elements Cu, Pb and Zn in the southwestern area, has no clear association with additional intake of potassium.

- If the high enrichment of these elements, with levels above usually standards for the present lithologies, is linked to the hydrothermal alteration, then the result would be more sericitic or propylitic stage of the process.
Integration of airborne geophysics and geochemistry for the selection of phosphorite targets in NE Goiás.

Ref.: FIANCO, 2011
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Airborne geophysics

Airborne gamma-ray spectrometry
Airborne geophysics

Ternary RGB gamma-ray map

Magnetic field analytic signal amplitude
Phosphorous content (ppm) in stream sediment samples.
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Statistical estimation

Phosphorous content (ppm) estimated from statistical regression using geochemistry and geophysical data.
Target selection

Selection of targets for field detailed investigation. Selection based on estimated anomalous P concentration.
Known occurrences of phosphorite in the area are associated to U and U/Th anomalies.
Selected targets based on U and U/Th anomalies proved successful.
The price per ton of lanthanum increased from $ 5,700 to $ 50,000 after China, accounting for 97 percent of world production of rare earths, limited the export quotas at the end of 2010. (Reuters, April 24)
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