GULF COAST ASSOCIATION OF GEOLOGICAL SOCIETIES TRANSACTIONS VOL. XLVIII 1998

A Geological Exploration Model for Offstructure Gas Accumulations in Geopressured Lower Miocene Sandstones, Offshore Texas

Charles Brewster[1], Charles Sharpe[2], Sharon Landeche[3], Lori Hathon[4], and Bob Klein[5]

[1]Texaco, P.O. Box 60252, New Orleans, LA 70160, [2]Amoco, P.O. Box 3052, Houston,TX 77253, [3]Amoco, P.O. Box 50879, New Orleans, LA 70150, [4]Shell E & P, P.O. Box 481, Houston, TX 77001, [5]Amoco, P.O. Box 3092, Houston,TX 77253

Studies of the Matagorda Island 519 field, offshore Texas (Figs. 1 and 2) have led to an exploration model to predict the existence of similar exploration targets in geopressured sandstones in flanking structural positions. These compartmentalized reservoirs are thought to form as a result of complicated secondary-porosity diagenetic processes related to fluid flow and pressure cell formation. Prediction of similar exploration targets can be enhanced through geochemical, pressure and seismic interval velocity analyses.

Matagorda Island 519 field produces from four wells in geopressured sandstones at depths from 14,200 to 17,300 ft downthrown to a lower Miocene expansion fault and flanking a diapiric shale ridge (Figs. 3 and 4). Ultimate recoverable resources of 300+ BCF of gas are attributable to this field. The deltaic sandstones have porosities of 0-23 percent and a high intergranular volume of 25-33 percent. The productive porosity is considered to be secondary porosity based on petrologic relationships and the result of ferroan calcite cement dissolution. Sandstone petrology suggests the following paragenesis: 1) mechanical compaction, 2) formation of clay grain coats on detrial grains, 3) calcite cementation, 4) partial dissolution of detrial feldspar and quartz, 5) dissolution of calcite cement and calcite detrital grains and variable cementation by poly-crystalline quartz, ankerite and pyrite. Zoning of authigenic cements is noted with poly-crystalline quartz/pyrite cement predominate updip and most proximal to the expansion fault (Fig. 5). This authigenic facies grades downdip into dolomite/Fe-ankerite and further downdip into Fe-calcite cemented facies. The best secondary porosities and the hydrocarbon productive reserviors are limited to the downdip dolomite/Fe-ankerite and Fe-calcite cemented facies. The well spacing of approximately 2000 ft between wells clearly demonstrate a diagenetic overprinting rather than a facies change origin of these relationships.

Geopressure cells are distinct and form a banded compartmentalization recognized in resistivity log patterns (Fig. 3). Above geopressure, sandstones are highly resistive (1.5-4 ohms), in a classic caprock formed by calcite mineral percipitation from fluids periodically expulsed from the pressurized zone (Fig. 6). The geopressure zone is a sharp transition about 300 ft thick (Compartment A to Compartment B on Fig. 3), where drilling mudweights increase from 13 to 17 lbs/gal. Corresponding shale resistivities drop from 1.5 ohms down to about 0.9 to 1 ohm in the geopressured interval. The first pressure band interval (Compartment B) is about 800 ft thick, and upon deepening, the well bores encounter the second geopresssure zone. This second geopressured zone (Compartment C) is a 18+ lbs/gal environment with corresponding shale resistivites of 0.3-0.5 ohms. The second geopressure compartment is about 1700 ft thick and shows increasing resistivity at the base. This is where the top of the reservoir becomes developed, and the resistivity increases to 1-2 ohms (entering Compartment D). Within the reservoir zone (Compartment D), the upper 200 ft is tightly ferroan-calcite cemented sandstones with 20-23 percent cemented intergranular pore space occupied by calcite cements. Upon entering the productive reservoir, the 20-23 percent pore-spaces are etched, interconnected voids filled with hydrocarbons. The reservoir pressure drops from the 18+ lbs/gal in the overlying second pressure compartment (C), to a 17 lbs/gal in the reservoir compartment (D).

