Basement Structure in the Northern Gulf of Mexico Province: Persistent Influence or Rejuvenated?

Michael Alexander and Karim Aimaddeddine

Integrated Geophysics Corporation, 50 Briar Hollow Lane, Ste. 400W, Houston, Texas 77027

EXTENDED ABSTRACT

There are numerous positive correlations between present-day bathymetry and a quantitative interpretation of the magnetic basement surface in the northern Gulf of Mexico Province. Bathymetric highs, escarpments, and slope breaks are shown to correlate closely with significant magnetic basement structural features.

Quantitative analysis of magnetic data to obtain discrete depth estimates and then the use of those depths to map magnetic basement structure in the northern Gulf of Mexico Province have been underutilized methods for semi-regional and regional exploration both onshore and offshore. Recent improvements in seismic acquisition and data processing now reveal that what was considered "basement" only a few years ago is in fact an acoustic basement that is shallower and far smoother than the deeper and more rugose basement seen on modern seismic data. Integration of magnetic basement depth and configuration data with publicly available modern seismic depth sections reveals a very strong correlation between the two datasets. Qualitative regional gravity interpretations can be ambiguous because the gravity field is so strongly influenced by terrain effect, deep crustal effects, and intrasedimentary density variations. These density variations and crustal effects are seldom adequately constrained.

Figure 1 is a 3rd order polynomial residual of the Sandwell 10.1 bathymetric map of the northern Gulf of Mexico Province. It is over-posted with key features and trends. Some prominent residual bathymetric highs are found immediately inboard from the Sigsbee Escarpment. Other highs radiate outward to the northwest, north, and northeast from the southernmost point of the Sigsbee Escarpment. Further to the east are two axes of high trends that extend southeastward from the Mississippi River delta area. At first glance it might appear that the bathymetry contours are primarily related to ancient levees and/or channels for an ancestral Mississippi River, but their correlation with basement features is strong. In the eastern Gulf is a major southwest-plunging bathymetric high which forces a bend in the Florida Escarpment. To the south, a much more subtle high creates a slight westward offset in the Florida Escarpment.

The magnetic basement map illustrates the major features and structural trends previously interpreted by the author (Alexander). The basement highs correlate well with bathymetric highs. Located in the central northern Gulf of Mexico Province are the cluster and/or alignment of high blocks inboard of Sigsbee Escarpment, the high ridge-like trends radiating shoreward from the Sigsbee Escarpment at its southernmost point and the two chains of basement highs trending southeast from the Mississippi River delta area. The western chain extends southeastward from South Pelto and terminates in two large basement high blocks in Lund Area. One of those high blocks is crossed by a published seismic line which confirms the basement high; both features have been described in the literature as Late Cretaceous volcanic edifices. The southern and eastern ends of the eastern chain terminate in three separate basement highs. Two large southwest-trending basement high complexes are located offshore Florida. The northern complex is named in the literature as the DeSoto Complex or Middle Ground Arch, and the southern complex is named the Sarasota Arch. Magnetic basement depths

Alexander, M., and K. Aimaddeddine, 2013, Basement structure in the northern Gulf of Mexico Province: Persistent influence or rejuvenated?: Gulf Coast Association of Geological Societies Transactions, v. 63, p. 517–518.

