Using Enhanced HRAM Anomalies to Correlate Faults between 2-D Seismic Lines

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Summary

Correlation of faults between 2-D seismic lines using enhanced magnetic anomalies is illustrated by this example from a High-Resolution AeroMagnetic (HRAM) survey near the Weyburn oil field in south-eastern Saskatchewan as part of the IAE Weyburn CO_2 Storage and Monitoring Project. Seismic fault picks, interpreted on 2-D seismic sections, closely correlate with linear magnetic anomalies on the filtered HRAM map. These fault-associated magnetic anomalies can be correlated within the 2-D seismic coverage area and beyond its limits.

Introduction

Correlation of faults between widely spaced 2-D seismic lines is always ambiguous, especially when seismic sections are of different vintages and processing quality. The ambiguity of this correlation can be significantly reduced by integration with HRAM data.

Structural discontinuities such as faults, lithological contacts, and depositional edges can create lateral contrasts in magnetization of rocks. Lateral magnetization contrasts often generate detectable magnetic anomalies (Glenn and Badgery, 1998, Goussev et al, 2003, Grauch et al, 2001, Peirce et al, 1998), many of which are sourced in the sedimentary section. Advanced HRAM filtering techniques can enhance these subtle fault-associated magnetic anomalies to make them coherent and correlatable between 2-D seismic lines and, potentially, 3-D seismic program areas.

Geological applications of the integrated aeromagnetic-seismic correlation include the mapping of dominant fault trends, identification of strike-slip faults, prediction of fault-associated zones of hydrothermal dolomitization and, sometimes, localization of salt dissolution / collapse structures.

HRAM Data

The S.E. Saskatchewan HRAM Survey was flown along orthogonal flight lines of 500 m x 1500 m spacing. This network provides a dense and even data sampling over the survey area. The processing of observed data included standard corrections (diurnals and IGRF), cultural editing, levelling and gridding at 150 m grid cell size. The gridded data were Wiener filtered to remove extreme high-frequency noise and then reduced to the pole to compensate for local inclination and declination of the Earth's magnetic field and center the magnetic anomalies over their sources.

The enhancement of subtle magnetic anomalies associated with the fault-like structural discontinuities was achieved by application of the cascaded Goussev filter (Goussev et al, 1998, 2003) as it provides a superior suppression of noise and improved coherency of filtered anomalies. For our study, this filter was designed as a 1.6-3.2 km band-pass of the difference between the total and horizontal gradients calculated after applying the depth separation (Jacobsen, 1987) to the total magnetic field.

Seismic Data

Three nearly parallel SW-NE oriented 2-D seismic lines (#1, #2 and #3) were chosen in the IEA Weyburn CO_2 study area with ~12 km spacing between lines #1 and #2, and ~14 km between lines #2 and #3. Seismic lines are from 48 km to 50 km length. The interpreted faults have small offsets and are related to both extensional and compressional regional stress regimes at different times. Two faults on lines #2 and #3 having apparent seismic signatures typical of strike-slip faulting are marked as PFS - "Positive Flower Structure" and NFS - "Negative Flower Structure" (Fig. 1). In the absence of complementary information, the correlation of interpreted fault picks from seismic data only is very ambiguous, especially for the strike-slip fault picks.

Correlation

Fig. 2 shows the enhanced HRAM anomalies overlain with 2-D seismic lines, interpreted fault picks and correlated faults. Note how closely the enhanced magnetic anomalies correlate with fault picks A, B, C, D and "strike-slip" fault picks PFS and NFS. Based on the geologically plausible assumption that a continuous (coherent) magnetic anomaly represents the same type of structural discontinuity over the area of its correlation, we can correlate the fault "A" between and beyond all three seismic lines. The same approach can be followed in correlating the faults "B" and "C" between lines #1 and #2.

Correlation of the fault picks PFS and NFS without reference to the HRAM anomalies is hardly possible at all. Separated by just 14 km, these faults seem to be associated with the opposite deformation styles: extensional NFS and compressional PFS. Both fault picks are in perfect correlation with enhanced HRAM anomalies which clearly show that these fault picks represent orthogonally trending strike-slip faults: the PFS fault trends WSW-ENE and the NFS fault trends SSE-NNW (Fig. 2).

Conclusions

1. Enhanced HRAM anomalies can be used to correlate faults between 2-D seismic lines and, potentially, 3-D seismic data.
2. Integration of the HRAM and 2-D seismic data provides reliable identification of strike-slip (wrench) faults and their trends.
3. When combined with seismic data, HRAM data can help to establish structural deformation styles over large areas.
4. HRAM data complements seismic programs and geological information from wells, both locally and regionally.

