The Use of Gravitational and Electrical Resistivity Techniques to Delineate the Big Barn Fault Located within the Gulf Coastal Plain, Montgomery County, Texas

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ABSTRACT

The Gulf Coast of Texas has been a known hydrocarbon basin for many years with various structural trapping mechanisms such as anticlines, faults and salt domes. While most large salt domes have been extensively studied in the Gulf Coastal Plain, many smaller normal faults have not been studied in detail. This research study employs an integrated geophysical approach to mapping the Big Barn fault in Montgomery County, Texas. This fault is located on the Gulf Coastal Plain and is approximately 20 miles north of Houston, Texas. Within the past 20 years, extensive deformation and fractures within the vicinity of the fault have formed on Interstate Highway 45 and caused damage to nearby businesses and residences. In this study, gravitational methods, electrical resistivity surveys, and traditional mapping techniques were conducted to assess the cause of deformation and the extent of faulting. Two-dimensional inverted resistivity models were created and found to be very useful in determining the structures and stratigraphy of the study area.

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A GEOPHYSICAL DELINEATION OF A NORMAL FAULT WITHIN THE GULF COASTAL PLAIN, MONTGOMERY COUNTY, TEXAS

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ABSTRACT

The Gulf Coast of Texas has been a known hydrocarbon basin for many years with various structural trapping mechanisms such as faults and salt domes. While most salt domes have been extensively studied in the Gulf Coastal Plain, many normal faults have not been studied in detail. This research study employs an integrated geophysical approach to mapping the Big Barn fault in Montgomery County, Texas. This fault is located on the Gulf Coastal Plain and is approximately 20 miles north of Houston, Texas (Figure 1). Normal faults in the Gulf Coastal Plain formed when the Gulf of Mexico basin opened during the Jurassic Period as a result of the breakup of Pangea and the rifting of North and South America. The Big Barn fault formed during the Jurassic but there is evidence that the fault plane has been recently reactivated. Within the past 20 years, extensive deformation and fractures within the vicinity of the fault have formed on Interstate Highway 45 (IH 45) and caused damages to nearby businesses and residences. In this study, gravity, electrical resistivity surveys and traditional mapping techniques conducted to determine the cause of deformation and the extent of faulting. Two-dimensional inverted resistivity models were made to determine the structures and stratigraphy of the area.