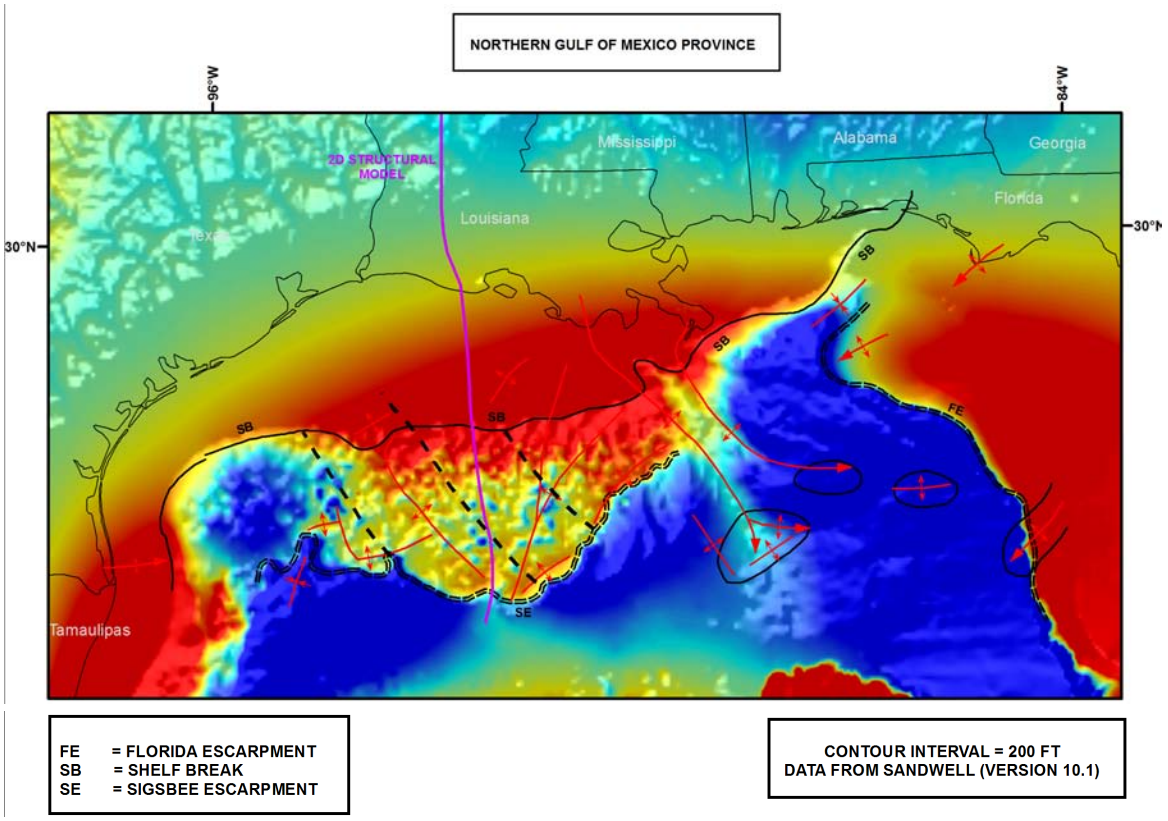

Figure 1. 3rd order polynomial residual of bathymetry, with anomalous features posted.

for both features are in agreement with published seismic reflection and/or refraction depths.

Other positive correlations with magnetic basement structure and bathymetry/ topography are illustrated or discussed: the shape and location of the salt canopy/deep allochthonous salt areas offshore Louisiana; the configuration of a Wilcox isopach which thins over basement highs; and correlations between basement features and onshore morphology.

Given those correlations, the evident question is whether the basement was a stable block over time, or was it active in the Cretaceous and/or earlier geologic time? If stable, what was the mechanism for maintaining stability? A mantle plume might have maintained a stable block or even caused some uplift, but the plume concept does not easily account for the pattern of radiating basement high trends, nor does it explain the basement highs in the east-central Gulf.

A different concept, that of an active basement with uplift resulting from Cretaceous volcanic activity, must be seriously considered. A Cretaceous intrusive offshore Louisiana has been documented, as are offshore Cretaceous extrusives and/or ash. If the basement is or has been active, was there lateral as well as vertical movement? Numerous papers present a case for a series of northwest-southeast transform or transfer faults crossing the northern Gulf of Mexico Province, and evidence for these trends can be found on both magnetic anomaly and basement structure trends. Very strong northeasterly trends area also present. The northeast-trending magnetic anomalies do not represent "transform fault segments," but are in fact basement ridges.