Fracture/Fault pattern delineation in Western Gulf of Mexico

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Abstract:

Fracture/fault pattern maps are one of the tools useful for explorationists to locate hydrocarbon prospects. Depth and lineament maps are generated from gravity and magnetic data on a regional scale using Euler deconvolution technique. Based on this study, it appears that the Euler depth maps are good at revealing the boundaries of major geological provinces and the lineament maps are good at identifying the fracture/fault trends. The mapped lineaments define all classes of fracture/fault patterns in the western Gulf of Mexico region.

The dominant trends in the lineament maps show approximately NE-SW and NW-SE directions. Some of these northwest-southeast trends are well correlated with the Matagorda, Galveston, Brazos and Sabine transfer faults. Character changes in fault structure and stratigraphy are evident across transfer faults. These transfer faults control the distribution of shale and salt basins as well as the hydrocarbon bearing basins in the Gulf of Mexico region. The mapped lineaments in the shelf area correlate with the Miocene faults, which are parallel to the synrift basement graben structure. These faults also serve as conduits for the migration of hydrocarbons into shallower reservoirs.

As several of the mapped lineaments correlate with published geological fault trends, the other lineaments may be indicators of new insights in this area. Some of these fault trends may very well represent the structural and stratigraphic discontinuities in the geologic horizons. The mapped lineaments may either reflect the nature of the underlying crustal and synrift structures and/or the overlying the sediments. Since hydrocarbon production in the Gulf of Mexico shelf and slope basinal areas are closely associated with the locations of the transfer faults, the mapped fracture/fault trends may reveal some new insights for hydrocarbon plays.

Figure 1: Study Area

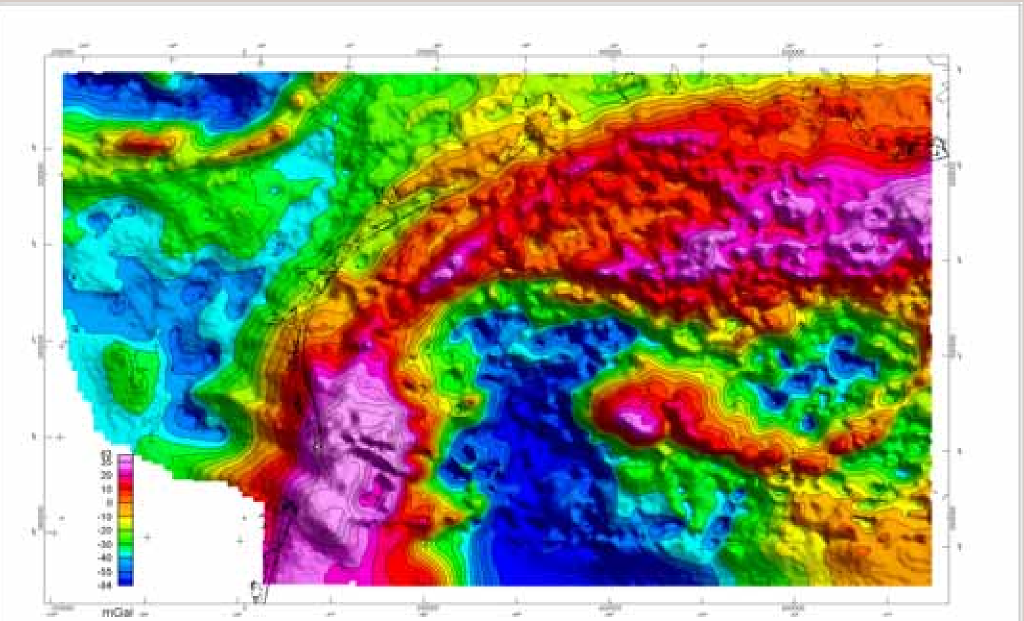


Figure 2: Free-air gravity

The Gulf of Mexico is a passive continental rift basin divided by an east-west trending band of oceanic crust. Although various models exist for the opening of the Gulf of Mexico, there is consensus that the main period of rifting occurred in the Middle Jurassic, followed by oceanic spreading in the middle of the basin and continuing possibly into the Late Jurassic (Peel et al., 1995). There is some evidence of Late Jurassic basement faulting on the periphery of the basin (Thomas, 1988), but in the offshore area there is no documentable evidence of subsequent active basement faulting. The basement structures and the modern distribution of salt and hydrocarbon production trends (Huh et.al., 1996) suggests that the northern Gulf rift basin is right-laterally segmented by a series of northwest-southeast trending transfer faults. These transfer faults probably formed along preexisting shear zones during rift-stage extension. Simmons (1992) has mapped and named several of these transfer faults.