The proposed geologic model is dynamic. It involves several periods of pressure formation and includes diagenetic mineral assemblages consistent with hydrothermal fluid flow alterations. Updip, a non-economic sandstone assemblage shows polycrystalline quartz and pyrite cemented sandstones with thin zones containing gas shows (Fig. 5). The non-economic, cemented sandstones are seen beneath two banded geopressured shale compartments (B and C). Downdip, the sandstones grade into reservoir quality, with a Fe-ankerite and Fe-calcite residual overprint. Detailed interval velocity analyses shows two tiered, slower velocity zones (in Compartments B and C) over the faster cemented sandstone, tight facies. Within the reservoir interval updip, fast, cemented sandstones are non-economic. The velocities slow downdip, where secondary, dissolution porosity is hydrocarbon saturated. The mechanism forming these accumulations is thought to be an interplay between geopressuring and diagenesis.

Exploring for these diagenentically controlled gas accumulation can be achieved through a combination of geological and geophysical techniques. First, electric logs can be screened for highly resistive sandstones with uneconomical gas shows. Cuttings from these logs can be obtained and analyzed for anomalous prite, ankerite and quartz mineralization. Samples showing such mineralization may be considered migration pathway indicators and thus high grade areas for more sophisticated geophysical techniques. Detailed interval velocity models can illuminate the structure of the geopressured compartments. Subtle velocity analyses can detect the limits of tight, cemented facies by their characteristic high velocities. Slower velocities should indicate the areas where porous, gas saturated rocks are located downdip. These methods, and this exploration model, may allow for the addition of significant resources to be discovered along the strike of this prolific hydrocarbon producing trend.

