MaFIC MAGNETIC INTERPRETATION IN 3D USING A SEISMIC WORKSTATION

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SUMMARY

An important component of any high resolution aeromagnetic survey interpretation is the computation and analysis of magnetic depth solutions. A variety of algorithms are commonly used in the industry to compute magnetic depth solutions and each method produces large quantities of depth data. Traditional methods for the interpretation of depth solution data are often arduous and time consuming.

We developed the MaFIC (Magnetic Fault Identification Cube) technique for converting magnetic depth solution data into a format which can be visualized and interpreted using seismic data interpretational tools. By this method we integrate the interpretation of magnetic data with other types of geological and geophysical data, using tools familiar to many in the exploration industry.

INTRODUCTION

Since 1994, new high resolution aeromagnetic surveys have been flown over the majority of the Western Canada Sedimentary Basin. The interpretation of aeromagnetic data commonly involves the computation of magnetic depth solutions. A variety of depth solution techniques are used to estimate the depth to anomalous magnetized bodies. Intra-sedimentary faults, believed to be magnetized by vertical fluid flow (e.g., Peirce et al., 1998) and structures where a lateral magnetic susceptibility contrast exists, are interpreted from trends of magnetic depth solutions.

The computation of magnetic depth solutions is computationally intensive for intra-sedimentary work and vast quantities of depth data are produced for a single survey. Traditional methods for interpreting these magnetic depth solutions are inefficient. For this reason, we developed the MaFIC technique to convert magnetic depth solution data to three dimensional SEG-Y data format. By this method, it is possible to visualize and interpret magnetic depth solution data using seismic interpretational tools. Furthermore, this technique integrates the interpretation of magnetic data, well data, seismic data and other geologic and geographic information, in software familiar to many in the hydrocarbon exploration industry.

METHOD - DATA PREPARATION

As part of our HRAM interpretation process, we compute Werner, 2D Euler and 3D Euler depth solutions from the magnetic data using MagProbe™ software in batch mode. The x, y and z coordinates of each solution are recorded digitally.

A three dimensional zero-matrix representing the volume of earth beneath the HRAM survey area is constructed for each type of depth estimate. The dimensions of the matrix elements are dependent upon the resolution that we wish to achieve.

Unit values are then added to the matrix elements that correspond to the locations of each of the depth estimates, and a three dimensional convolution process is applied to the matrix for purposes of visualization. As a result of the convolution process, matrix element amplitudes are much higher in zones where points are closely clustered. The resultant digital matrix is converted to SEG-Y data format and loaded into any seismic interpretation tool as in Figure 1.

By this technique it is possible to perform an integrated interpretation of magnetic maps, magnetic depth solution data, seismic data, well data and other geologic and geographic information, using seismic data interpretational software, tools familiar to many in the exploration industry.

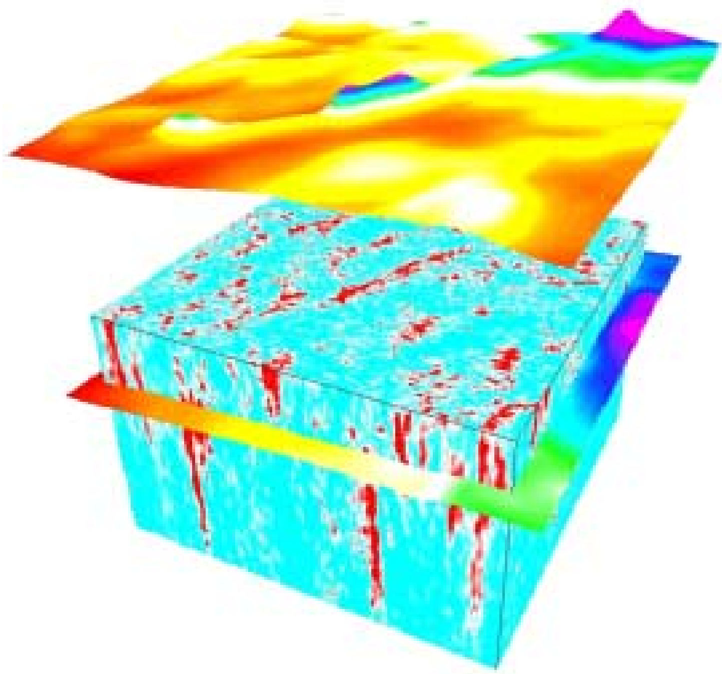

Figure 1. Image of a MaFIC (Magnetic Fault Identification Cube) data volume generated using a seismic voxel visualization and interpretation tool. This data set includes only Werner depth solutions. The surface shown above the cube represents the total magnetic field, and the surface which transects the volume is a formation top generated from well data.

