Structural Modeling of Overturned Beds Using Dips from Wells Near Salt Structures, Northern GOM*

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Abstract

Many oil fields in the Gulf of Mexico (GOM) basin are affiliated with salt structures. With new technologies, more oil is being extracted from these fields. However, subsalt exploration and development presents various challenges to the oil industry, one of which is to define structures and reservoir volumes beneath salts. As more wells have been drilled around salt domes, it is observed that many beds around salt domes are overturned. The overturned beds are found in offshore subsalt fields as well as onshore fields related to shallow piercement salt domes. These overturned structures can sometimes be interpreted from regular, open-hole wireline logs, such as Gamma Ray curves and Spontaneous Potential curves. They show up symmetrically about a hinge point. Regular wireline logs, however, are usually one-dimensional. Many overturned structures coexist with faults and local unconformities, and do not have symmetric log features. All these make the interpreting of overturned structures near a salt dome very difficult, if not impossible.

Dips from borehole images have been used to define reservoir structures for many years; dips from tri-axial resistivity logs have started being used only recently. However, the interpretation of the dips from these tools is not straightforward, especially when overturned folds and faults are present near salt structures. Software for structural interpretation and visualization from formation dips derived from borehole images is sometimes used to model structures. Its application in the GOM to visualize overturned structure affiliated with salt domes has helped in the interpretation of these complex structures.

This paper presents interpretation of overturned structures using structural modeling and visualization software in a few examples from the GOM. The results suggest that many oil reservoirs surrounding salt structures in Louisiana and Texas remain to be exploited for remaining reserves. Without the use of dips from open hole logs and structural modeling, it would not have been possible to identify these structures.

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Outline

- Introduction
- The Method (FMI*) - using new technology in old fields
- Case Study – drilling new wells in old fields with new perspectives
- Summary

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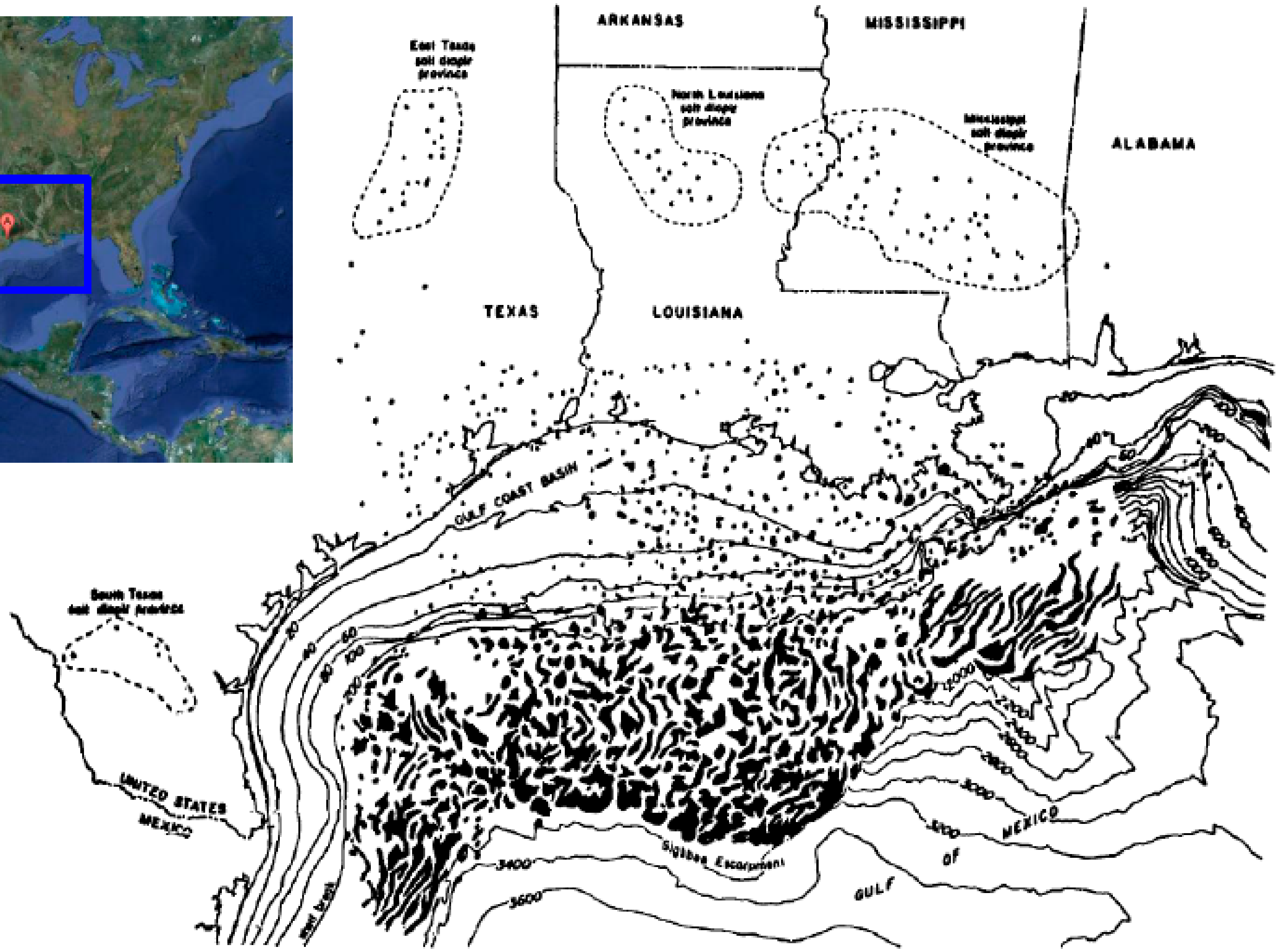
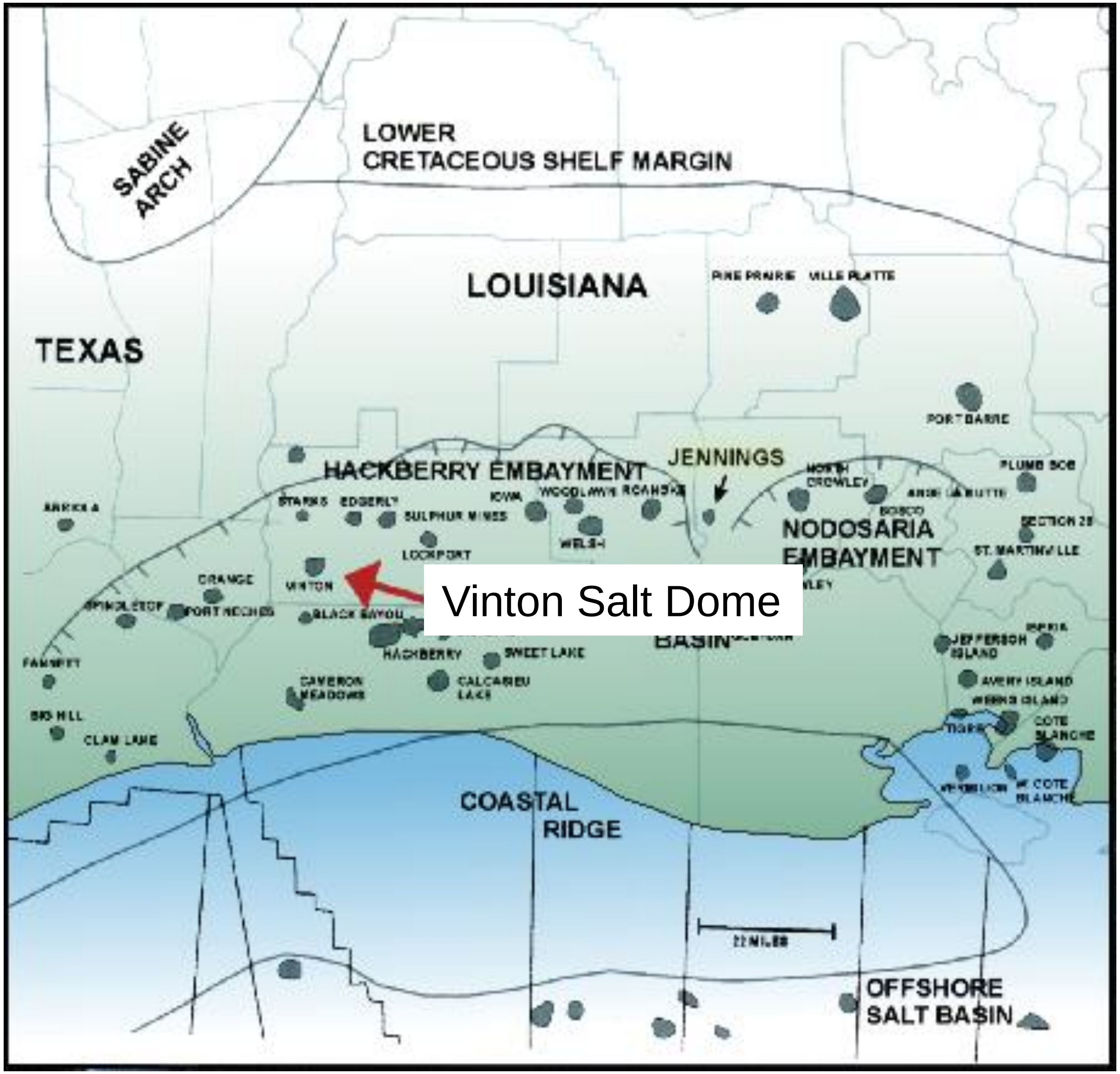