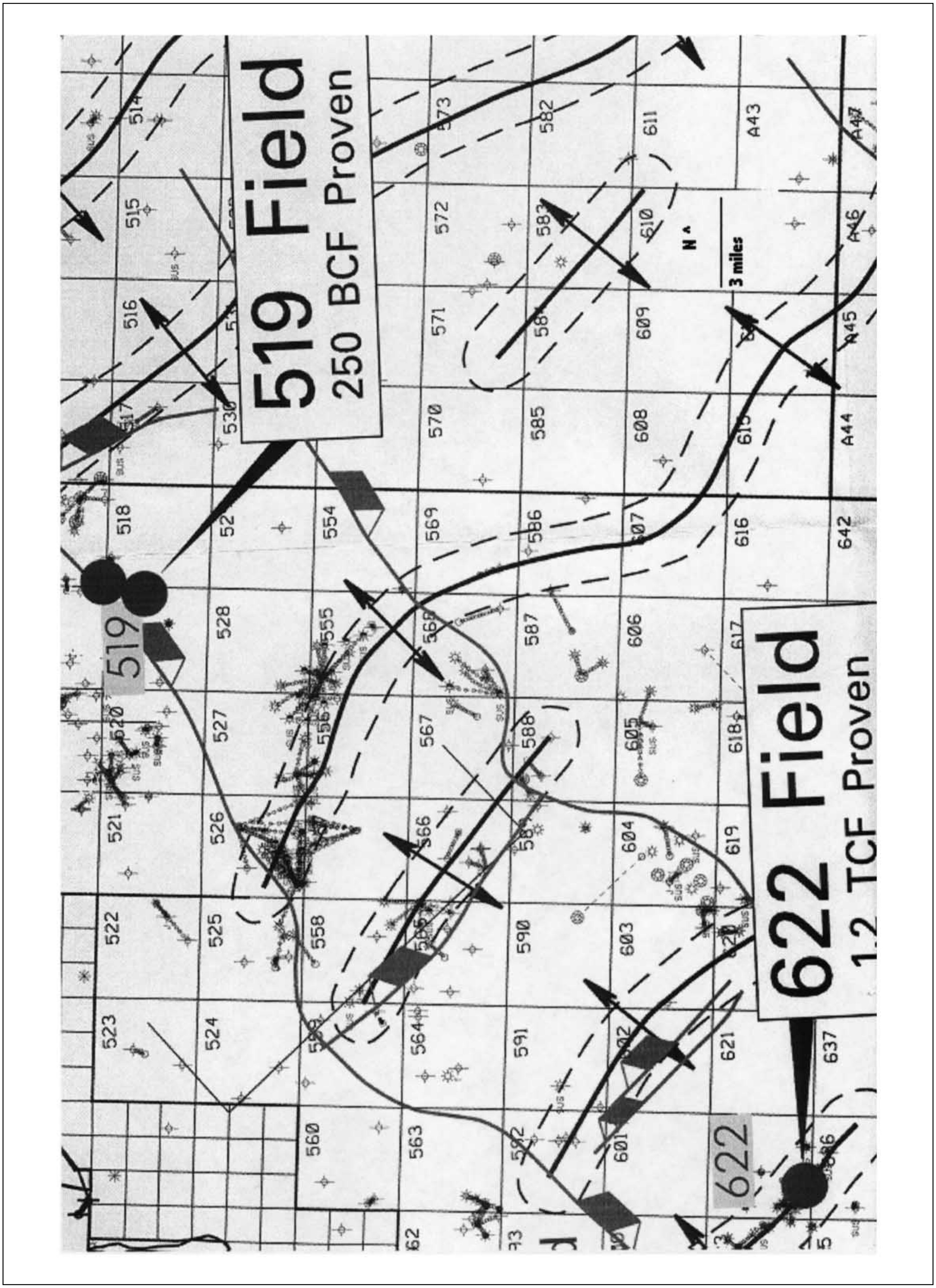

Figure 1. Location of Matagorda Island 519 field, offshore Texas. Axes of depositionally perpendicular shale ridges and lower Miocene expansion faults are shown schematically.