STUDY AREA

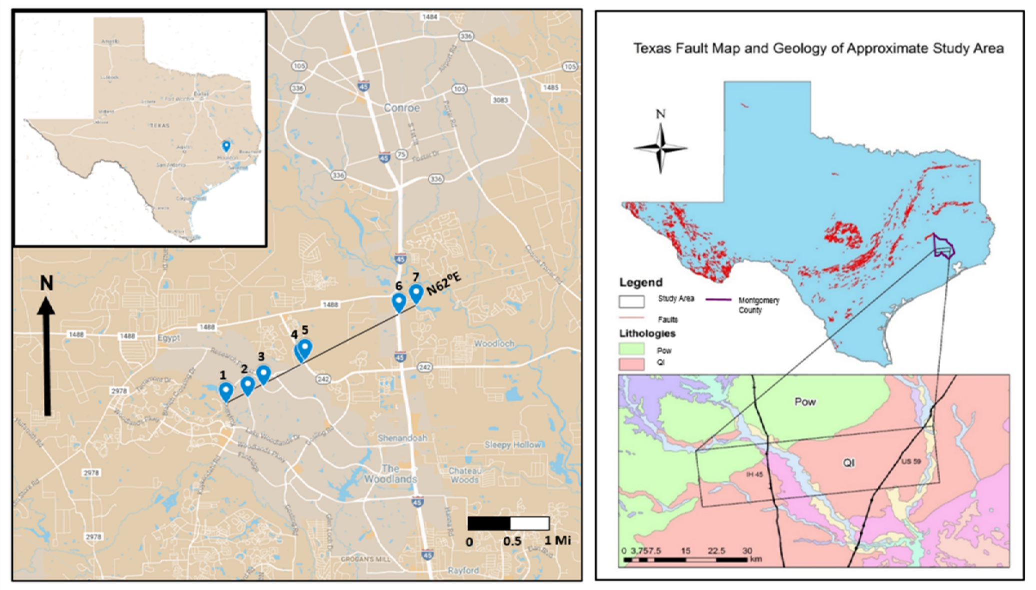


Figure 1. Study Area

REGIONAL GEOLOGY

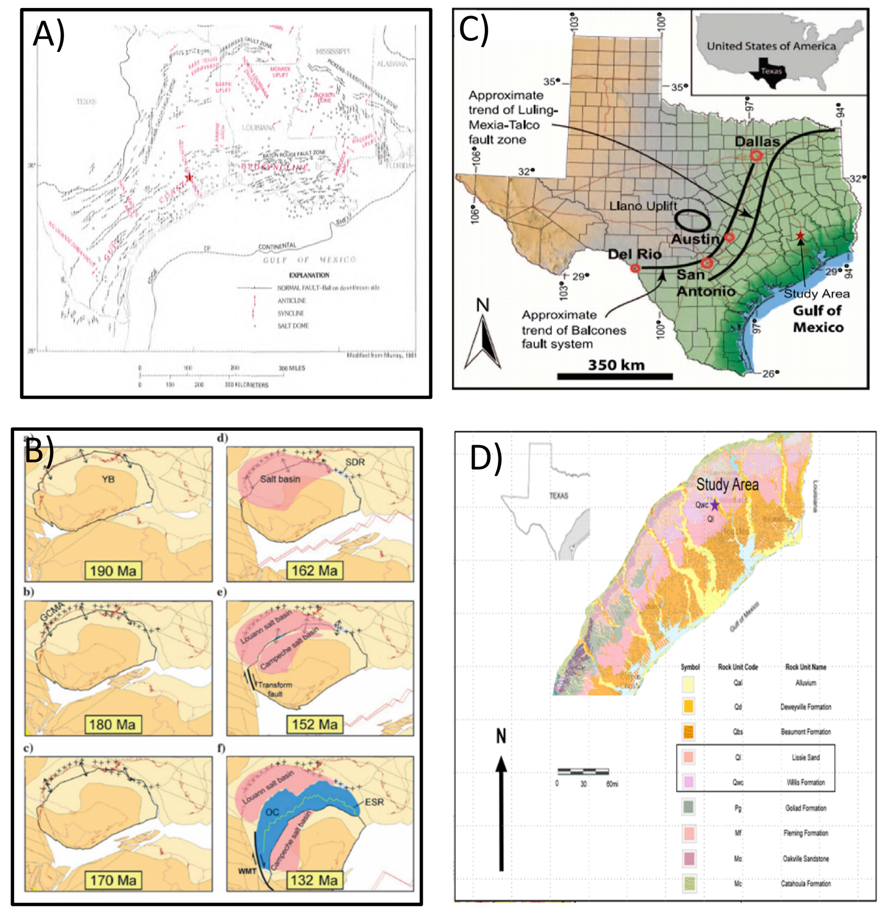


Figure 2. Regional Geology

A) Major structural feature found along the coast of the Gulf of Mexico are growth faults and salt domes. B) After Pangea broke apart, North and South America started spreading away from each other and the Gulf of Mexico Basin formed. This basin became a topographic low and filled with water. C) To the North and South of the basin normal faults started to form parallel to the coast. These normal faults caused the downthrown or southern end of the Gulf Coastal Plain to dip down toward the coast. The Luling-Mexia-Talco fault zone and the Balcones fault system are the primary faulting zones in the region. D) The primary stratigraphic units in the study area were the Willis Clay and the Lissie Sand.

METHODOLOGY

Geophysical research was conducted on the Big Barn fault in Montgomery County, Texas. Electrical resistivity and gravity methods were used to delineate the Big Barn fault. A CG-5 Autograv was used to measure gravity while an Ohm Mapper and an R2 SuperSting unit were used to measure electrical resistivity, while a. Field observations were first completed to determine areas with the most visible deformation. Broken up roadways that fell within the trend of the fault that had a sharp decrease/increase in elevation on either side of the fracture were examined. A Brunton compass was also used to determine the trend of the fault scarp.