Presenter’s notes: The GOM basin is one of the largest oil-bearing basins on the world. It locates in the south US. This map shows the distribution of salt structures in the GOM basin. Most salt domes are in the northern area, and salt canopies in the southern area.



Salt domes of southwest Louisiana. (Spencer and Sharpe 1993)

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The Challenge –

How to find new reserves in a field that has been drilled and produced for over a hundred years and worked by many generations of good geologists?

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“We usually find oil in new places with old ideas.

Sometimes, also, we find oil in an old place with a new idea, but we seldom find much oil in an old place with an old idea.

Several times in the past, we have thought we were running out of oil whereas actually we were only running out of ideas.”

(Parke A Dickey, 1958)

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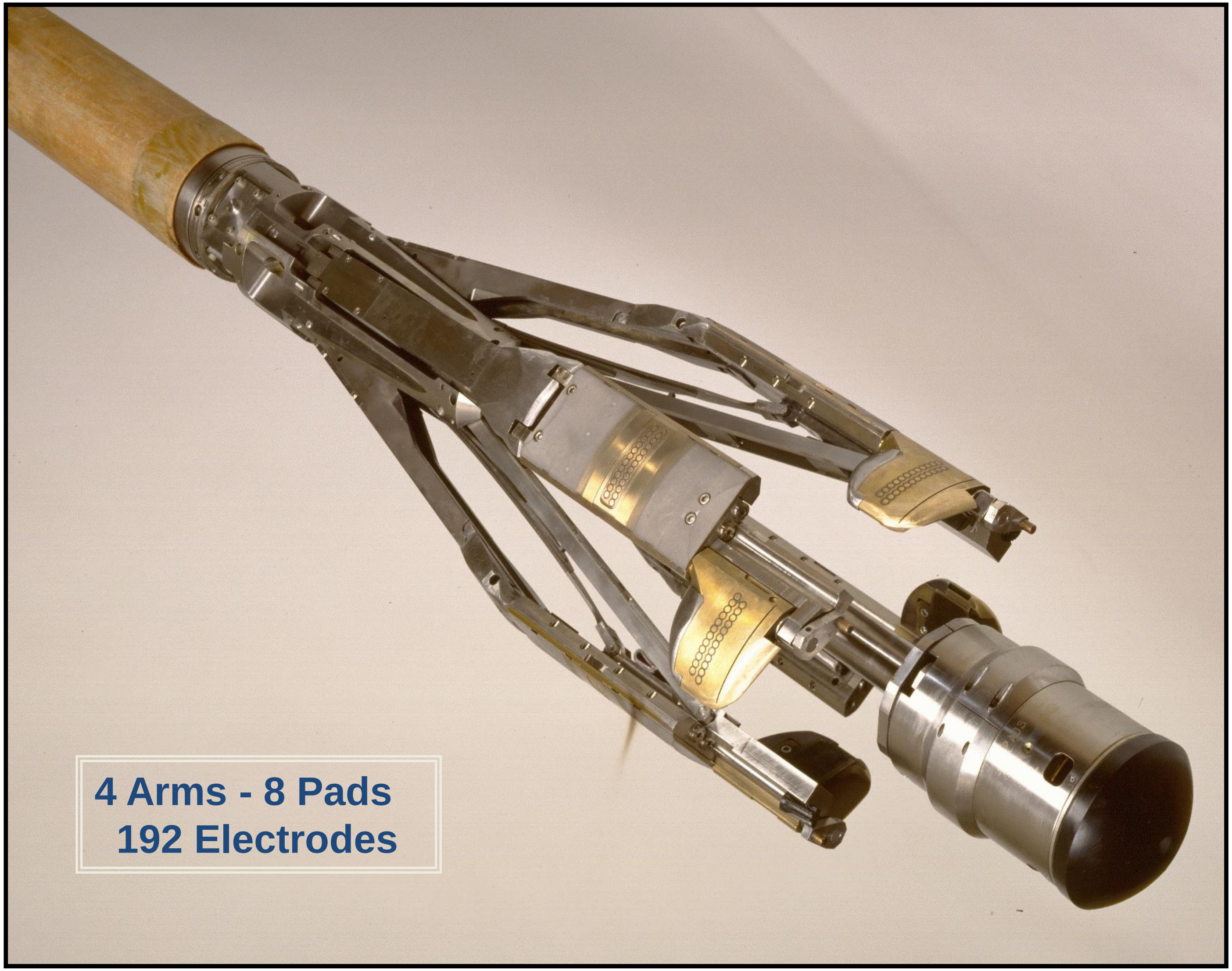
FMI* – Fullbore Formation MicroImager



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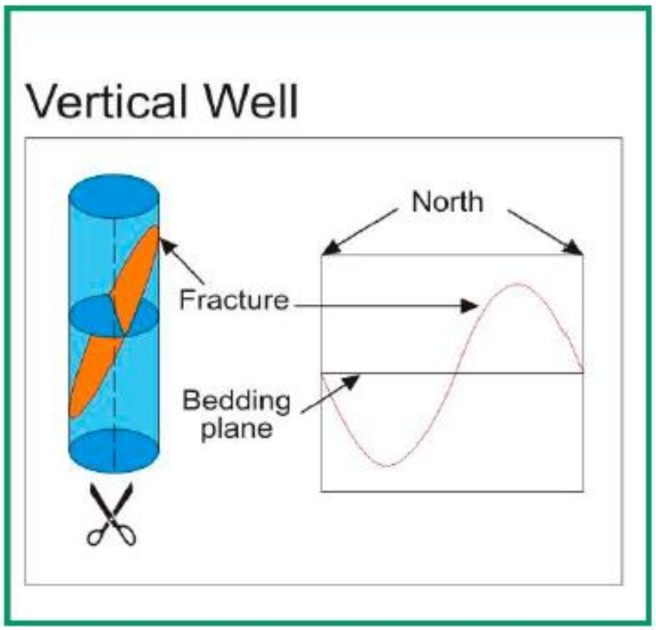
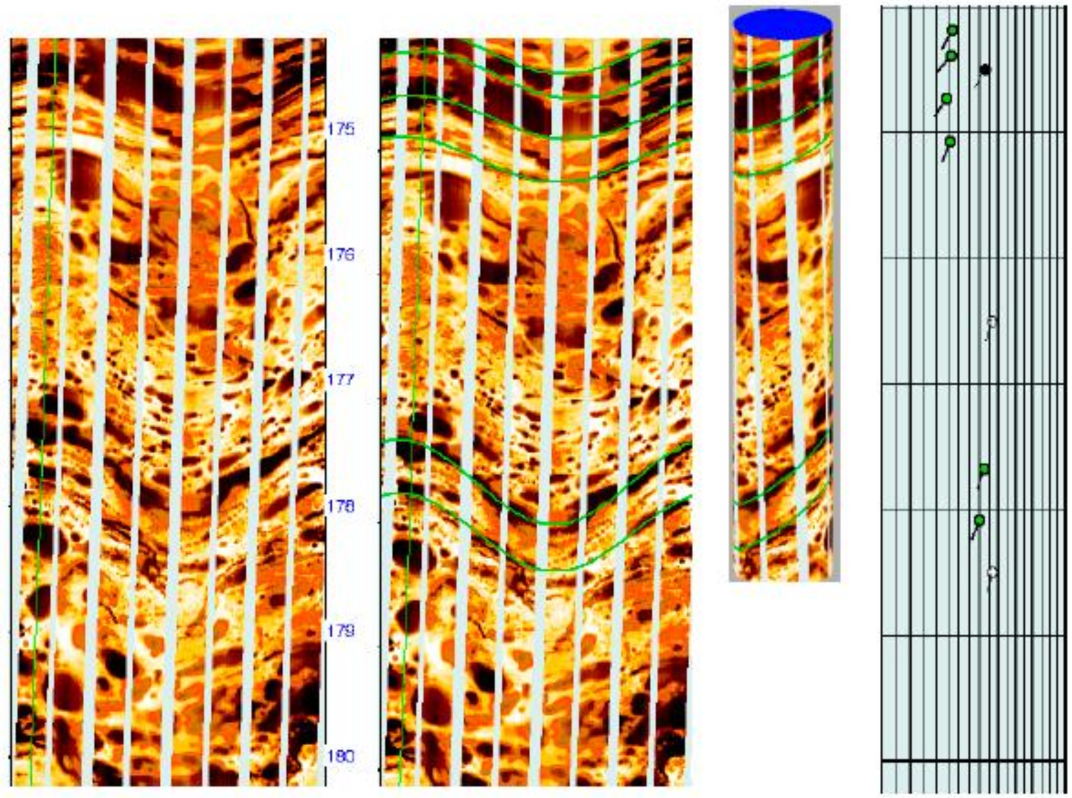
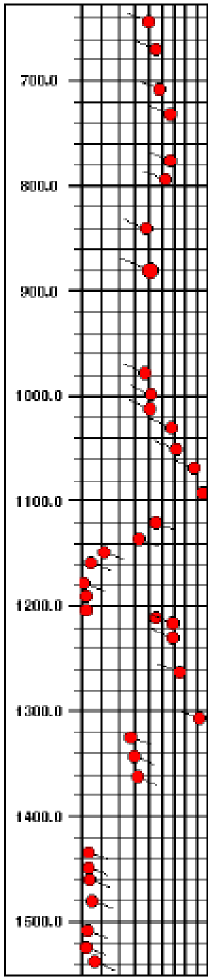
Basics of FMI*