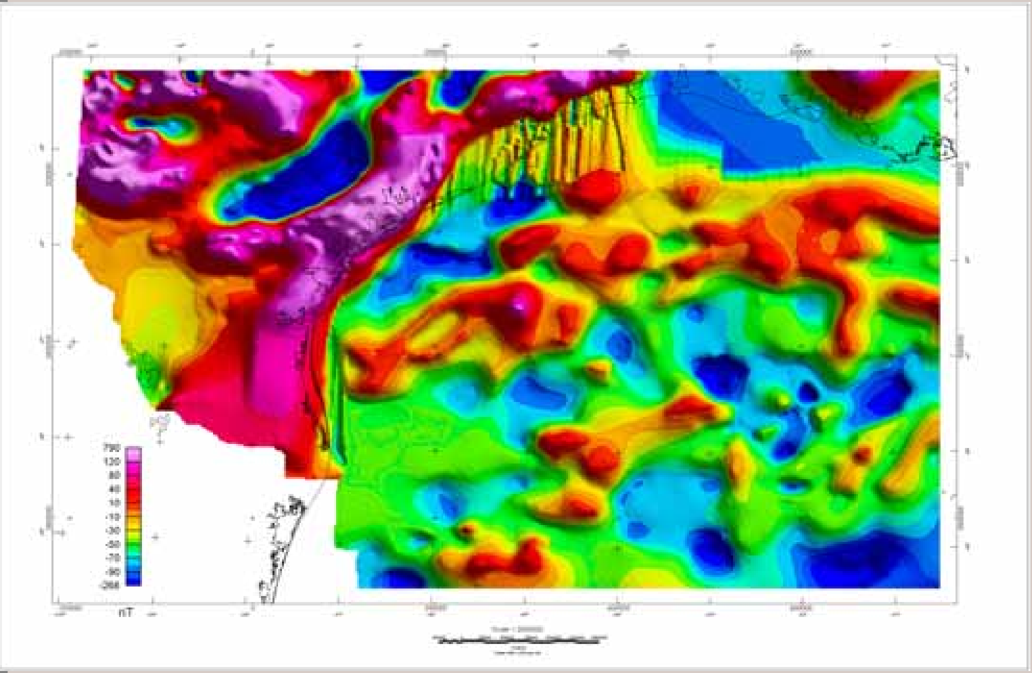


Figure 3: Total Magnetic Intensity Map

The DNAG gravity and magnetic data are used in this study were obtained from the USGS website. The DNAG data were available for every 4º latitude increments in x,y,z format with approximately 4000 meters sampling interval.

After gridding and contouring with 2000 meter grid interval the DNAG gravity and magnetic maps are shown in Figures 2 and 3. Although the total contour range of free-air gravity is 147 mGal (-84 to 63 mGal) , the majority of the area on the map is within the anomaly range of -70 to 40 mGal. Similarly in the case of magnetics, the dominant anomaly range is –150 to 200 nT although the total range in the shadow map is –268 to 790 nT.

The gravity and magnetic anomalies follow nearly NNE-SSW and NE-SW directions in southern portions and turn to nearly east-west direction in the Louisiana shelf and slope areas (eastern portions). These trends probably represent the structural trends and NW-SE low amplitude anomaly trends may be the expressions of transfer faults.