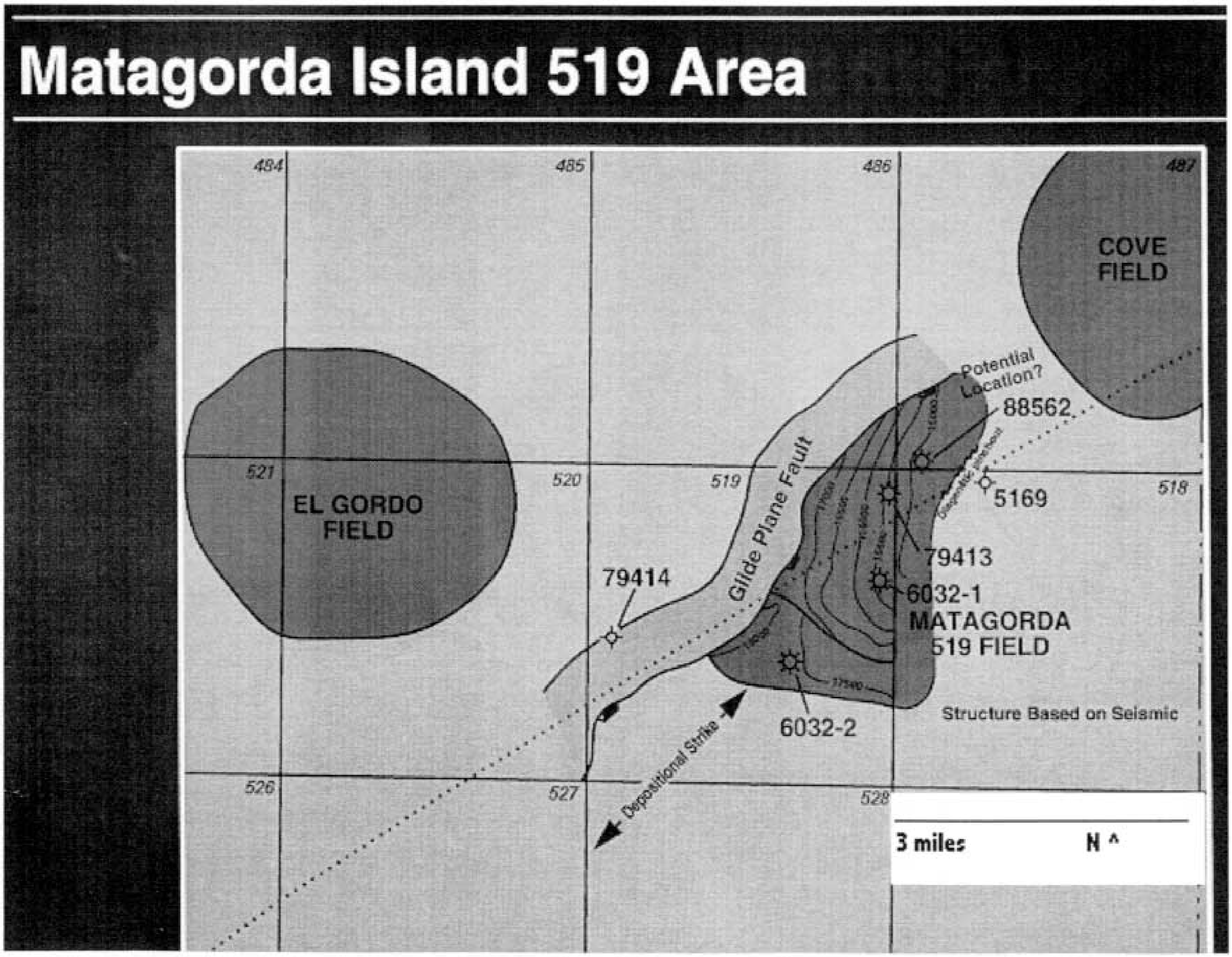

Figure 2. Structure Map of Matagorda Island 519 field showing the locations of El Gordo and Cove field.

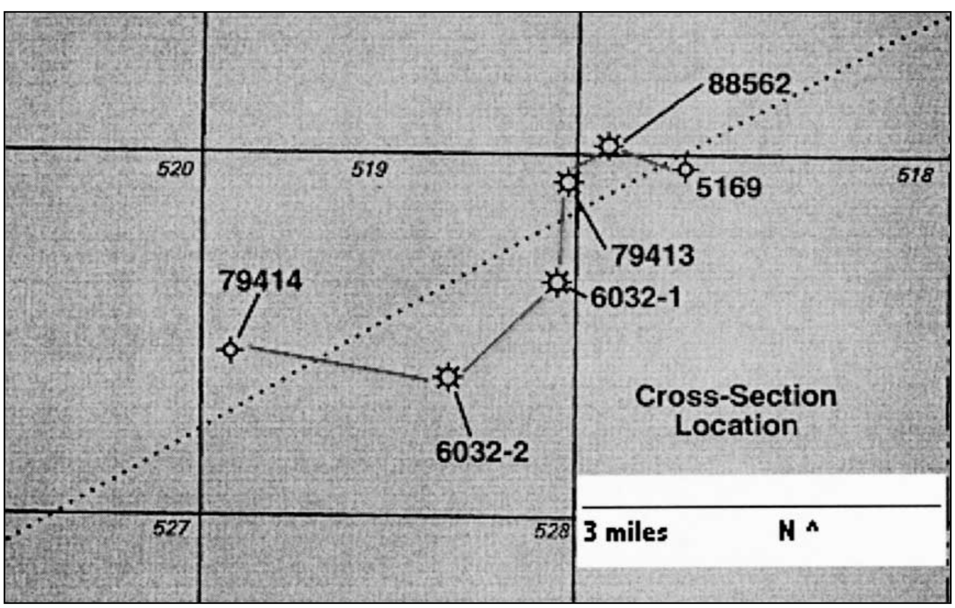

Figure 3. Line of cross-section through the Matagorda Island 519 field.