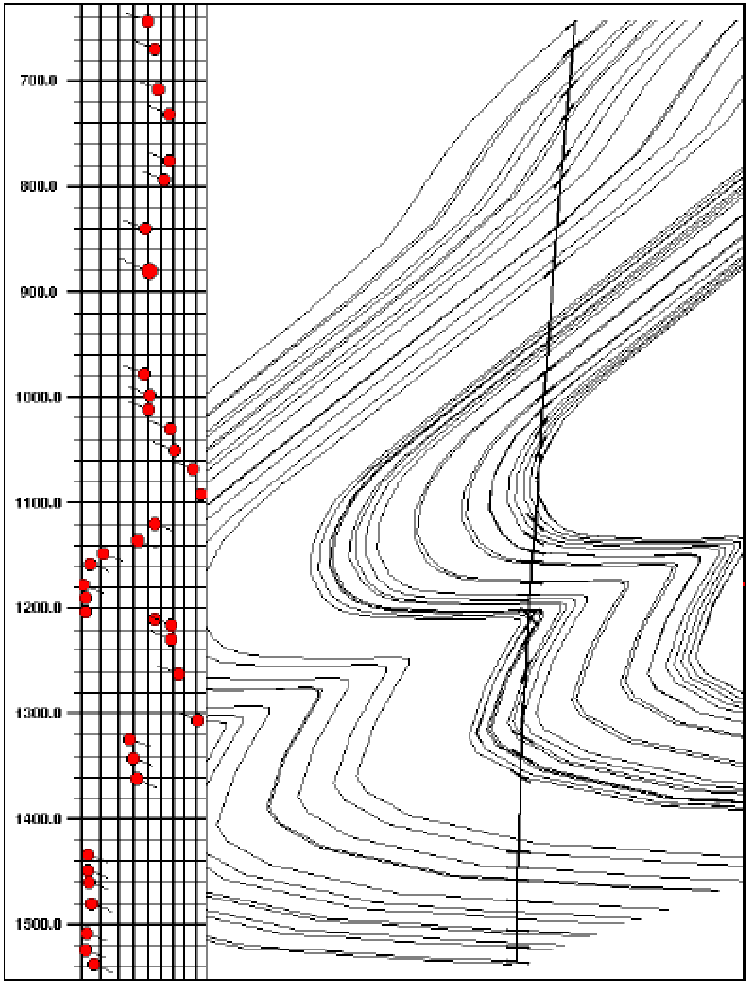




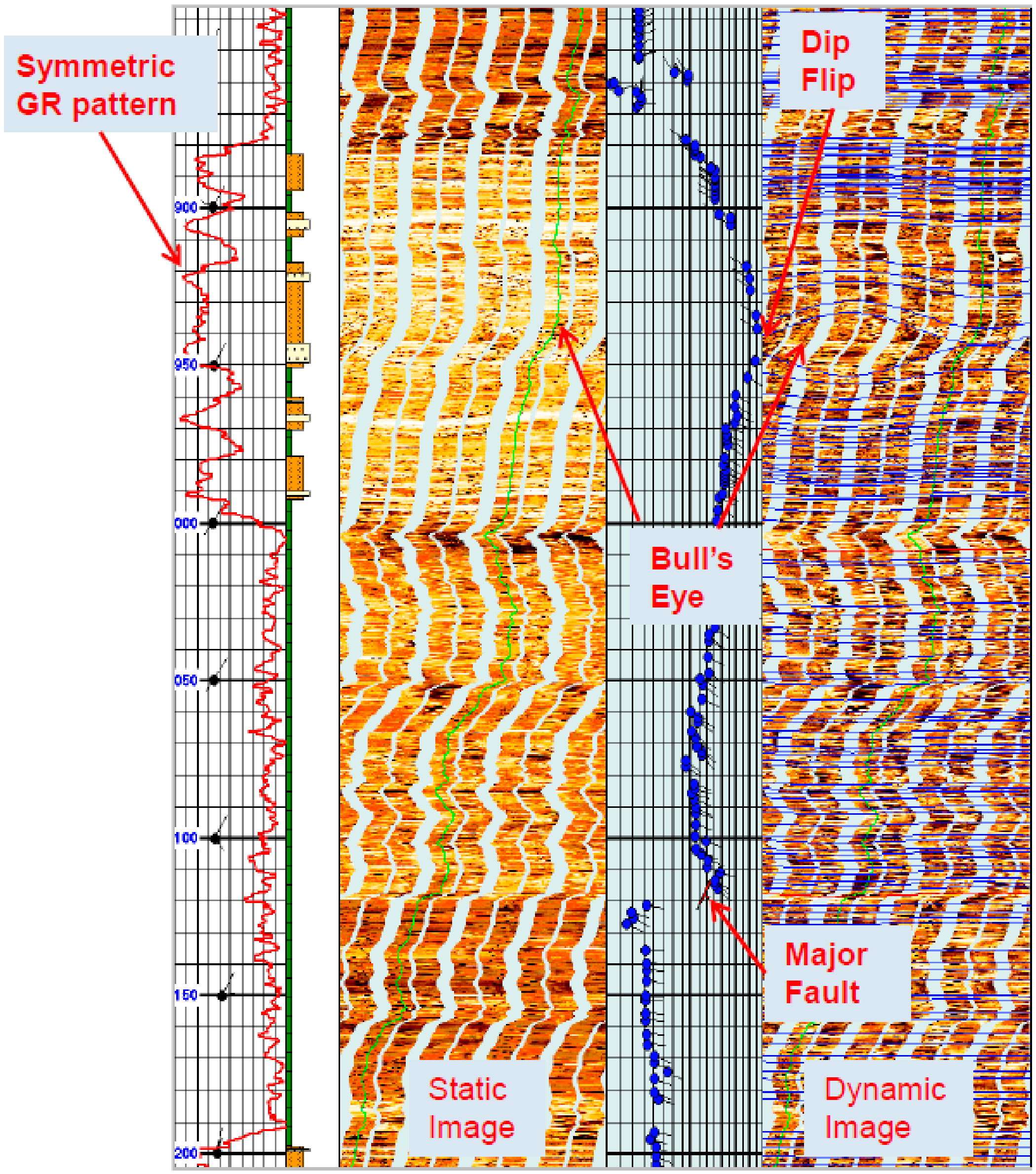
Presenter's notes: The FMI tool measures resistivity on the well bore. Since the well bore is 3d, the measurement is 3d. That is why it can measure the dips of geological features. However, our computers work better on 2D displays. Therefore, the image is displayed in 2D. It opens the 3D cylinder of wellbore. We do interpretation on