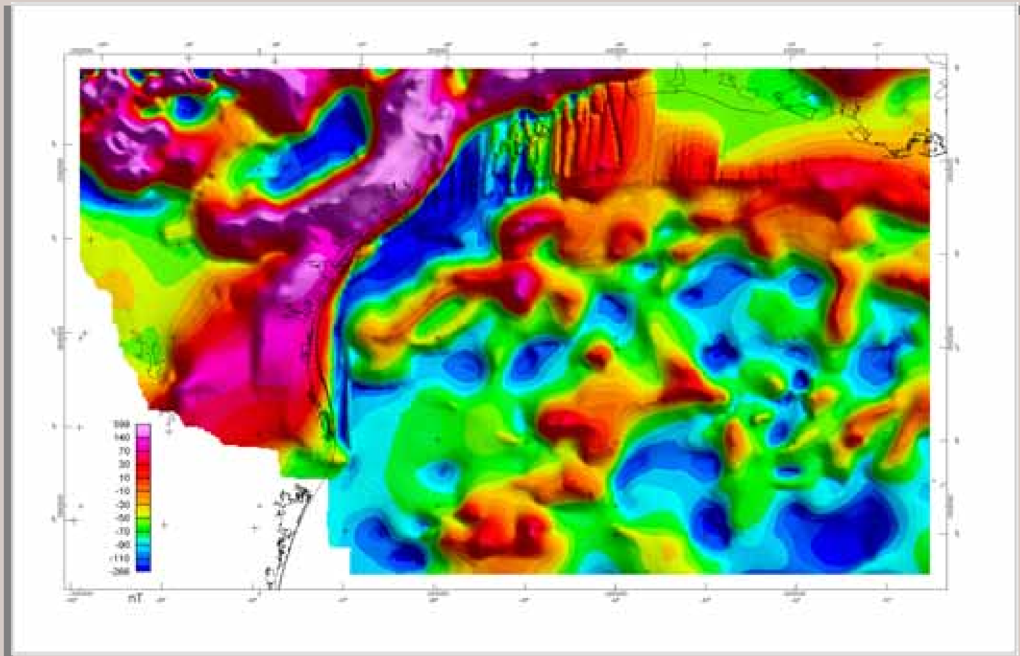
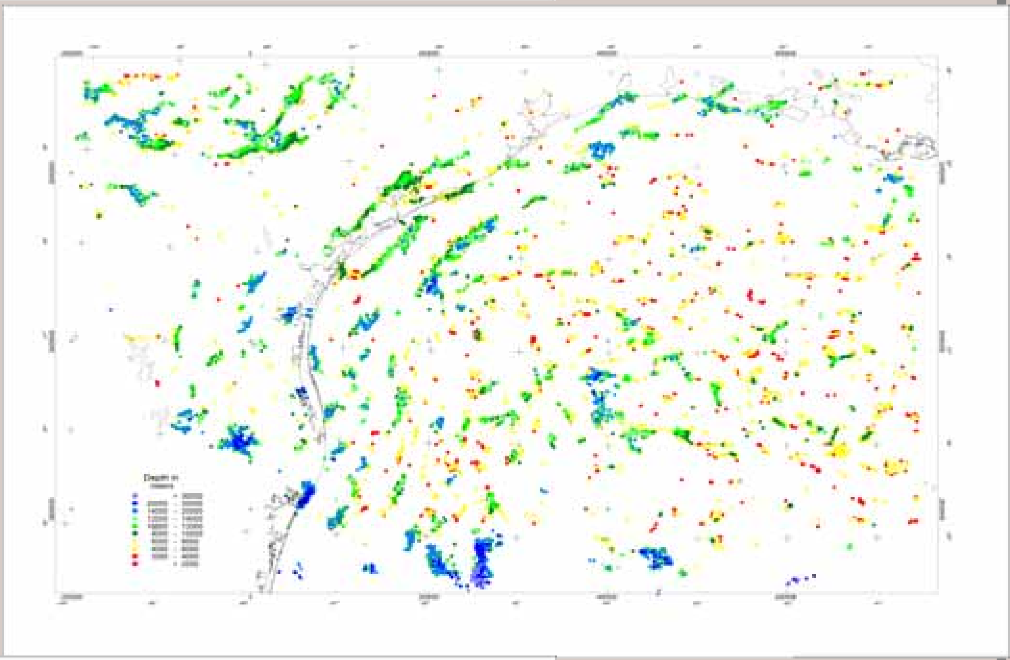


Figure 4: Reduction To the Pole Map

The RTP operation removes anomaly asymmetry caused by inclination and declination and locates anomalies above the causative bodies. The average inclination and declination values for this area are 56.2^0 N and 5.6^0E respectively.

Figure 5: Fracture or fault trends (lineaments) derived from free-air gravity.