INTERPRETING MAFIC USING A SEISMIC WORKSTATION

Werner and Euler depth solutions are commonly computed for HRAM surveys. We prepare separate three-dimensional SEG-Y data volumes by the technique described earlier for each depth solution type. The data sets are loaded into a seismic workstation and displayed as variable intensity images in colour. Furthermore, the magnetic field map and various filtered variations of the magnetic data were loaded as grids for displaying on the base map. This is a very important step in the integrated analysis of magnetic field maps with other data types in an interpretation project.

Well data, including formation tops, are loaded into the project and a time/depth relation is entered, for them to be displayed correctly in depth. The data set is interpreted in profile view using the fault picking tool. (Figure 2) Using horizons constructed from formation top data as reference, anomalies are grouped according to era. The time savings earned by this method, over more traditional interpretation methods are great, and structural grain maps are easily constructed.

In addition, depth slices, extracted from the data set are interpreted. (Figure 3) When scrolling through the magnetic depth solution data in depth slices, coherent trends of depth solutions, come in and out of focus. The depth slicing technique is very important because some depth solution trends are only apparent within relatively thin regions of depth and may not be identified in profile view. Furthermore, seismic interpretation software provide a means to extract slices of magnetic depth solution information along specific formations. This technique is useful for surveys where the basement relief is much greater than the vertical sampling interval.

Isopachs may also be computed from formation-top data using well data loaded into the seismic workstation. Striking correlations have been observed when overlaying fault picks from the (MaFIC) magnetic depth solution interpretation on isopachs displayed on the base map. Magnetic anomalies in the profile and depth slice views are also easily compared with the isopach images, since the cursor's position on the seismic display window is shown as a dot on the base map.