the 2D display. Planner features become sinusoids. Dips are displayed as tadpoles. The circle of the tadpoles represents the dip magnitude, and the tail points to the dip azimuth.

StrucView* Modeling

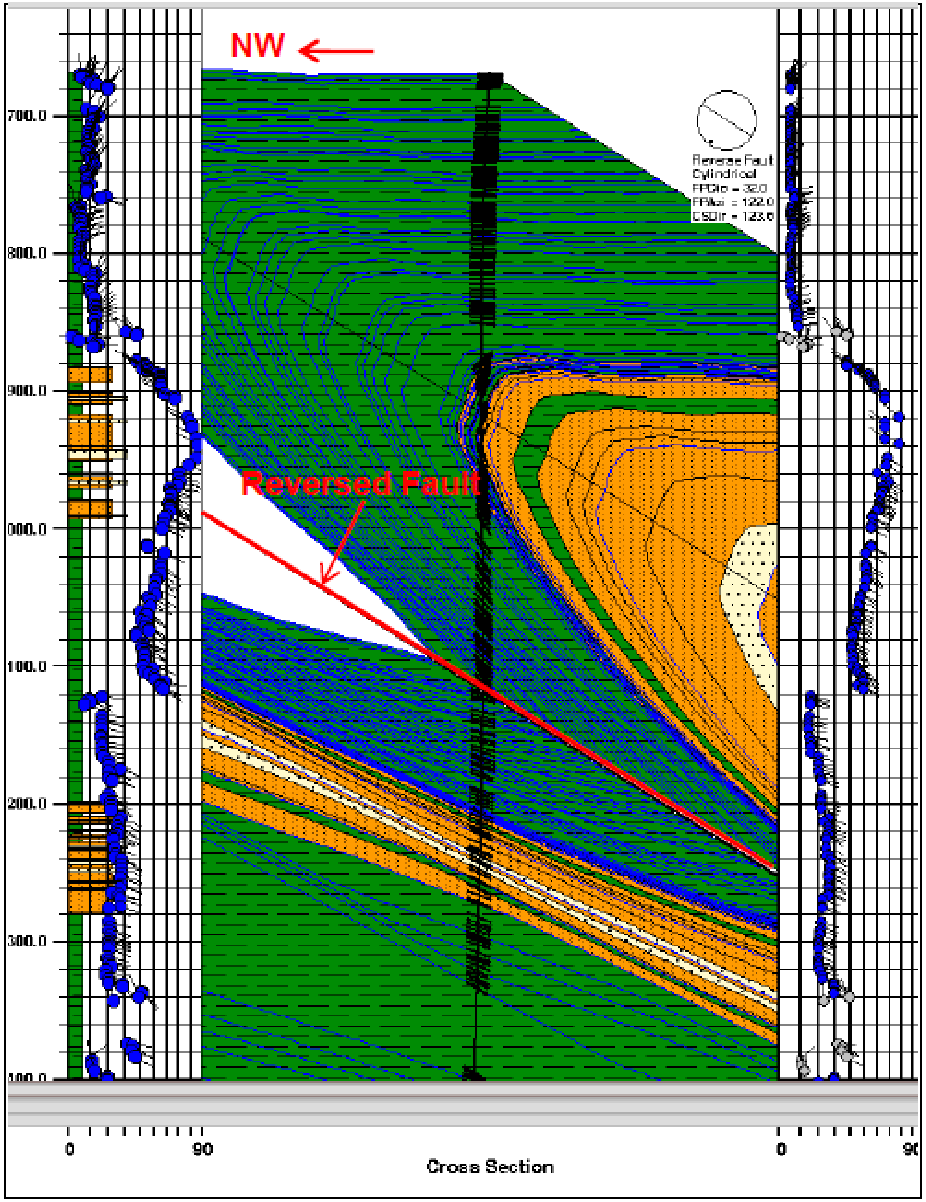




Presenter's notes: Once we have the dip set, the structure can be modeled with software. We use StrucView. The cross section is representing a cross section on this outcrop.



