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The Use of Aeromagnetics and Airborne Gravity in Petroleum Exploration

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Summary

Airborne magnetics and gravity have been used widely in the past for surveying large areas as a way of mapping out basins and basement structures. These methods have often been used as a precursor to seismic surveys as a way of highlighting possible target areas for stratigraphic or structurally controlled oil traps. With the improvement in sensitivity and resolution of these two methods it is now possible to map in more detail the actual oil traps and provide high resolution data to aid seismic interpretation. In addition to hardware improvements, in the last decade we have witnessed a great improvement in 3D modeling techniques (Fernando et al, 2007). It is now possible to create a 3D Inversion Model for both gravity and magnetics within a short time. The detailed 3D model provides magnetic susceptibility and density information that is indispensable for aiding seismic interpretation and filling in the gaps between seismic survey lines.

Introduction

In the past few decades exploration geophysics has attained a great significance in understanding the structure of geosynclinal areas, platform regions, and tectonic movements and for locating structures favorable for accumulation of oil and gas. These investigations are usually carried out by magneto-telluric sounding, deep seismic sounding, geothermal, gravity and magnetic methods. Regional gravity and magnetic anomalies connected with deep features occupy large areas (~ 10 to 500 sq.km) have large intensity and reflect the structural feature of earth's crust.

Airborne magnetic surveying has been used extensively in oil exploration, for mapping bedrock structure and depth to basement. Capable of detecting structures holding oil and gas includes (a) folded structures, anticlines, domes and salt domes; (b) homoclinal structures cut by dyke etc, (c) faulted structures etc situated deep within the earth, aeromagnetic surveys are fast, low-cost methods of

covering large areas. Salt dome mapping is another application where the susceptibility contrast between the sediments and the salt is measurable and salt diapirs, domes and ridges can be mapped. Airborne gravity surveys are a more recent addition to the exploration toolbox, and can map structures represented by density variations. The regional coverage of aeromagnetic and airborne gravity surveys can be used to characterize entire basins, linking together more sparsely distributed seismic data.

Theory and Method

The fact that the presence of oil and gas in subsurface formations does not change the physical properties of the formation appreciably; geophysical exploration for oil and gas envisages the investigation to locate structures capable of holding oil and gas. Such types of structure are generally associated with gravity low of the order up to 50mgal from the surroundings because of the horizontal density contrast between the basement and the oil bearing strata. Similarly



the horizontal magnetic susceptibility contrast across the basement is reflected in the magnetic field measured. An “Airborne Gravity/Magnetic Survey” involves the use of a stabilized gravity meter and a high-sensitivity magnetometer, installed on a fixed-wing aircraft, to acquire data over a given area concerning the earth’s gravity and magnetic fields. The data acquired by such a system was previously used to:

- locate sedimentary basins
- infer the location of the thickest sedimentary section
- delineate basin outlines and boundaries
- define plate tectonic structures
- map structures within the basin

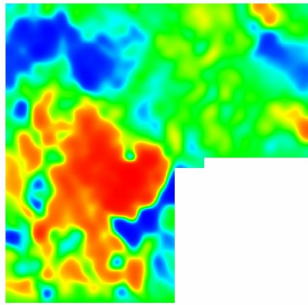


Figure 1: Example 2D image of semi-regional gravity survey for locating oil traps.

However, with the advent of the airborne gravity gradiometer system it is now possible to map oil bearing traps in much more detail. The addition of 3D Inversion Modeling software now makes airborne gravity a powerful tool for estimating density variations within a stratigraphic or structural trap (Davis and Li, 2007). Airborne gravity surveys are usually conducted in association with aeromagnetic surveys which provides a very reliable and relatively precise (typically 5 percent or less of the depth below the flight level) method of determining the depth to distinct density or susceptibility changes within an oil trap or its enclosing formation.



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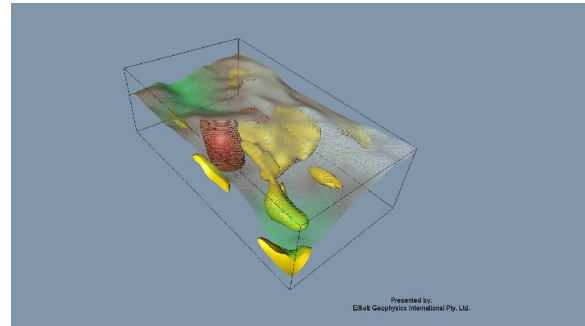


Figure 2: 3D inversion model of gravity and magnetic data over a restricted target area, with a topographic overlay.

Conclusions

Airborne gravity and magnetics have become powerful tools in facilitating the detailed study of both stratigraphic and structural oil traps; Especially when used in conjunction with existing seismic information. Advances in both instrumentation and 3D inversion modeling techniques now enable the explorer to use airborne gravity and magnetics in more detailed studies of oil reservoirs.

References

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