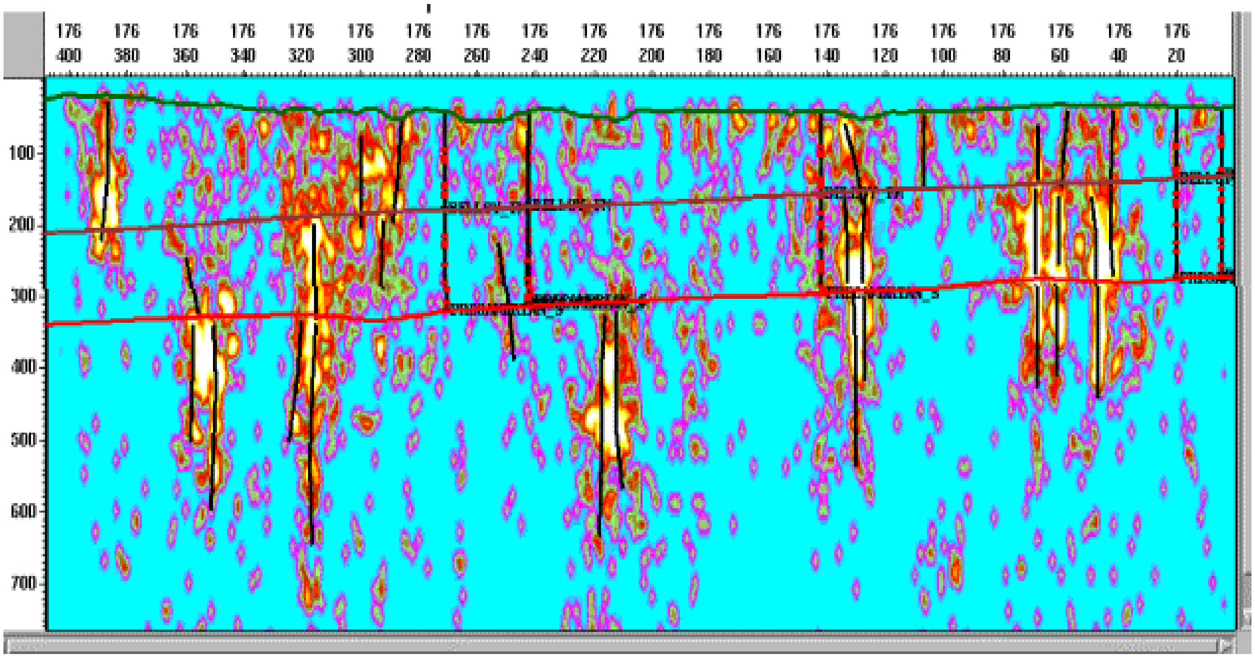

Figure 2. Example interpreted profile through a MaFIC data volume. Precambrian wells, surface topography, Belloy formation and the Precambrian surface are displayed on the section. The magnetic anomalies are interpreted using the fault picking tool of the seismic workstation.

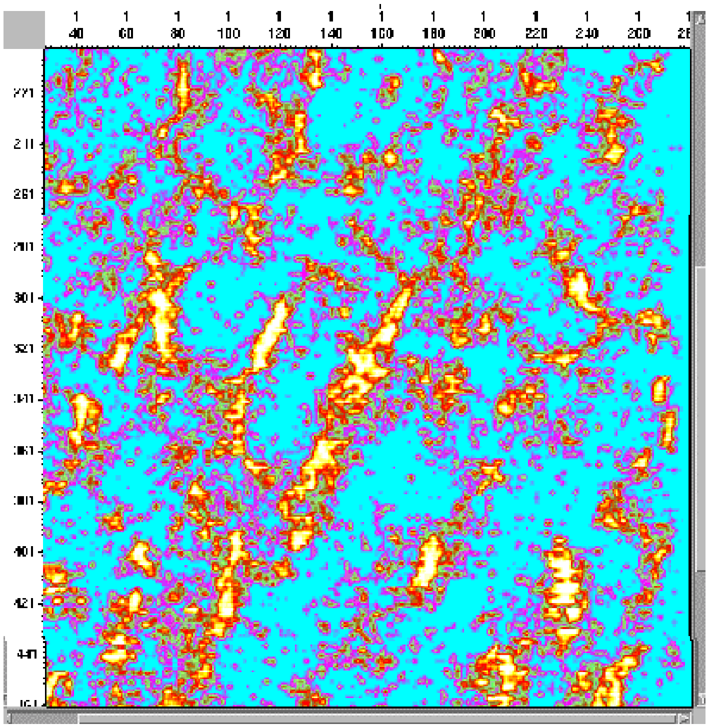

Figure 3. Example MaFIC depth slice – Extracted from a 3D SEG-Y data set. When scrolling through a data volume in depth slices, coherent trends of depth solutions come in and out of focus.

CONCLUSIONS

Seismic data interpretational software provide a very effective medium for the visualization and interpretation of magnetic maps and magnetic depth solutions of various types. Apart from time savings over more conventional potential field interpretation techniques, we also benefit from the highly developed functionality of seismic interpretational software, which are commonly used by exploration geoscientists.

By converting magnetic depth solution data by this method into 3D SEG-Y data format, it is possible to integrate magnetic data, well data, seismic data and other geologic, geophysical and geographic information, in a single exploration project on a workstation.

The magnetic depth solution data can be readily visualized in slices of any orientation. Furthermore, the data can be visualized in three dimensions, as semi-transparent volumes, using voxel visualization and interpretation tools. Magnetic anomalies delineated by trends of magnetic depth solutions are efficiently interpreted in depth using fault and horizon picking tools provided by any seismic interpretation package.

REFERENCES

Peirce, J.W., Abercrombie, H.J., DePaoli, G.R., Goussev, S.A., Charters, R.A., 1998, Intra-sedimentary magnetization by vertical fluid flow and exotic geochemistry: The Leading Edge, January 1998, 89-92.