Aeromagnetic Interpretation of the Dianongo Trough HRAM Survey, onshore Gabon

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Summary

The objective of this HRAM survey over the Dianongo Trough of onshore Gabon was to map basement structure associated with rifting and related intra-sedimentary faulting over several producing fields for analog purposes and over Ocelot=s exploration acreage to assist in exploration. The Dianongo Trough lies immediately west of the Precambrian basement outcrop and it is part of the South Gabon Basin. The production in the area, including the giant Rabi-Kounga Field, comes from the Cretaceous sands below Ezanga salt, which is Aptian in age. In most parts of the basin seismic is ineffective at imaging structures below the base of salt. So any geophysical control on deeper structure would improve exploration results.

The interpretation of this survey has been successful at mapping several sets of basement faults, as well as identifying a complex set of post-salt arcuate ridges which had previously been unrecognized. These surface ridges are related to gravity sliding along a decollement in the Ezanga salt and younger Madiela shales. These faults are magnetized by fluid flow and are clearly visible on the 1st vertical derivative map (Fig. 1).

The interpretation identified numerous structural leads as areas on which to focus additional exploration effort. It has also provided a regional structural model which will assist in the interpretation of deeper seismic data which is very difficult to correlate between lines.

Introduction

The Dianongo Trough (Gabon) High Resolution Aeromagnetic (HRAM) survey was designed to take advantage of the new interpretive capabilities in aeromagnetics by using high resolution acquisition and interpretation techniques combined with interpretation of RADARSAT data (Davies and Berger, this volume). This is a difficult area to map beneath the Aptian Ezanga salt using reflection seismic surveys because of diffractions and scattering from complex post-salt structures caused by gravity sliding of the younger section. In the main part of the basin there are very few coherent reflections below the salt. The overall objective of this survey then is to map regional structure from aeromagnetic data and to relate the structure to potential exploration leads. The specific objectives of the survey are: 1) to map basement and intra-sedimentary faulting patterns beneath the Ezanga salt; 2) to develop structural templates over existing fields to assist in exploration; 3) to identify exploration leads based on the location and pattern of these faults; and 4) to ascertain the relationship between post-salt faulting and pre-salt faulting.

The survey was flown by Sander Geophysics in 1998. In-field quality control was provided by Erwin Ebner of ELS Consulting. The survey area covers from latitude 00E50' S to latitude 02E03' S and from longitude 09E48' E to longitude 10E23' E. All data were referenced to the WGS-84 datum. The survey was flown with N/S traverse lines at 600 m spacing and 60E- 240E control lines at 1800 m spacing with ground clearance of 120 m (drape). The total line kilometers for the survey is 12,009 km, for a total area of 5470 km$^{2.}$

The interpretation has been a joint effort of GEDCO, Image Interpretation Technologies and Ocelot Nze Gabon Inc., in order to combine skills in HRAM and RADARSAT interpretation with the accumulated exploration experience of the operator. The available seismic data was used to constrain the structural style of the HRAM interpretation without engaging in a formal seismic interpretation as part of this project.

Data Preparation

The data were culturally edited (Hassan, et al., in press) to remove the influence of pipelines, wells and other man-made magnetic anomalies. The result is a much cleaner final data set for analysis. Band pass, including pseudo-depth slices, and gradient filtering were used to highlight features of interest. The choice of filters was guided by spectral analysis, but the final selections were chosen empirically based on our judgement of what produced the most useful images for structural interpretation.

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The depths to magnetic sources were estimated using MagProbe which is a software program which uses a variety of magnetic depth estimation techniques. The depth solutions were interpreted using a combination of manual and automatic (MaFIC methods (Rhodes and Peirce, this volume). These provided information on the location of faults (Peirce, et al., 1998; Roundtable, 1999) and contacts, as well as estimated depth to magnetic basement. The structural grain maps summarize the basement and the intra-sedimentary faults which are magnetized.

The basement structural grain map integrates the deep well control and the interpreted magnetic depths to the basement into one basement structural map. There are 80 wells in the area of which 23 penetrate Precambrian basement, so we have a general framework of basement depth on the north half of the area from well control. The basement structure is contoured at a 200 m contour interval. Basement structure is consistent with the block (horst and graben) faulting that occurred during rifting in the Late Jurassic and Early Cretaceous. The basement deepens to the southwest, with several horsts and basement noses interrupting this general trend. Several structural leads are identified.

The intra-sedimentary interpretation map shows interpreted faults where the depth analysis indicates they are occurring above basement. Most of the intra-sedimentary structural leads appear to be associated with deeper basement blocks. However, in the southern part of the basin there are several leads identified which do not have detectable basement structures beneath them. In particular, we can find no evidence for a deeper basement structure underneath the Rabi-Kounga Field, contrary to the previously published interpretation (Boeuf and Hombroek, 1991).