Presenter's notes: When we do interpretation, we also use other indicators. They are symmetric log curve patterns: GR, SP, resistivity; Dip Azimuth Flip; Bull's Eye on Image



Presenter's notes: Once we have all those information, we now can confidently say that there is an over-turned fold.

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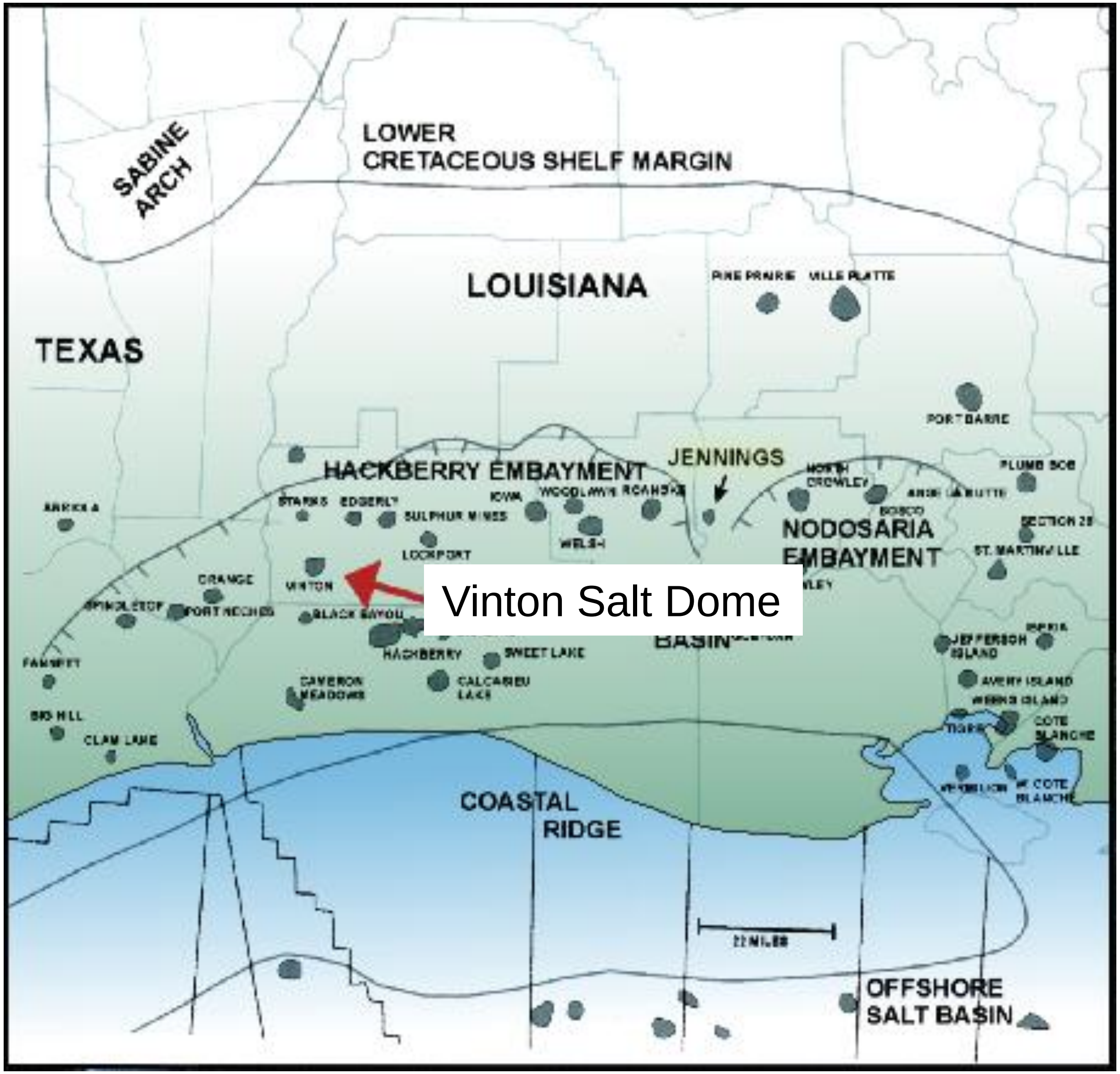

Salt domes of southwest Louisiana. (Spencer and Sharpe 1993)