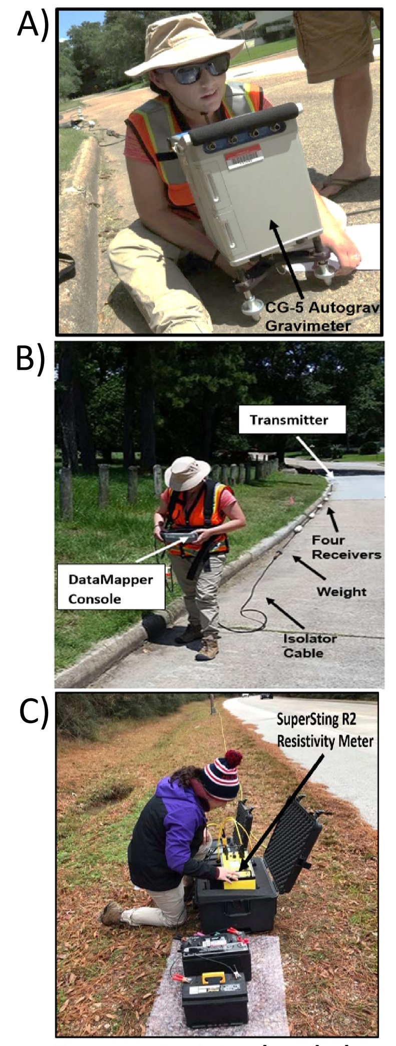
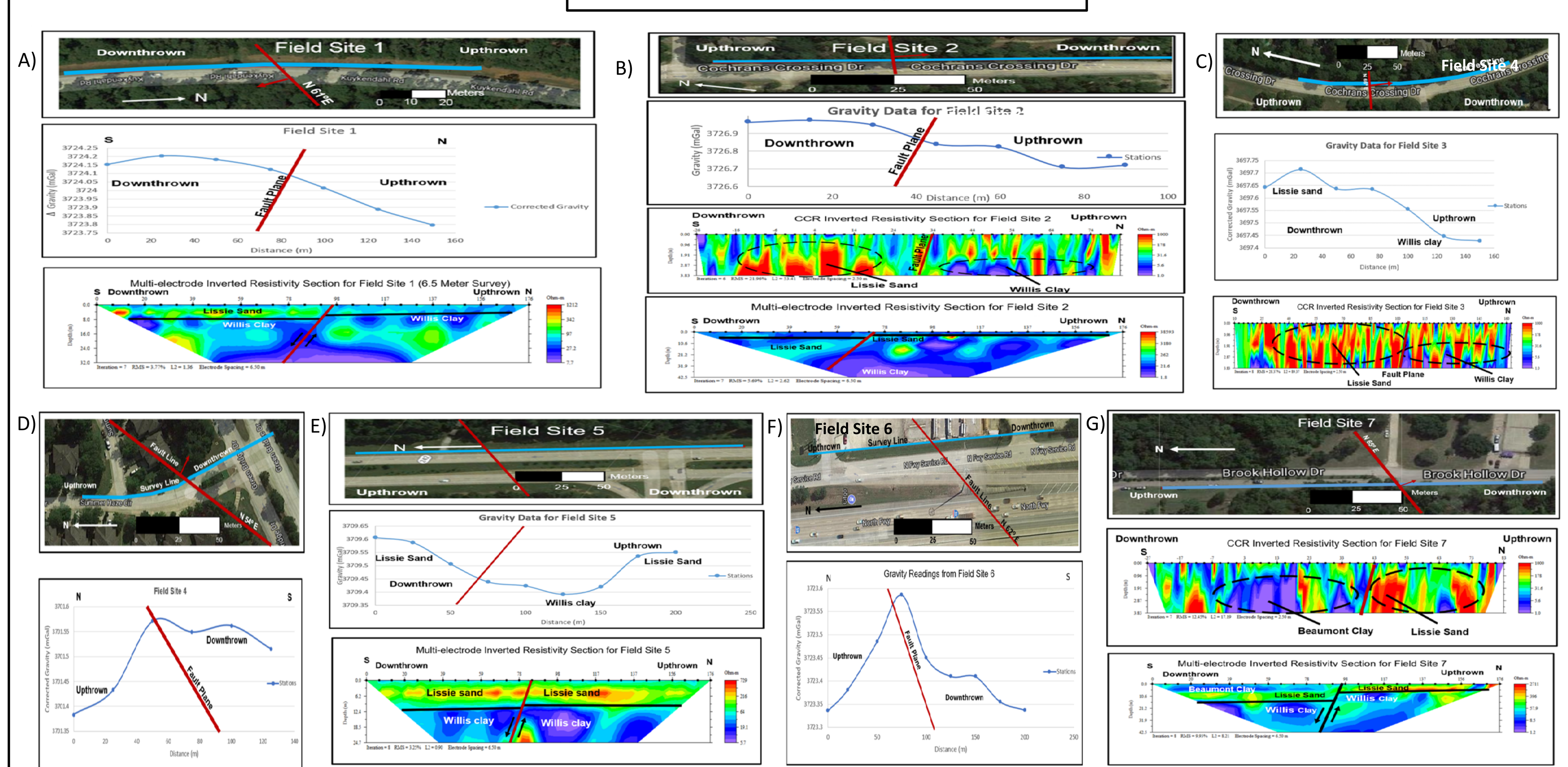


