Under the northern Gulf basin: basement depths and trends

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Summary

A new quantitative magnetic interpretation of the northern Gulf basin maps magnetic basement structure in greater detail over a wider area than is known to be available elsewhere. This interpretation is based on magnetic depth estimates derived from the analysis of over 100,000 line miles of aeromagnetic data and 25,000 line miles of marine magnetic data. Depth estimates have been correlated with published seismic reflection and refraction data, well data, and to a lesser extent, published gravity data. The integration of various independent data sets thereby permits a more confident separation of, and mapping of, magnetic anomaly sources as either basement related or intrasedimentary. Results of the quantitative interpretation demonstrate that qualitative gravity/magnetic interpretations must be used with care.

There are strong correlations between many of the geologic trends documented onshore Texas and Louisiana and the interpreted magnetic basement features, both onshore and offshore. Most basement features are either subparallel or subnormal to the coast. NE structures and fault trends are dominant offshore Texas and form important crosstrends offshore Louisiana. At lease three named NW-SE crosstrends or transfer zones continue from onshore Texas into the Texas offshore. There are good correlation between interpreted basement block boundaries and major Tertiary fault zones such as the Corsair, Wanda, South Cameron, and South Timbalier-Ship Shoal.

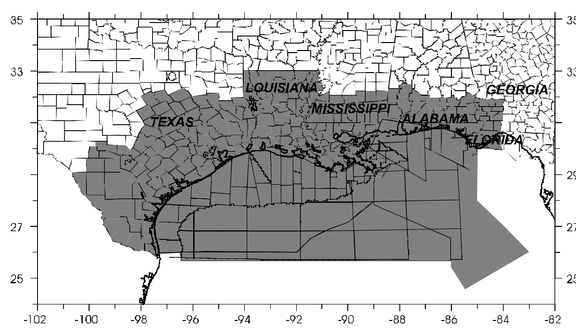
Magnetic basement indicates that presence of more that twenty subbasins with sufficient sediments to be of exploration interest. Offshore, the basement depths range from about 30,000 feet (9.1 km) over features such as at the Perdidio Uplift to 70,000 feet (over 21 km) in some of the Tertiary deeps.

Introduction

A reasonably detailed basement structure map is an integral part of any regional geological or hydrocarbon evaluation process. Such a map identifies critical structural trends, the locations of the region's prominent structural prospects, and the location and geometry of the hydrocarbon depo-centers. A basement structure map also forms a base for the interpretation of major geological processes in the area.

Prior to the work presented here, few - if any - detailed regional structural interpretations of the magnetic/crystalline basement are known to have covered the northern Gulf Basin, both offshore and onshore U.S., from Texas to Florida. The published maps describing basement behavior, history, and of regional structural trends are numerous; but all are based solely on individual geological-geophysical concepts, or on projections of regional structural trends from surface outcrop areas of East Texas, South Oklahoma-Arkansas and the Appalachian region into the offshore subsurface. Therefore, these interpretations are very regional, lack detail and rely on qualitative -- not quantitative -- analysis of the geophysical and geological data. Development and status of many of these previous basement structure interpretations have been summarized by Salvador (1989) and Worral and Snelson (1989).

The current work has quantified the northern Gulf basin architecture for an area which encompasses three major onshore basins: East Texas Basin, Houston Salt Basin and Louisiana Salt Basin, plus the Texas-Louisiana-Mississippi-Alabama-Florida continental shelf and deep water blocks. The interpretation area as shown on the Index map covers approximately 334,000 square miles.



Index Map

Basement Definition

The geologic term *basement* can be defined several ways. In the Gulf Coast province. *basement* has been equated by some authors (e.g., Buffler and Thomas, 1994; Rosenthal and Buffler, 1990) to a mid-Jurassic sequence boundary (MJS) below which lie high-density formations of various lithologies. This interpretation considers basement to be magnetic or crystalline basement as defined in

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Encyclopedic Dictionary of Exploration Geophysics. Magnetic basement may therefore include not only Precambrian plutons, but perhaps also Paleozoic igneous intrusives, thick sequences of Triassic extrusives and/or Cretaceous igneous plugs. Consequently the MJS basement and magnetic basement may sometimes be coincident but often divergent, with magnetic basement typically deeper than the MJS by up to several thousands of feet.

Refraction ***basement*** is usually identified with the first deep high-velocity refractor having velocities ranging between 5.4 to 7.0 km/sec, but typically about 6.3 km/sec.

Structures and Depths

There are strong correlations between many of the geologic trends documented onshore Texas and Louisiana and interpreted magnetic basement features, both onshore and offshore. Most basement features are either subparallel or subnormal to the coast. NE structures and fault trends are dominant offshore Texas and form important crosstrends offshore Louisiana. At lease three named NW-SE crosstrends or transfer zones continue from onshore Texas into the Texas offshore. There are good correlation between interpreted basement block boundaries and major Tertiary fault zones such as the Corsair, Wanda, South Cameron, and South Timbalier-Ship Shoal.