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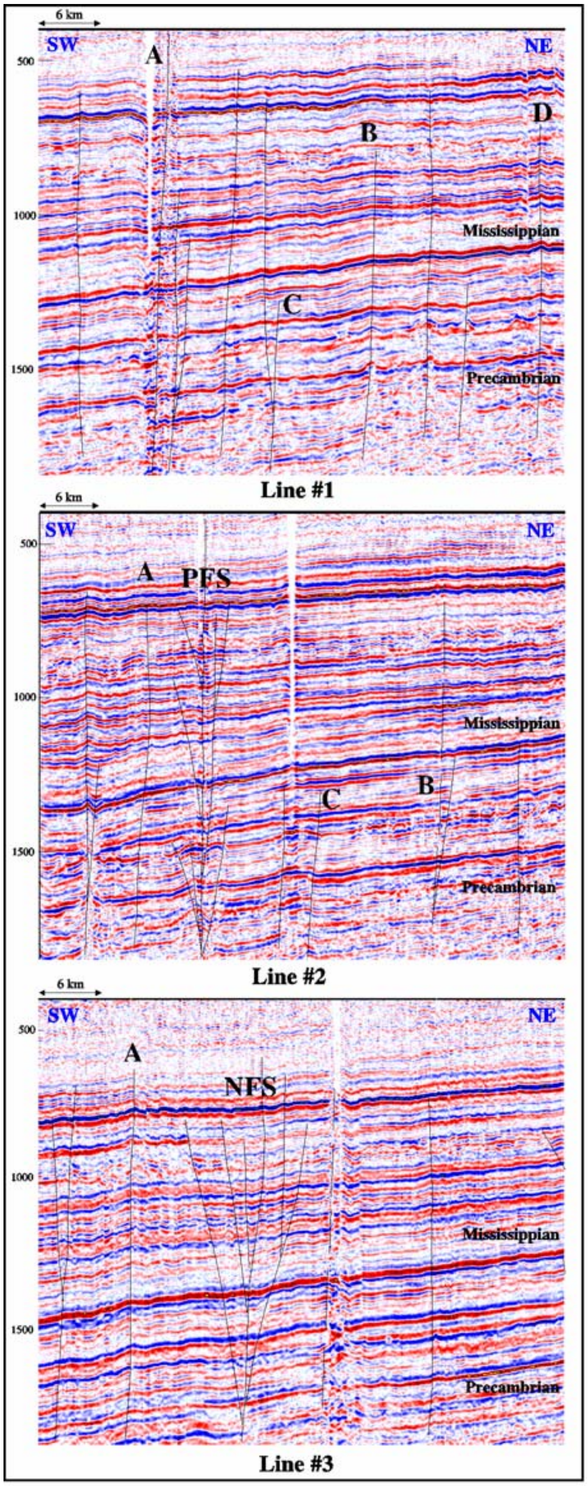
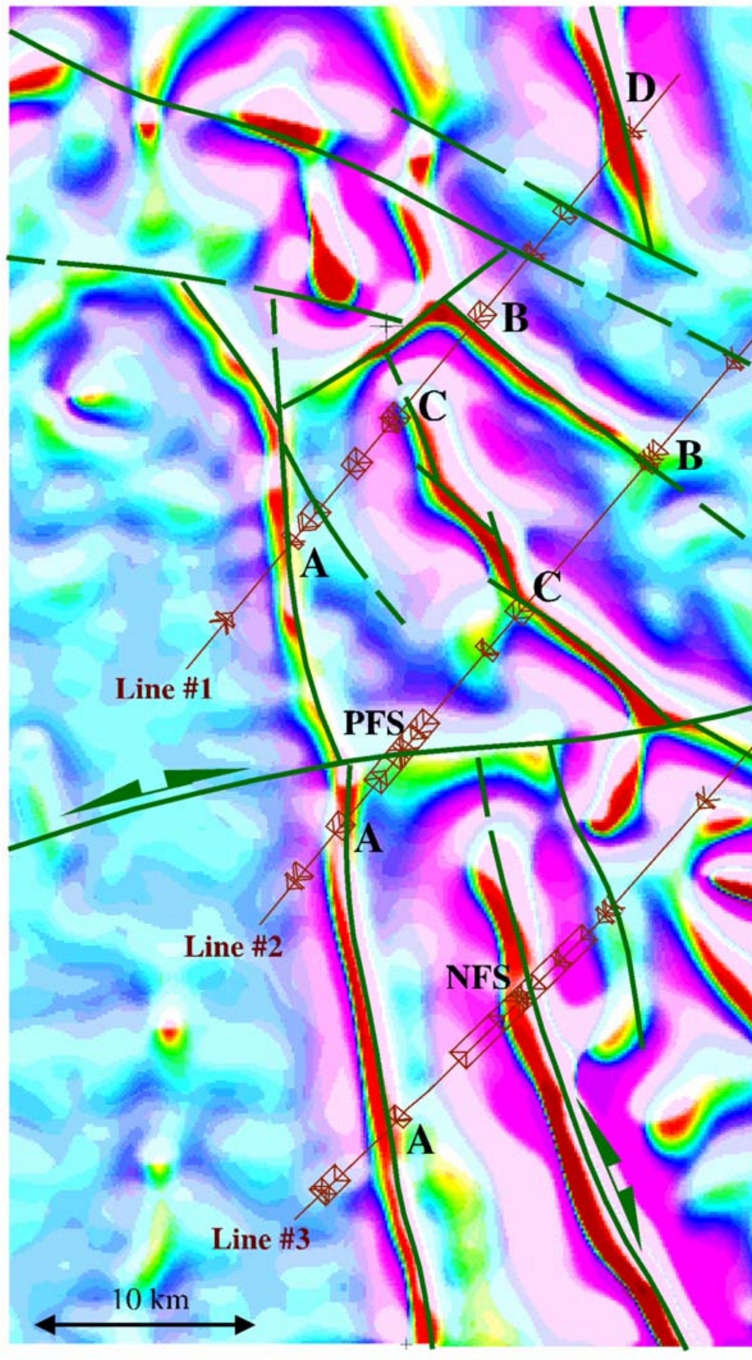


Fig. 1



2-D seismic lines, fault picks and interpreted faults on top of the filtered HRAM map

Fig. 2

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