Coal Research Follow Up on RS-SC Coastal Region Using Aeromagnetic Data Interpretation

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This paper was prepared for presentation during the 11th International Congress of the Brazilian Geophysical Society held in Salvador, Brazil, August 24-28, 2009.

Abstract

The Brazilian Geological Survey (CPRM) at the eighties did an extensive continental coal research Project over Paraná basin, south of Brazil, and as result some economics coal deposits was discovered at Rio Grande do Sul (RS) and Santa Catarina (SC) states. Nowadays, with the increasing needs for energy resources, a follow up is concentrated over coastal and offshore areas to understand the coal bed extension in that direction. This paper deals with old aeromagnetic data, recovered by digital processes over Magnetic Total Field maps. First vertical derivative, reduction to the pole, Euler deconvolution and satellite gravimetric data were the main techniques used. A better understanding of the tectonic styles of the basement, the influence of volcanic rocks and some considerations about the Paleozoic layers extension under the sea are presented.

Introduction

The Continental Shelf RS-Cabo Frio Aeromagnetic Project was flown in 1969 for Petrobras by Prakla Seismos and covers 219,000 km^2 from Rio Grande do Sul to Cabo Frio, RJ, extending in a range of 150 to 220 km from coast line. The flight lines interval was 5000m and the line direction, perpendicular to the coast. Precision measures was 1 nT. The original data was lost and the ones used came from digitalization of old contour maps of the total component of the magnetic field. In this paper we take a small area of this project which can be of interest to the new coal project carried out by CPRM. Original data was acquired at 700m barometric height and to take advantages of a very small smooth, we did an upward continuation of 300m. Figure 1 shows the Total Magnetic Field reduced from IGRF (1970) at 1000m height.

Reduced to the pole map

The reduction to the pole is a very effective way to visualize the geological structures due the fact that the positive anomalies became positioned directly over the magnetic causative body. It is defined by

$$L(\theta) = N / (D1 * D2)$$

Where $N = \left(\sin(I) - i\cos(I) * \cos(D-\theta)\right)^2$

$$D1 = \left(\sin^2(Ia) + \cos^2(Ia) * \cos^2(D-\theta)\right)$$
$$D2 = \left(\sin^2(I) + \cos^2(I) * \cos^2(D-\theta)\right)$$

With

$I =$ magnetic inclination (-30º on June 1st, 1969)

$D =$ magnetic declination (-12º on June 1st, 1969)

$Ia =$ amplitude correction factor (70º used)

Figure 2 shows the shadowed reduced to the pole map.

The first derivative map

The magnetic field varies faster over the contacts than far away, and filters based on this fact are commonly used to trace the contacts between rocks with magnetic susceptibilities differences. Figure 3 shows the first vertical derivative of the magnetic field and this was a very meaningful map on interpretation.

The Euler deconvolution map

Euler equation for homogeneous functions uses the first partial derivatives and states:

$$(x - x0)\left(\frac{\partial f}{\partial x}\right) + (y - y0)\left(\frac{\partial f}{\partial y}\right) + (z - z0)\left(\frac{\partial f}{\partial z}\right) = nf$$

Where:

x, y and *z* are the coordinates of the measuring point, *x0*, *y0* and *z0* are the source coordinates, *n* depends on the type of the source (it is called "structural index" or SI) and *f* is the magnetic (or gravimetric) intensity of the field.

Figure 4 shows the Euler deconvolution of the magnetic data using an SI = 1 which corresponds to sills or dikes

Satellite gravity data map

Public data available from University of California at San Diego (http:// topex.ucsd.edu/cgi-bin/get_data.cgi) was used mainly to trace the limits of the Paleozoic Basin under recent sediments or shallow sea water. Figure 5 shows the satellite gravimetric data on the area.

Interpretation of results

Three magnetic patterns are clearly seen on the maps, all of them with NE-SW main direction. The first derivative map increases the contacts signatures of these areas and it is clear that all reflects the continental basement rocks, by its parallelism with the outcropping pre-Cambrian regional rocks of the continent. Intrusive basic rocks on crystalline or sedimentary sequences add a new pattern over the first ones.

Figures 1 to 4 show these patterns as three strips, parallel to the coast line. The first vertical derivative map of the total intensity of the magnetic field was used as the base for interpretation.