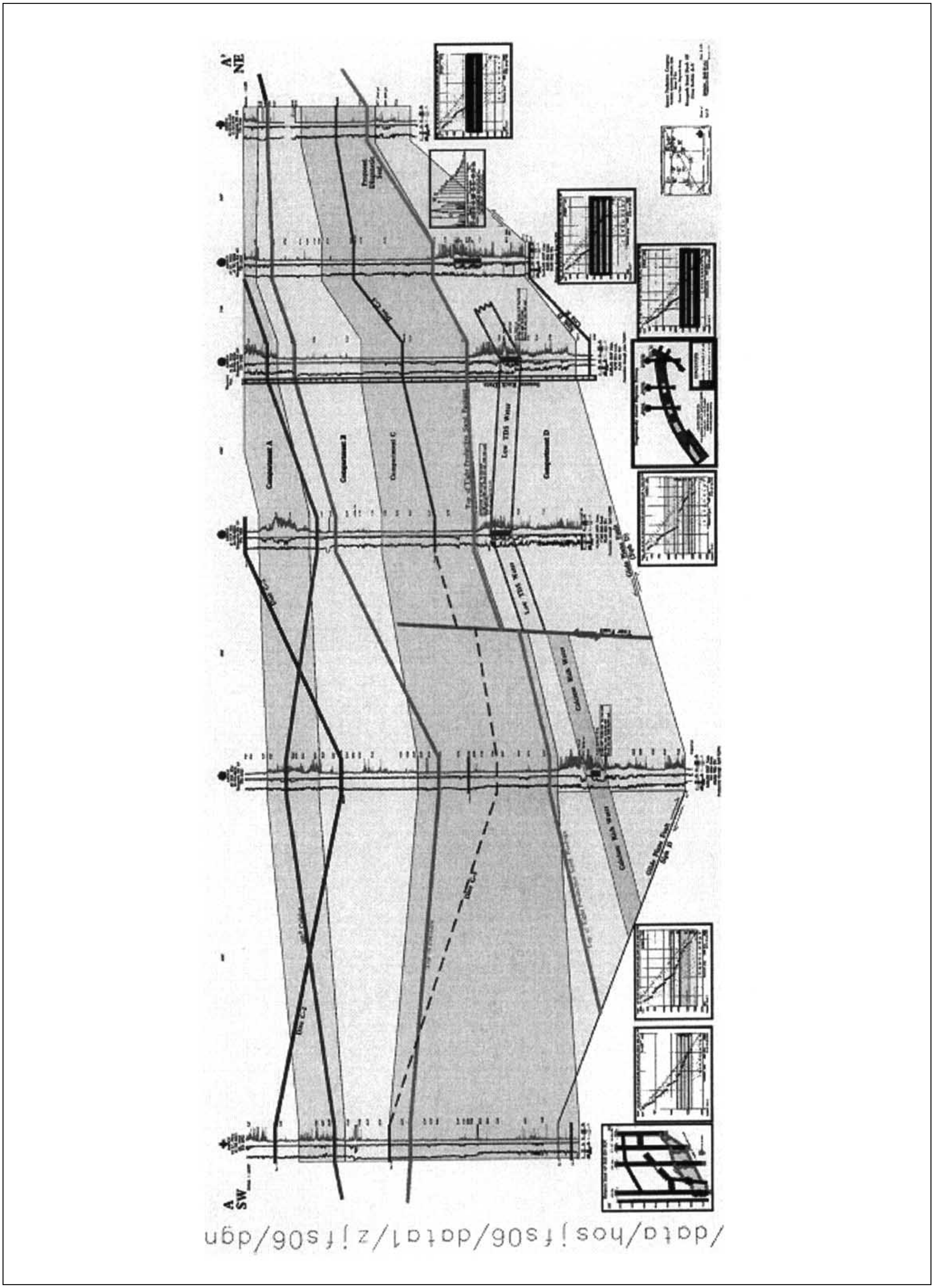

Figure 4. Cross-section through Matagorda Island 519 field showing resistivity-defined geopressure compartments.