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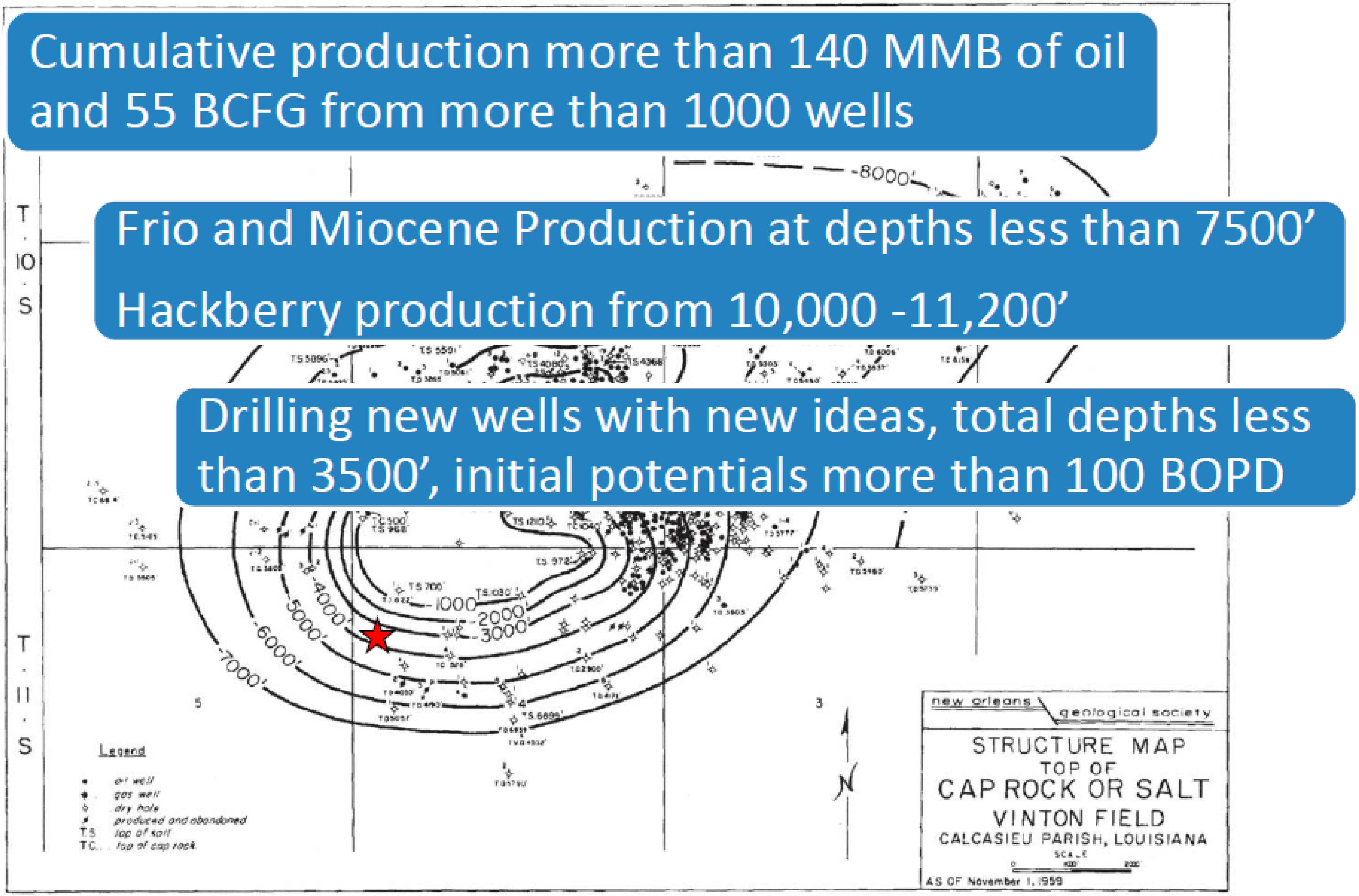

Presenter's notes: The Vinton oil field is a 4-way closure reservoir. Most wells were drilled in the east – northeast area over the structure.

History of the Vinton Field

1870s | **1901** | **1911**

Locals noticed oil seeps and recognized the oil potential

The first well was drilled and oil shows were found

Early Boom Production reached 2 MMBO per yr

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History of the Vinton Field

1917-18

1973

1998

Second Boom Production increased in 1917 with deeper wells.