To offshore direction, the first strip (GRA) is more homogeneous (low to mid frequency pattern) and by correlation with the surface mapping of Horbach et al., (1986) and Willig et al., (1974), it represents the granites rocks of Dom Feliciano belt in Rio Grande do Sul or Santa Catarina states. The middle strip (MIG) shows a very strong orientation NE-SW (high frequency pattern) indicating rocks with accentuated alternation of high and low magnetic susceptibilities, and takes us to consider them as belonging to the Cambuí Group, constituted by migmatites, amphibolites and metabasites. The more distal strip (DB) was interpreted as “deep basement” and the contact between the last two as the hinge line of the Pelotas Basin.

The last one strip (DB) with low frequency pattern can be considered as shallow (GRA) strip or deep (MIG) strip. The low frequency oriented magnetic anomaly and the mantle ascension indicated by the gravity data (Figure 5), directed us to the second hypothesis. A 2D magnetic modeling would be of interest, but it is not presented in this paper.

Extensive and intensive faulting with NW-SE direction (and minors with E-W direction) affects the area and this effect is better seen in the middle pattern magnetic zone (MIG) due to high frequencies, but they continue both to the east at the low frequency pattern area as well to the west into the low to mid pattern frequency area.

At least three main E-W lineations in Morro dos Conventos – South of Torres region reflect regional faults which control the sediment filling, as is the case of Torres synclinal.

The Euler Deconvolution for sills and dikes using an window of 10km x 10km was applied on the magnetic data. In spite of limitations due to be a statistical method of interpretation, we can see concentrations of magnetic sources in Torres and Morro dos Conventos region, and on hinge line, south of Torres latitude. These concentrations points to a behavior of sill type.

The most part of sources has a NE-SW orientation revealing dikes concordant to regional rocks and a minor but expressive part, as discordant dikes, in NW-SE direction.

From Morro dos Conventos to SW of Torres was mapped an area (PB) of possible extension of Paraná Basin under sea or recent sediments. Practically no variation of the magnetic field and negative gravimetric anomaly (mass lack) indicate the presence of a thick sequence of Paleozoic sediments. The region mapped as PB in figure 6 does not mean that the Paleozoic occurs only in it, but that it is well developed there. Some magnetic lineations (NE-SW) and variations on the contours of gravitational data, point to the presence of sills or dikes as shown in figures 4 and 5.

Conclusions

Old and lost aeromagnetic data recovered by digitalization of contours maps joined with satellite gravity data was able to reveal some important aspects of subsurface geology on RS-SC coastal area an brought new ideas to review the seismic and drill data in respect to coal follow up. Ground and possible shallow water geophysical acquisition will be the next steps on the research program.

Acknowledgments

The authors are grateful to CPRM and ANP for the use of data and authorization for publication of this paper.

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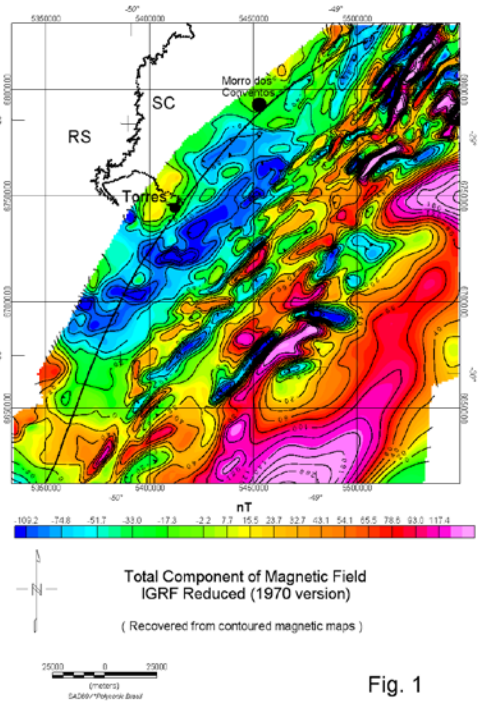

