Advancements in earth mapping technologies, coupled with the industry's emerging need to characterise subsurface systems, have led to a resurgence of interest in using gravity and magnetic methods in oil and gas exploration and development. With global fuel shortages and oil prices at record levels, oil and gas explorers are looking at deeper and more expensive targets. Proven, low cost techniques such as gravity and magnetics are being brought in earlier in the project cycle to minimise the risk of more costly seismic investigations.

Gravity and magnetic (or potential field) methods have a long history of use in the oil and gas industry dating back to the 1920s, but the petroleum industry lost interest in these techniques during the early '90s due to the rapid advances in seismic techniques. Faced with the challenge of meeting growing global demand for gas supply, the industry has been steadily expanding exploration efforts into frontier and seismically challenging areas. Both environments are ideally suited to gravity and magnetic techniques.

‘Potential fields are typically used in frontier areas to do reconnaissance exploration, to look for new basins, and to investigate large areas that might be prospective for doing more detailed and expensive seismic work,’ said Gerry Connard, Petroleum Industry Market Manager with Geosoft Inc., a Canada based exploration software company.
Although seismic visualisation technology still remains the powerhouse of oil and gas exploration, the industry now has the tools and the knowledge to integrate the best of this technology with gravity and magnetic methods. By combining technologies, the industry has added a new, robust dimension that enables explorers to look more quickly and efficiently into the uncharted frontier, while reducing the risks associated with technically challenging exploration.

Exploration in the new frontier areas can be an order of magnitude more costly when using seismic visualisation compared to the less expensive potential field methods. Economics aside, Connard says that gravity and magnetic methods are commonly used in areas where seismic work is difficult or impossible. He notes, as an example, instances where an explorer is trying to gather images beneath basalt covered areas that have high velocity rocks near the surface or exploring subsalt plays. ‘When visualising salt structures, seismic technology is very effective for imaging top of salt but has difficulty imaging below the salt because of the high velocity of salt,’ Connard said. ‘Gravity and magnetics have been used extensively in subsalt exploration to integrate with the seismic data and image the base of the salt, or to assist in the processing of the seismic data.’

**Exploration success in South America**

Brazilian based Petrobras has experienced major success using gravity and magnetic methods with the discovery of a major natural gas and condensate field in the presalt layer, at a depth of 5000 m, in the Santos Basin located in the southeastern part of the country. The field, named Jupiter, may have the same dimensions as Tupi, a field believed to be Brazil’s biggest oil bearing area. The Jupiter well is 290 km off the Rio de Janeiro state coast and 37 km east of the Tupi area. The Petrobras discovery reinforces the notion that there is decreased exploration risk in the presalt layer. In the company’s announcement of the discovery, Guilherme Estrella, Petrobras Exploration and Production Director, is quoted as saying, ‘all of the presalt blocks achieved exploratory success, something that confirms the region’s high prospectivity.’

In the Santos Basin alone, the company has stakes in 13 blocks in initial exploratory phase in the presalt layer. The Tupi field discovery was considered a new frontier for the industry. The state run oil firm reported that production tests confirmed the existence of a ‘significant volume’ of 30˚ API crude oil. The field is located more than 7000 m below the ocean’s surface.

Gravity and magnetic methods are also starting to be used by junior companies engaged in frontier exploration. ‘There’s been an explosion of smaller oil companies starting up and getting into exploration in the last several years. These companies are really flying under the radar and are having great success,’ Connard said. ‘Many of them are starting to use gravity and magnetics in their exploration particularly in the frontier areas that have not been explored extensively in the past.’

**Technology advantage**

Advances in software that provide the ability to effectively display, rapidly assess, and dynamically experiment with multiple datasets have helped to reduce risk and increase prospecting capabilities in exploration. These technological innovations have helped to make the use of gravity and magnetic methods in the oil and gas industry more effective. ‘From the interpretation side, there is better software available to integrate the gravity and magnetics with the seismic and other geophysical and geological data,’ Connard said. ‘This kind of technological integration has been key.’

Utilising today’s visualisation tools, geoscientists are able to reduce risk and increase their understanding by looking at as much different data as they can, in as many different ways as they can, within compressed project time frames.