In the northeastern Gulf, deep basement structural trends shoreward from the Ttuscaloosa Fault System-Carbonate Shelf Margin alignment are primarily NE-SW. Seaward of the alignment the primary trends are NW-SE. The magnetic basement structure in the northeast gulf is complex, numerous igneous plugs sourcing suprabasement sills or buried volcanic.

In addition to the expected NE-SW and NW-SE trends, at least four N-S basement trends extend from onshore into the deep offshore. They are discontinuous, but correlate locally with major features, such as the Sabine Uplift and the LaSalle Arch.

Magnetic basement interpretation maps more than 20 subbasins with sufficient area and sedimentary thickness to be of exploration interest. Offshore, the basement depths range from about 30,000 feet (9.1 km) over features such as at the Perdidio Uplift to 70,000 feet (over 21 km) in some of the Louisiana and Texas Tertiary basins. These magnetic depths fit well with depths from 60 seismic refraction points.

Many have assumed a simple flat and unstructured erosional contact at the base of salt of the mid-Jurassic Louann Formation (Hall et al,1993). With the onset of pre-salt exploration interests, the basement surface and composition has gained importance. The interpretation to be discussed reveals a rugose basement surface resulting from both compressional and extensional tectonic events. As a result of these events, basement has been deformed into a complex of sub-basins, horst-and-graben structures, thrusted blocks, and igneous plugs

Data Sources

The Gulf of Mexico has been intensely explored, both regionally and in detail, by means of gravity and reflection seismic surveys for over 50 years. Although interpretations of both types of data have allowed successful mapping of structures associated with salt and/or clastic sediments, neither method provides significant detailed information about 'crystalline' basement structure and the primary basinal architecture underlying the sedimentary column.

Basement mapping must therefore rely on the interpretation of magnetic and refraction seismic data. Refraction seismic, while areally limited, has the capability of providing basement values with adequate accuracy for regional mapping. The data sources, type of data, and the volume of data, used in this interpretation are summarized in the following table.

Data Sources

Geoterrex Ltd., Ottawa, Canada	aeromagnetics:	73,000 line miles
EDCON, Denver Colorado	marine magnetics	25,000 line miles
AIRMAG, N. Philidelphia, Penn	aeromagnetic	9,370 line miles
NURE	aeromagnetics	35,000 line miles
Defense Mapping Agency(DMA)	gravity files	1982 & 1985
LDGO Refractions sites		60 sites
Various sources	Onshore wells	64 wells

Conclusions

Basement depth ranges from 70,000 feet (21 km) in a series of narrow, nearshore troughs subparallel to the Texas and Louisiana coastlines, to an average depth of about 50,000 feet (15.2 km) at the south and eastern limits of the interpretation area. Structural closure is often, but not always, dependent on flanking faults. Vertical relief on individual basement structures may be as great as 12,000 feet. Many magnetic anomalies and associated basement features are asymmetric, which may represent tilted fault blocks or half-grabens.

There is good correlation in both trend and location between the major basement troughs and the major Tertiary depocenters. There is also good correlation in trend, if not in exact location, between basement structures, and trends, and overlaying sedimentary fault systems. These positive correlations strongly suggest that the sedimentary section, even as recent as Tertiary has been influenced by the underlying basement architecture.

References

Buffler, R.T. and W.A. Thomas, 1993. Crustal structure and evolution of the southeastern margin of North America and the Gulf of Mexico basin. GSA, Geology of North America, vol. CTV-1.

Hall, D.J., Bowen, B.E., Rosen, R.N., Wu, S. and A.W. Bally, 1993. Mesozoic and Early Cenozoic development of the Texas margin: A new integrated cross-section from the Cretaceous shelf edge to the Perdido Fold Belt. GCSSEPM Foundation 13th Annual Research Conference, Proceedings, p. 21-31.

Marton, G., and R.T. Buffler, 1994. Jurassic reconstruction of the Gulf of Mexico basin. International Geology Review, vol. 36, p.545-586.

Salvador, A., 1987. Late Triassic-Jurassic paleogeography and origin of the Gulf of Mexico basin. AAPG Bulletin, vol. 71, p. 419-451.

Worral, D.M. and S. Snelson, 1989. Evolution of the northern Gulf of Mexico, with emphasis on Cenozoic growth faulting and the role of salt. Geological Society America, The Geology of North America, vol. A, p. 97-138.

Acknowledgements

Geoterrex Ltd.
EDCON
AIRMAG Surveys