Fig. 1

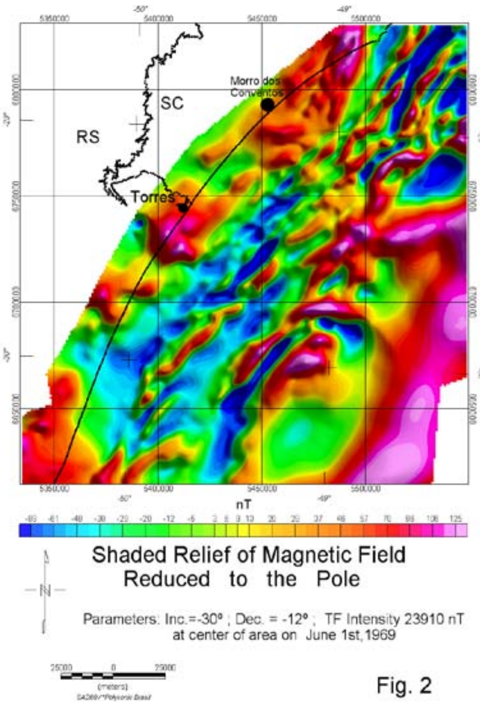

Fig. 2

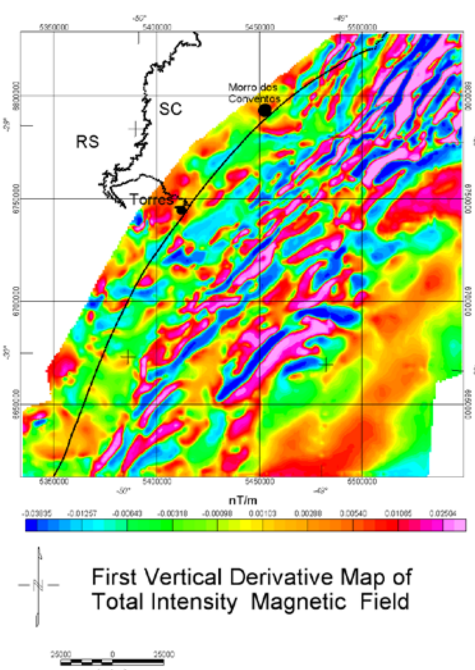

Fig. 3

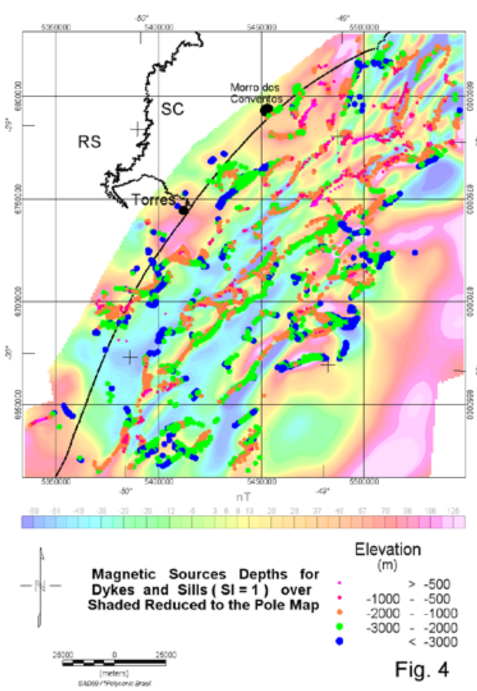

Fig. 4

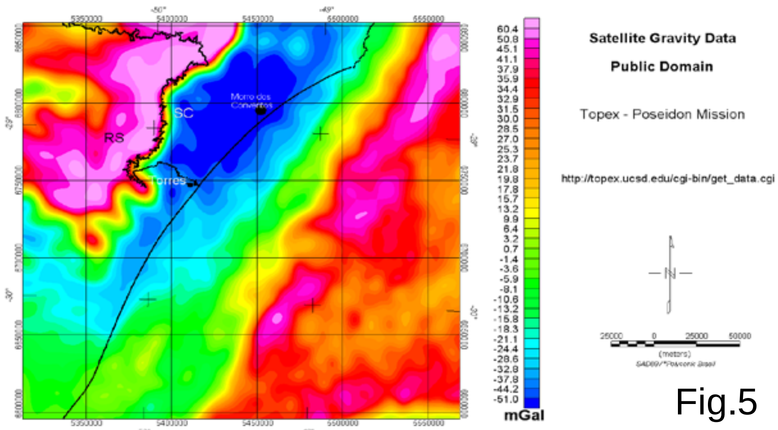
Satellite Gravity Data
Public Domain
Topex - Poseidon Mission
http://topex.ucsd.edu/cgi-bin/get_data.cgi
mGal
RS
SC
Torres