The calculation of depth to gravity or magnetic sources is dependent upon the existence of a density/susceptibility contrast. In the absence of a contrast, no sub-surface information can be obtained from potential fields data. These contrasts can and do occur both laterally and vertically throughout the sub-surface.

The depths to the gravity and magnetic sources are estimated using Euler Deconvolution technique. It is a rapidly calculable gradient technique. The error in most gradient techniques is less than 10% when anomaly interference from other nearby sources and noise are non-existent.

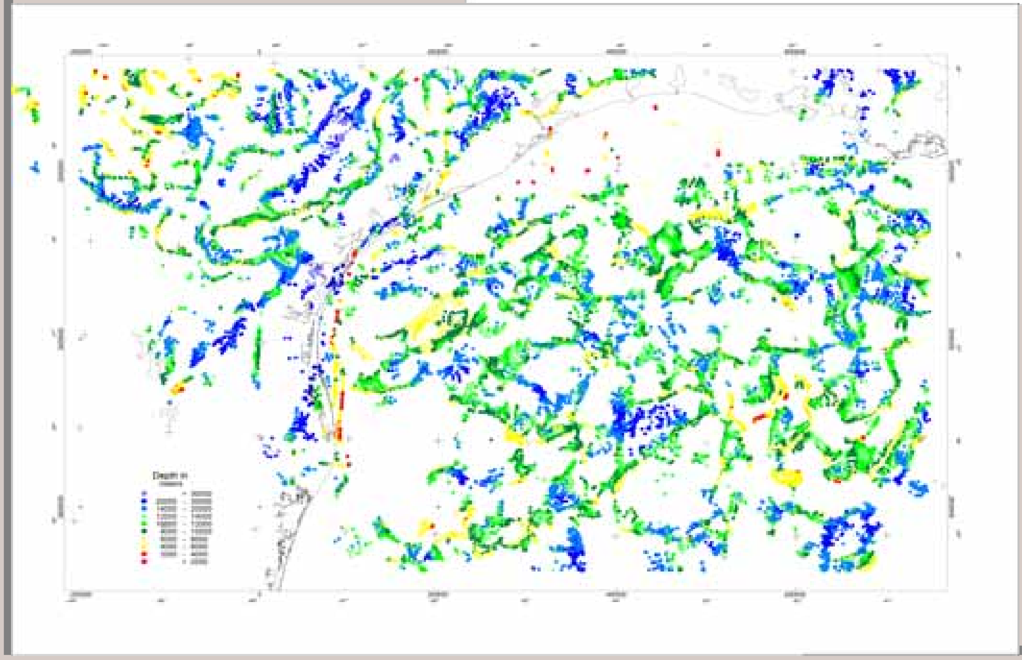


Figure 6: Fracture or fault trends (lineaments) derived from Reduction to the Pole data.

In the geological terms, the Euler depths represent the structural and/or stratigraphic changes of various geological formations. In other words, they appear wherever there are lithologic discontinuities existing in the geological formations.

The Euler depths locations appear to detect the edges of the geological formations as well as fractures or fault patterns.