Figure 3. Methodology

A) Gravity data was acquired using the CG-5 Autograv and was used along various roadways that bisect the fault line. The gravitational force exerted on the mass inside the instrument is balanced by a spring and an electrostatic restoring force (Scintrex, 2008). Since faults commonly juxtapose rocks of different densities, gravity surveying turned out to be a viable tool for the identification and detection of subsurface faults (Hatherton and Hunt, 1968).
B) Traditional electrical resistivity with a dipole-dipole array was used for both the OhmMapper and the SuperSting in this study. Resistivity data was first collected from the OhmMapper with a TR4 setup.
C)Electrical resistivity was also collected using a Super Sting R2 resistivity meter produced by *Advanced Geosciences, Inc.*

RESULTS



For this study gravity and electrical resistivity methods were used to delineate the Big Barn fault in Montgomery County, Texas. After examining geologic maps it was determined that the Big Barn fault was found to be at the intersection of the Lissie sand and the Willis clay. Gravity data confirmed this because the majority of the field sites showed a higher gravity on the downthrown side of the fault, which had higher accumulations of the Lissie sand. Since sand is denser than clay, it will have higher gravity readings. The Ohm Mapper was also able to confirm that in most of the field sites studied that the downthrown side had a higher resistivity and corresponded to the Lissie sand while the upthrown side of the fault had a lower resistivity and was determined to be the Willis clay. The offset of layering was found using the SuperSting because it allowed for a greater survey depth. In most of the field sites the offset of the layers is clear along with a distinct border between the Lissie sand and the Willis clay.

CONCLUSION

For this study the Big Barn fault was examined using electrical resistivity and gravimetery techniques. Seven field sites were examined in total and each site used varying methodologies to delineate the fault and define the geology of the upper rock units. All field sites showed significant fractures in roadways along with a sharp contrast in elevation from the upthrown side of the fault to the downthrown side. The N62ºE trending fault line was found to trend along the same path as the intersection of the Lissie Sand and Willis Clay, in most cases.

Gravimetery techniques were first used to delineate the fault and identify the varying densities of the Lissie Sand and Willis Clay. All field sites showed a contrast between the Lissie Sand and the Willis Clay. The Lissie Sand was found to be denser than the Willis Clay because it had higher gravity readings. The gravity data was compared to the electrical resistivity data to determine the subsurface features in each field sites. The electrical resistivity data matched the gravity data which showed that the Lissie sand was on the downthrown side of the fault and had higher resistivity. The multi-channel electrical resistivity data also showed that the Willis clay was found mostly on the upthrown side of the fault and was characterized by lower resistivity readings. The capacitively coupled resistivity readings were used to define the top layer geology and showed a contrast between the Lissie sand and Willis clay.

Field sites 1, 2, 5 and 7 showed an offset between the Lissie Sand and Willis Clay that ranged from 2-5 meters.

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