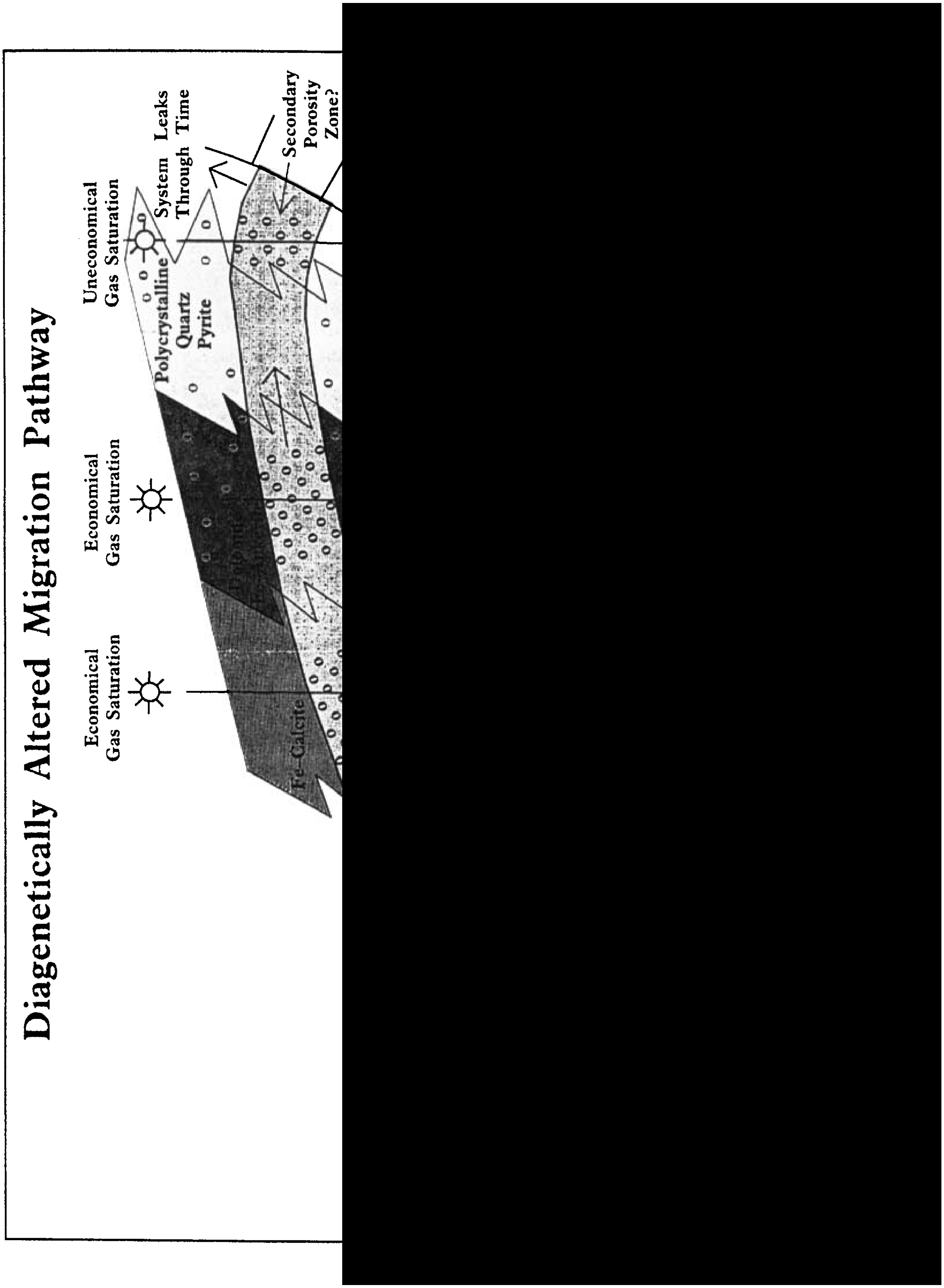

Figure 5. Geochemical facies zonation formed along diagenetically altered migration pathway accumulations