Fig.5

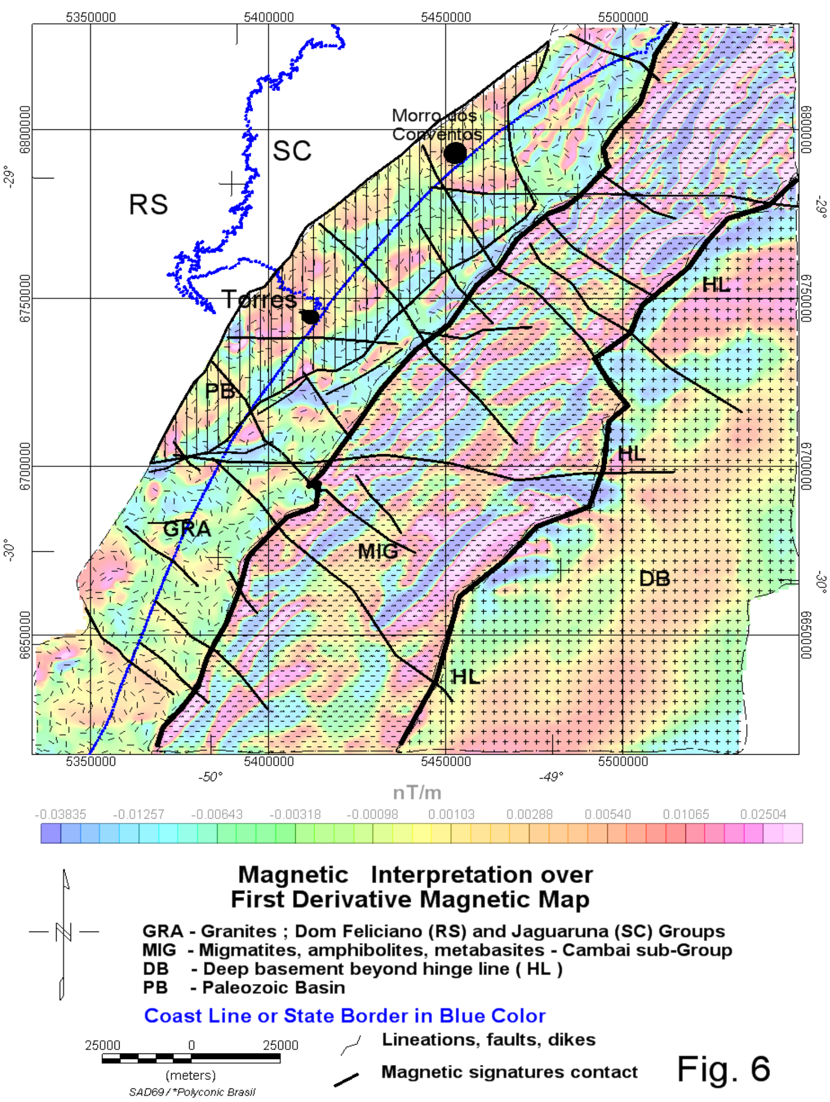
5350000
5400000
5450000
5500000
6800000
6750000
6700000
6650000
-29°
-30°
-50°
-49°
Morro dos Conventos
SC
RS
Torres
PB
GRA
MIG
HL
DB
nT/m
-0.03835
-0.01257
-0.00643
-0.00318
-0.00098
0.00103
0.00288
0.00540
0.01065
0.02504
Magnetic Interpretation over
First Derivative Magnetic Map
GRA - Granites ; Dom Feliciano (RS) and Jaguaruna (SC) Groups
MIG - Migmatites, amphibolites, metabasites - Cambai sub-Group
DB - Deep basement beyond hinge line (HL)
PB - Paleozoic Basin
Coast Line or State Border in Blue Color
Lineations, faults, dikes
Magnetic signatures contact
25000
0
25000
(meters)
SAD69 / *Polyconic Brasil

Fig. 6