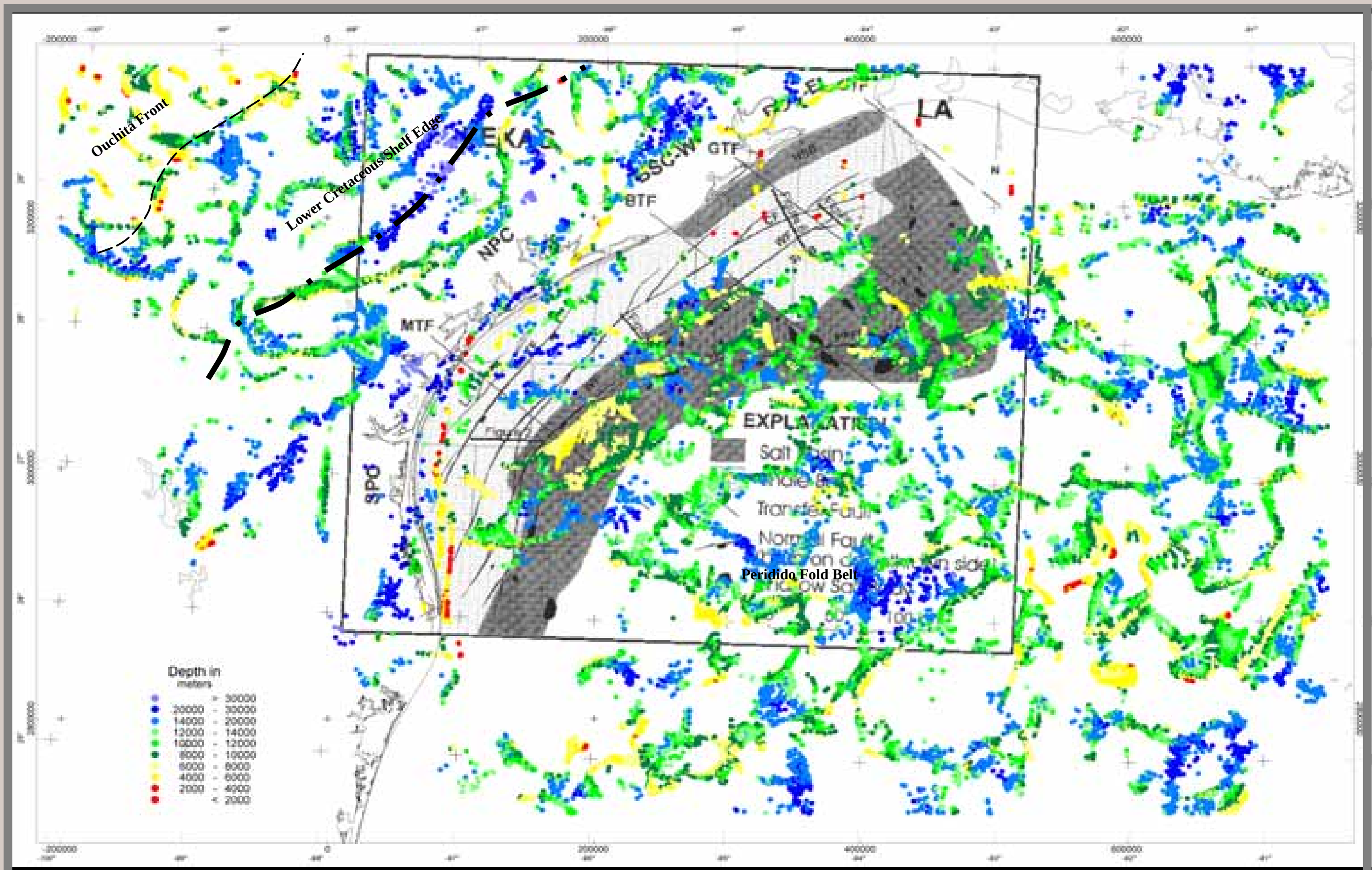


Figure 7: Fracture/fault trends (lineaments) map georeferenced with published map of Hue et al., (1996). The major tectonic and structural features of the Texas Shelf are shown.

Transfer Faults: MTF-Matagorda; BTF-Brazos; GTF-Galveston; STF-Sabine

Some of the mapped lineaments are well correlated with the Matagorda, Galveston, Brazos and Sabine transfer faults. These transfer faults control the distribution of shale and salt basins as well as the hydrocarbon bearing basins in the Gulf of Mexico region (Bradshaw and Watkins, 1995). The mapped lineaments in the shelf area correlate with the Miocene faults like the Corsair and Wanda Fault (shelf area and lies in between BTF and GTF) zones. Hue et al., (1996) believed these Miocene faults are parallel to the synrift basement graben structure. These faults also serve as conduits for the migration of hydrocarbons into shallower reservoirs.

A number of nearly east-west trending lineaments are dominating in the southern portion of the map mostly to the south of 27^0N probably related to the oceanic basement trends as the continental margin of Gulf of Mexico is divided by an east-west trending band of oceanic crust.

Conclusions:

- The Euler depth and lineament maps generated from gravity and magnetic data are helpful for the explorationists working on a regional scale.
- The mapped lineaments may either reflect the nature of the underlying crustal and synrift structures and/or the overlying the sediments
- As several of the mapped lineaments correlate with published geological fault trends, the other lineaments may be indicators of new insights in this area.
- High resolution aeromagnetic, marine magnetic and gravity data would certainly give better results than the data used in the present study.

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