EAGE

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Gravity Gradiometry Resolution Study and its Application on Synthetic Data from the Middle East

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SUMMARY

Gravity Gradiometry has long been known as a fundamentally useful geophysical quantity. Early applications of Gradiometry surveying required cumbersome instruments that required time consuming and delicate operation, making effective coverage of large areas difficult and expensive. Modern instrumentation has enabled Gravity Gradiometry to be performed from an airborne or marine platform, enabling accurate measurement of gravity gradient over explorationally significant areas in a reasonable time scale.

The ability of a modern moving platform gradiometer to isolate its measurement from the acceleration of the aircraft over a bandwidth between ~300m and 100km enables the complete field to be measured, without spatial aliasing, at low observation height. This allows the survey to capture signal from subsurface anomalies through the depth range of interest to both mineral and hydrocarbon explorationists, while facilitating accurate definition of the overburden through integrated interpretation.

Construction of an Earth Model is a fundamental operation to the interpretation of potential fields data. The possibility that many distributions of the source property (density, magnetic susceptibility, conductivity) may return the same field at the observation position requires us to add constraint in some form to the model. The natural combination of seismic data and Gravity Gradiometry provides an efficient means of providing constraint. Seismic reflectivity is a function of the acoustic impedance of the subsurface, which in turn is a function of density. As density is the material property controlling the gravity field there is a direct link through material property between seismic and gravity interpretation. The Earth Model is present in the *processing* of seismic data in the form of the velocity model; hence the critical link in co-operative interpretation is the development of a relationship between density and seismic velocity that enables the same Earth Model to fit both sets of observed data.

This approach has been demonstrated successfully using conventional gravity measurement and Gravity Gradiometry in other parts of the world (Davies and Dyer, Seismic velocity model development: An integrated approach using Gravity Gradiometry Imaging, Magnetic Gradiometry and Full Tensor Inversion, GEO 2008 Bahrain). In making use of a direct measure of gravity gradient we exploit the availability of greater bandwidth to better constrain the velocity-density relationship through a more compatible measurement scale and reduce uncertainty in velocity determination on a seismic scale. This approach can also enhance describing and mapping the PSDM velocity models.

A demonstration of the application of this approach, in a typical Middle Eastern salt structure in areas of seismic uncertainty, is made through the construction of a “realistic synthetic” gravity gradient dataset, using an Earth Model and imposing realistic survey noise and uncertainty. The Earth Model parameters are perturbed to demonstrate sensitivity to typical time and depth domain velocity (structural) uncertainty and density uncertainty to derive the sensitivity of the integrated technique to variations in the subsurface.

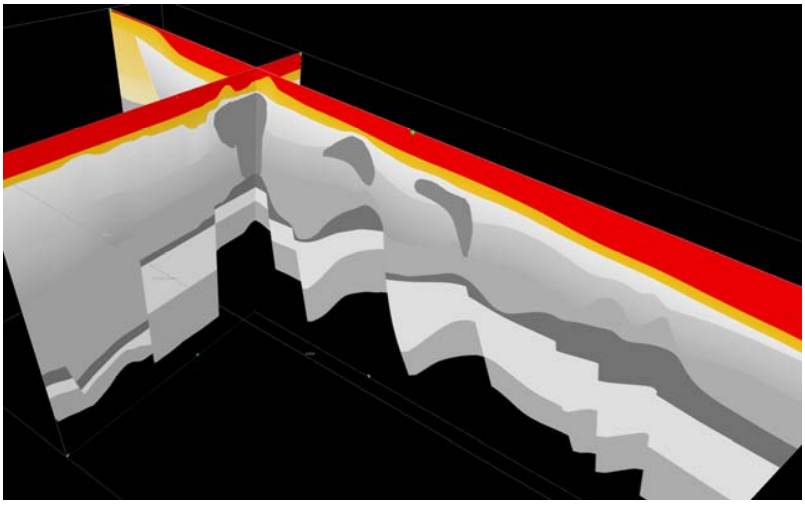

Figure 1
Excerpt from "realistic synthetic" earth model.

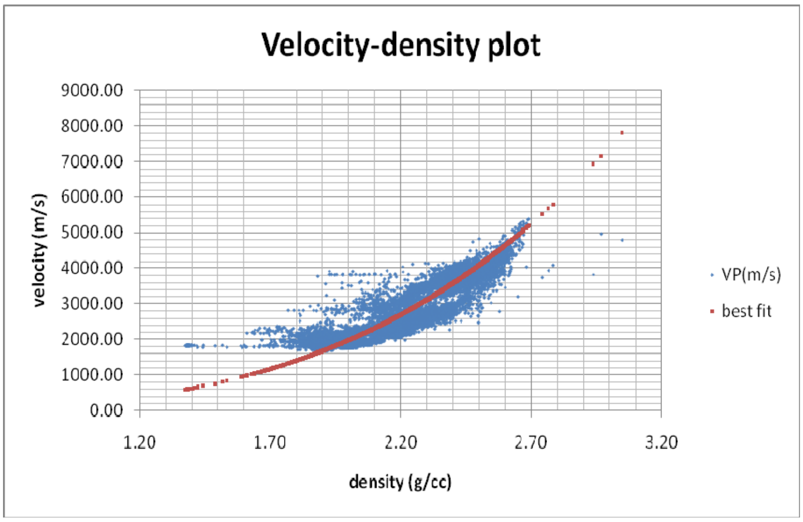

Figure 2
Example velocity density relationship with modified Gardner's relationship curve attached.

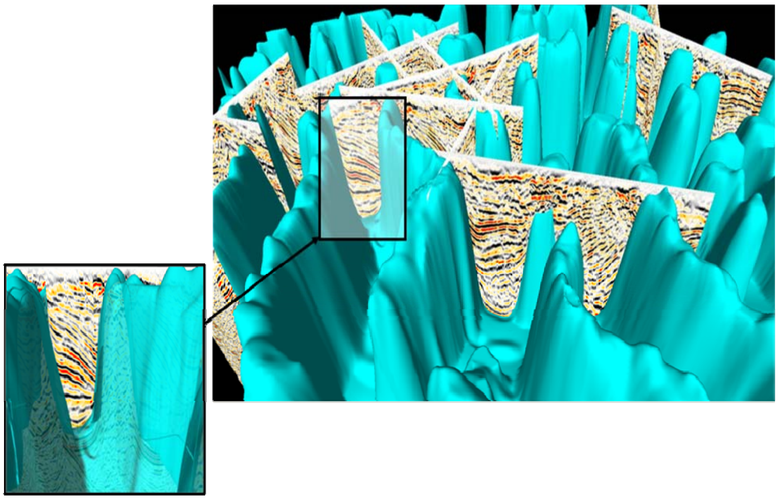

Figure 3
Case history image - sparse coverage of 2D depth migration yields the continuous 3D velocity model when the Earth model is constructed in an integrated workflow.