RECENT ADVANCES IN HIGH RESOLUTION AEROMAGNETICS FOR HYDROCARBON EXPLORATION IN THE PERMIAN BASIN

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ABSTRACT

World Geoscience Corporation, through its subsidiary BGM Airborne Surveys Inc., acquired 20,300 miles (33,500 km) of high resolution aeromagnetic data at a line spacing of 0.62 miles (1 km), tie line spacing of 1.86 miles (3 km) and flying height of 500 ft (150 m) over the Val Verde Basin and adjacent provinces. These data were integrated with public domain gravity data, consisting of approximately 2,000 stations and geological information to produce a structural interpretation of the area including a depth to magnetic basement map.

The high resolution, low level data displayed short wavelentth, small amplitude features on enhanced images of the magnetic data which have been interpreted to reflect faults within the sediments.

Reduction to pole (RTP) processing of the magnetic data is an important step in the interpretation of the data. Magnetic highs, which may coincide with basements highs, migrate laterally up to 5 miles (8 km) on RTP processing.

Three basement regions have been distinguished on the basis of magnetic character. The northern area is characterised by high intensity and short wavelength anomalies. The eastern and southern areas have lower magnetic intensity. Depth to magnetic basement calculations using a new Euler deconvolution technique confirm shallow basement depths along the northern and southern margin of the basin and depths in excess of 20,000 ft (6 km) immediately to the north of the southern uplifted boundary of the basin. The Gomez and Puckett Fields correspond closely with magnetic highs after RTP processing. Basement trends are unusually variable, especially in the northern area, but NW to WNW trends are more prevalent.

Short wavelength/low amplitude linear to irregular magnetic anomalies have been mapped throughout the survey area. Three trends dominate among the linear anomalies, NNW, NW-WNW, and to a lesser extent E-W. The NNW-trending linears tend to be more continuous and discrete. The NW-WNW linears are less continuous, but also cluster into NW to WNW-trending zones. The E-W linears are largely restricted to the southwestern and eastern parts of the region, and appear to cut the other sets without obvious displacement. Most of these linears are interpreted to represent fault zones within the sedimentary sequence. The origin of the magnetic linears is unknown, but in this basin we favour either chemical remnant magnetization associated with alteration along fault/fracture zones or juxtaposition of weakly magnetic units with different magnetic susceptibilities. Irregularly shaped pathes of "micromagnetic" response are clearly resolved on the filtered images of the magnetic data, especially the vertical derivative products.

There are three main types of micromagnetic response:

*** The major oil and gas producing areas are characterised by high amplitude "spikes" which represent well casing and/or well-head facilities. At fields such as Yates and Gomez, close well spacing produces a classical, albeit high amplitude, micromagnetic signature which corresponds closely to the field outline. In other areas, individual wells can be resolved as anomalies on the automatic gain control (AGC) and vertical derivative images.**

*** Elsewhere, areas of low amplitude micromagnetic response occur where there is little or no culture. In the southwestern part of the survey, these anomalies are elongate E-W and are commonly bounded by E-W linears. They correspond in part to topographic trends and to the outlines of Cretaceous units.**

*** Even lower ampitude and shorter wavelength anomalies have been recognized in the magnetically quietest parts of the area. These features are only resolved on the high-pass filtered flight-line profiles.**

The major linears have been interpreted as faults within the sedimentary section. There is a good

correspondence between the positions and orientations of the mapped faults and known faults from public domain exploration data, especially near producing fields. There is also agreement between some of the magnetic structures and Landsat linears. Most importantly, the structural picture which has evolved from the magnetics provides for the first time a clear view of the position, orientation and extent of structures through the Val Verde Basin.

When integrated with the gravity data, the following structural synthesis emerges. The Val Verde Basin is localized along a major transfer/transform offset in the early Palaeozoic passive continental margin. This offset, which connects the Ouachita trend and its southwesterly extension beneath the Gulf Coast to the Marathon Ranges section to the west of the survey area, is approximately parallel to the enigmatic Texas Lineament trend. We interpret it to have developed as a transfer faulted margin segment, perhaps controlled by a pre-existing Precambrian basement fault/shear zone along the Texas Lineament trend.

During the late Paleozoic collision between North and South America, convergence appears to have been in a northwesterly direction. The evidence for this convergence direction comes principally from the orientation of the classical foreland fold and thrust belts exposed in the Ouachita and Marathon Ranges, and inferred beneath the Gulf Coast. The tectonic environment in the Permian Basin region during the Pennsylvanian-Permian collision was therefore essentially one of compression. However, the detailed structure and geometry of the Val Verde Basin was strongly influenced by the pre-existing WNW-trending offset and parallel basement structures in the early Palaeozoic passive margin.

In detail, this geometry has led to an oblique compressional or transpressional structural environment, in which classical compressional (i.e., thrust) structures occur in close proximity to and in geometric harmony with wrench structures. At the next level of structural detail, the structure is also strongly influenced by a set of NNW-trending basement faults which appear to have been present, although of less importance than the WNW structures, during early Palaeozoic. The NNW-trending structures are prominent throughout the Permian Basin on all scales, from individual faults associated with petroleum fields through regional fault systems to the boundries of a number of the major paleogeographic subdivisions such as the Central Basin Platform.

The two main fault trends identified from the potential field data (NW-WNW and NNW) are dominantly steeply dipping, and probably have a significant component of strike-slip movement. There are some segmented easterly to northeasterly trending low amplitude/high frequency features in the eastern part of the area, some of which correspond to the inferred position of the Marathon thrust front where it is reasonably well defined near the Thistle oil field. The segmentation of these features appears to be along NW-trending structures and they are tentatively interpreted to be a linked thrust/wrench fault array that accommodates the apparent bend in the Marathon "thrust front".

There is a correlation between known oil and gas fields and fault intersections in the survey area. The magnetic interpretation emphasises the importance of intersections between the linears, and a simple structural model based on successive strike-slip motions on the two fault sets can be erected to explain the localisation of compression (i.e. reverse faulting and anticline formation) at such intersections.

The structural interpretation developed from the magnetic and gravity interpretation also has important implications for design of seismic surveys, especially in the southern part of the Val Verde Basin. Because the compression or tectonic transport direction is predicted to be NW throughout the basin, true structural "dip" profiles should be oriented NW rather than NE as in most existing surveys.