Despite the fact that exploration companies are leaner, with fewer people and shorter project time frames, Dr Michal Ruder, Consulting Geophysicist and Principal of US based Wintermoon Geotechnologies Inc., has seen exponential improvements in productivity and data quality as a result of new software for mapping and visualisation. For Dr Ruder, whose livelihood depends upon delivering accurate, up to date maps
to clients in the oil and gas sector, recent advancements in integrated exploration tools mean smoother workflow and higher productivity in both 2D and 3D environments.

Where it used to take weeks to process and interpret geoscience datasets, today it’s not uncommon for geoscientists to address the salient issues of interpretations in the course of one or two days. Increasingly, what is required for exploration is software that can handle large volumes of data and multiple data sources and data types, such as geophysical data, geochemical data, drillhole data, satellite imagery and GIS data within one single environment or transparently linked environments. ‘I can remember doing batch maps, in paper copies, back in the 1980s,’ Dr Ruder said. ‘Since then, the ability to image geoscientific datasets on a computer screen in real time, and continual improvements in visualisation software, has had an amazing impact on what we can do, as geoscientists, and how quickly we can do it.’

Interpretation results are also more accurate because geoscientists have the tools to view the quality of the data in every single phase, from initial data processing and quality control through to visualisation, integration and the final interpretations.

**Dynamic and integrated visualisation**

Equipped with her laptop and mapping software, including ArcGIS and Geosoft’s Oasis montaj mapping and processing software, it is not uncommon for Dr Ruder to do on the spot interpretations in collaborative meetings with her major oil and gas customers. ‘My mapping software offers a lot of interactivity and testing of their hypothesis, and I can show customers results in real time.’

There are efficiency and quality advantages to being able to dynamically pull customer data in, and immediately look at it as part of the interpretation whether it is well data, satellite imagery or other types of data. The dynamic linking of multiple views of imagery, maps, profiles, plots and data in Oasis montaj also provides an easier point of reference for visually linking common features or areas of interest. This type of rapid assessment and dynamic experimentation depends on the ability to interactively display, and enhance, different attributes in different ways, whether through contrast enhancement, shaded relief, angle illumination, or 2D or 3D displays. Speed in creating and recreating visualisations, or refreshment time, is also an important consideration, especially when dealing with large datasets.

**3D modelling**

The use of specialised 3D modelling software for prospect modelling of salt bodies can help to further reduce risk in areas such as potential field exploration. ‘It’s very prudent to do 3D modelling for prospect modelling of salt bodies when you’re considering a very expensive well in deep water,’ Dr Ruder said.

Geosoft’s GMSYS 3D application is integrated with, and fully exploits, the 3D visualisation capabilities of Oasis montaj. Geoscientists can use the software to plot 3D displays of the entire model in one simple step, while retaining control over each element in the 3D visualisation. The 3D visualisations update automatically during inversion and structure editing. Geoscientists can also add wells, seismic sections, or other vector or raster information to their 3D model visualisations. ‘We’ve been using 3D seismic volumes, and approximations of a 3D velocity volume in our interpretations for some time,’ Dr Ruder said. ‘With modelling software such as GMSYS 3D, we can convert that to depth, and ensure that it makes sense with the observed gravity and magnetic data.’

**Software and data integration**

Today’s visualisation software is required to enable and support the easy integration of different types of datasets, including geoscientific data, satellite imagery and other GIS data, into the mapping environment. Working in multiple software environments is a reality for geoscience consultants who need to meet their needs, as well as the needs of customers with a variety of software preferences. ‘In general, I find that the software tools I use work well together,’ she said. ‘I also welcome the ability to distribute datasets and grids back and forth between my GIS and mapping software, with programs like Geosoft’s Target for ArcGIS.’

While geoscientists recognise that there is a lot to gain by looking at different types of data, Dr Ruder admits that there is still a tendency, within each discipline, to use the data that they understand the best. ‘I think people don’t realise how easy it is to integrate all of their datasets, whether it’s seismic and non-seismic, raster and vector.’

**Note**

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