Conclusions

The results have provided a dramatically new perspective of the tectonics of the survey area. Most notable in this regard is the discovery of a set of arcuate ridges in the center of the survey area. These ridges are formed in response to gravity sliding of the entire post-salt section on the Ezanga salt. The exact mechanism for the formation of these ridges is still a matter of debate, but salt flowage and salt dissolution both appear to play a role. The degree to which deeper fault patterns influence the position and shape of these ridges is still unresolved.

Several sets of faults related to rifting have been defined. There appear to have been at least two geometries associated with early rifting. The interference of these two stress patterns and the reactivation of pre-rift faults produce a complex fault pattern which form several possible structural leads for further exploration. Coucal is the only existing field in the survey area where we can demonstrate a probable basement component to the structure. In contrast, the giant Rabi-Kounga Field, although clearly evident on the higher frequency components of the magnetic data, does not appear to be related to any basement structure.

The following summary conclusions are reached:

1. A set of arcuate and parallel ridges was discovered in the middle of the survey area. These low relief ridges are formed in response to gravity sliding of the younger post-salt section, based on the following observations:
    1. the topographic ridges correlate with seismically high, post-salt structures underneath;
    2. the seismic highs, although they appear at first glance to be diapiric in nature, have internal reflectors which are not coherent within each block;
    3. the troughs between the ridges correlate with magnetic highs (Fig. 1), indicating that the fault zones between the ridgesare magnetized;
    4. Seismic evidence in the northern part of the basin demonstrates that the post salt section is gliding on a decollement within the Ezanga salt and or the Madiela shales. The direction of sliding appears to be to the west and south.

2. Basement structure is consistent with block faulting associated with rifting in the Late Jurassic and Early Cretaceous. There is a second set of faults running at a small angle to the main rift faults. These may be related to a second phase of rifting. The interpretation of these faults on the magnetic data is supported by the IIT interpretation (Davies and Berger, this volume) of the RADARSAT data, including the exposed Precambrian outcrops to the east of the survey area.

3. We have identified numerous pre-salt structural leads from the magnetic data. Some of these leads include known fields in the area. Most of the structural leads group into two trends: one trend associated with the arcuate ridges and a second trend related to cross-faulting along the Coucal trend.

4. Direct comparisons of magnetized faults from the final magnetic interpretation to long regional seismic lines indicate that over 75% of the seismically imaged faults in this area are magnetized.

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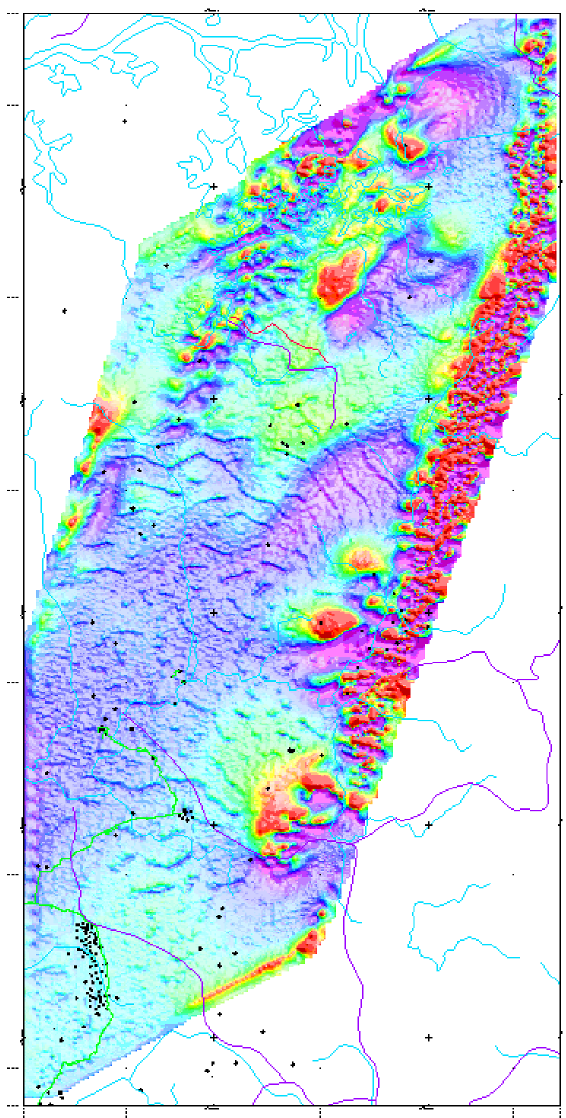

Figure 1. First vertical derivative of Total Magnetic Field, Dianongo Trough, onshore Gabon. The data have been correct for IGRF, no reduction to the pole has been applied., and every profile has been culturally edited to remove 90-95% of the magnetic response of manmade installations. The giant Rabi-Kounga Field is the large field in the SW corner of the survey. Ocelot=s Obangue discovery is at the southern end of the lake in the south central portion of the survey. The map area is approximately 65 x 130 km. Note the arcuate, high frequency magnetic anomalies in the central part of the survey. These are magnetized faults which bound the arcuate ridges discussed in the text.