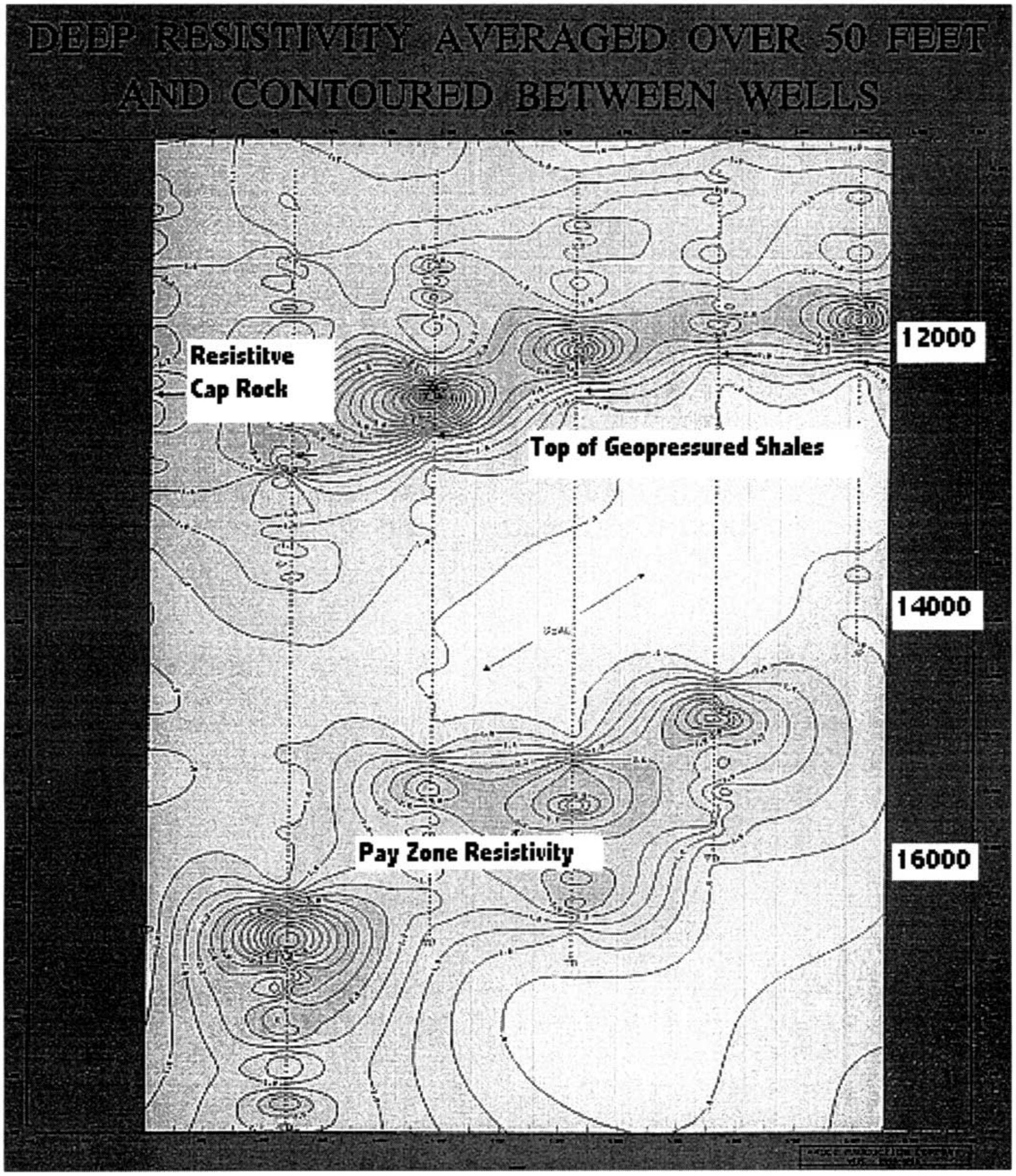

Figure 6. Resistivity cross-section showing caprock above geopressure and the pay zones within lower Miocene sandstones.