Production reached 3 MMBO per yr Production dropped after then

…

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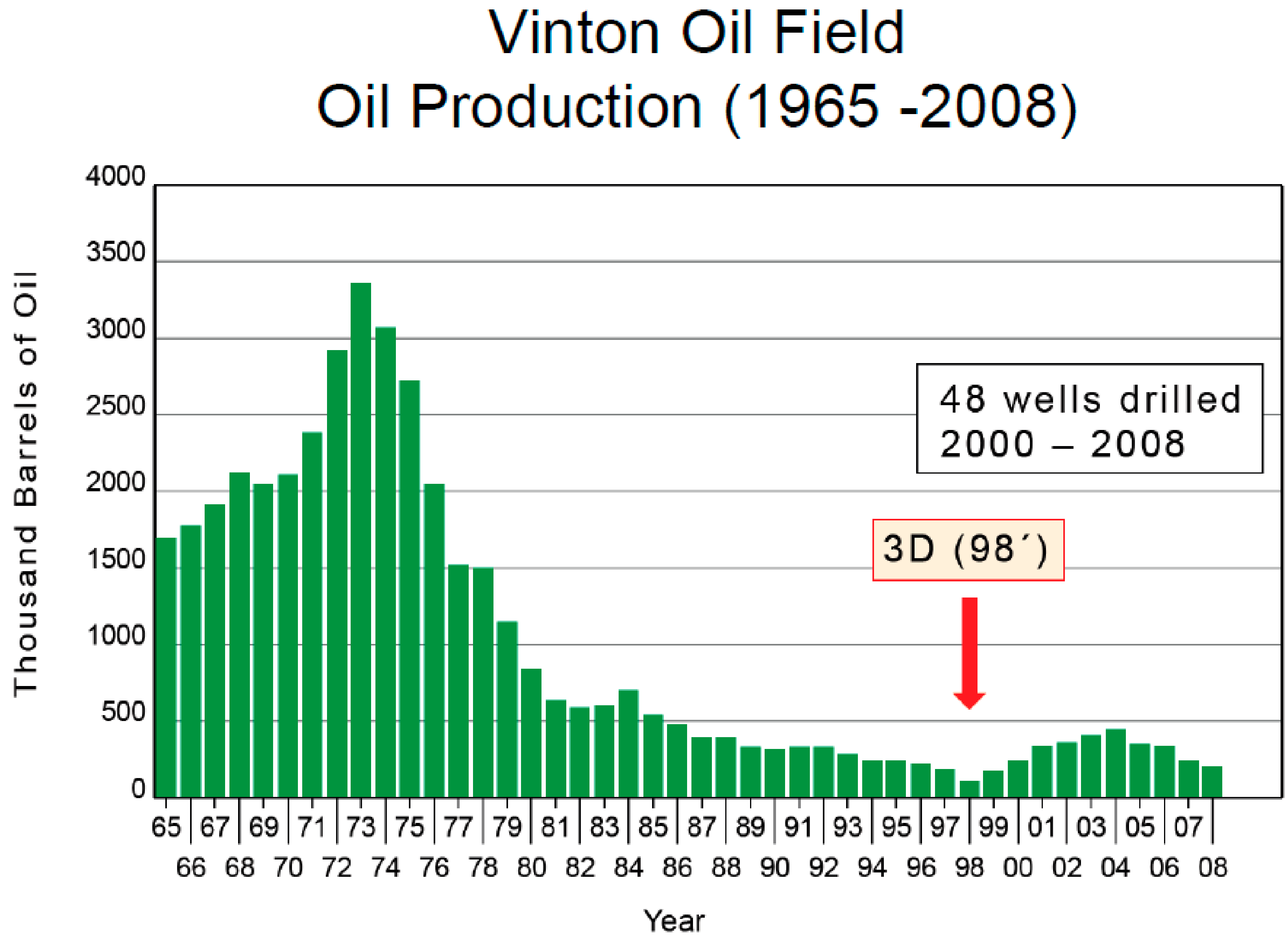
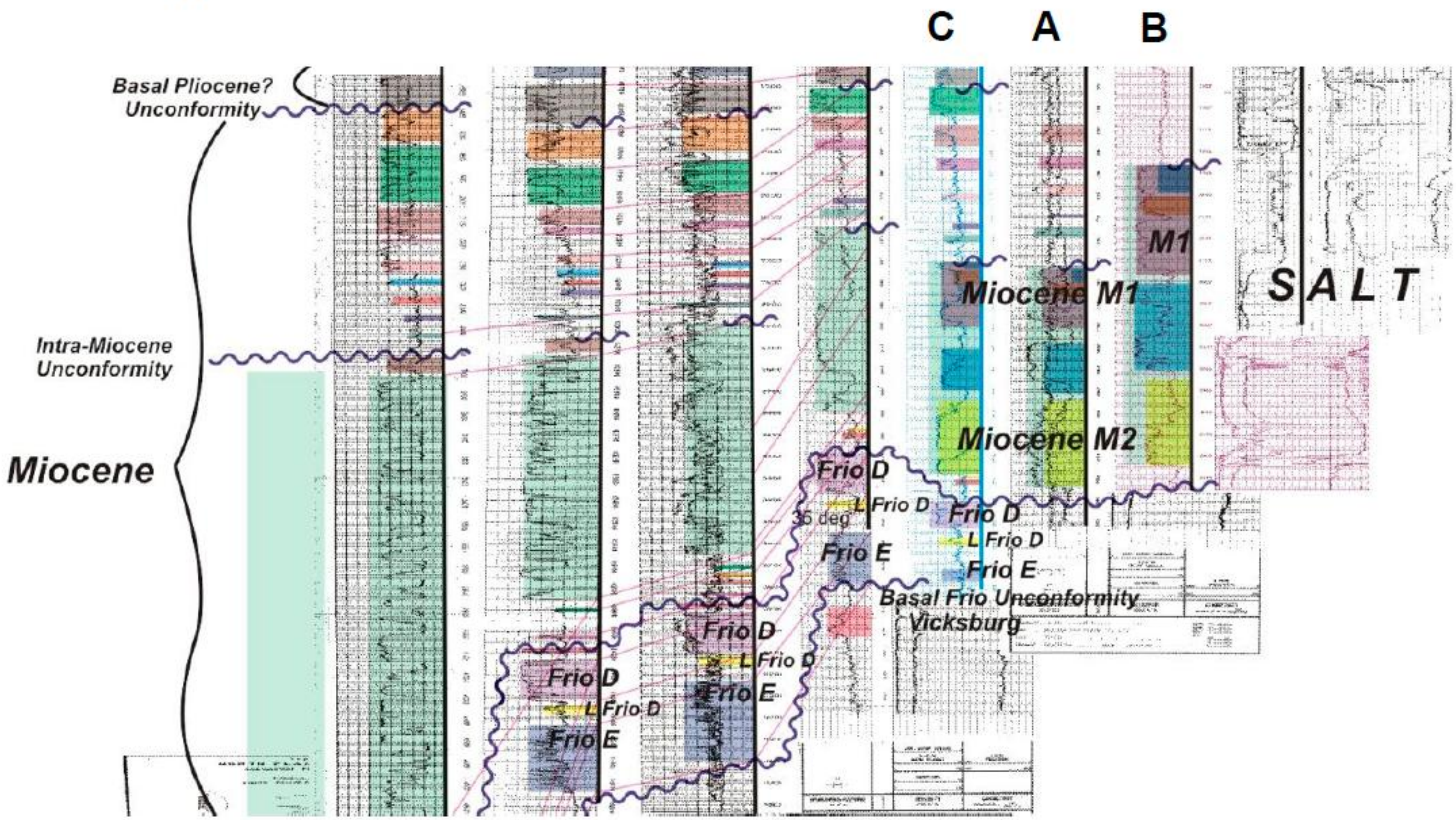
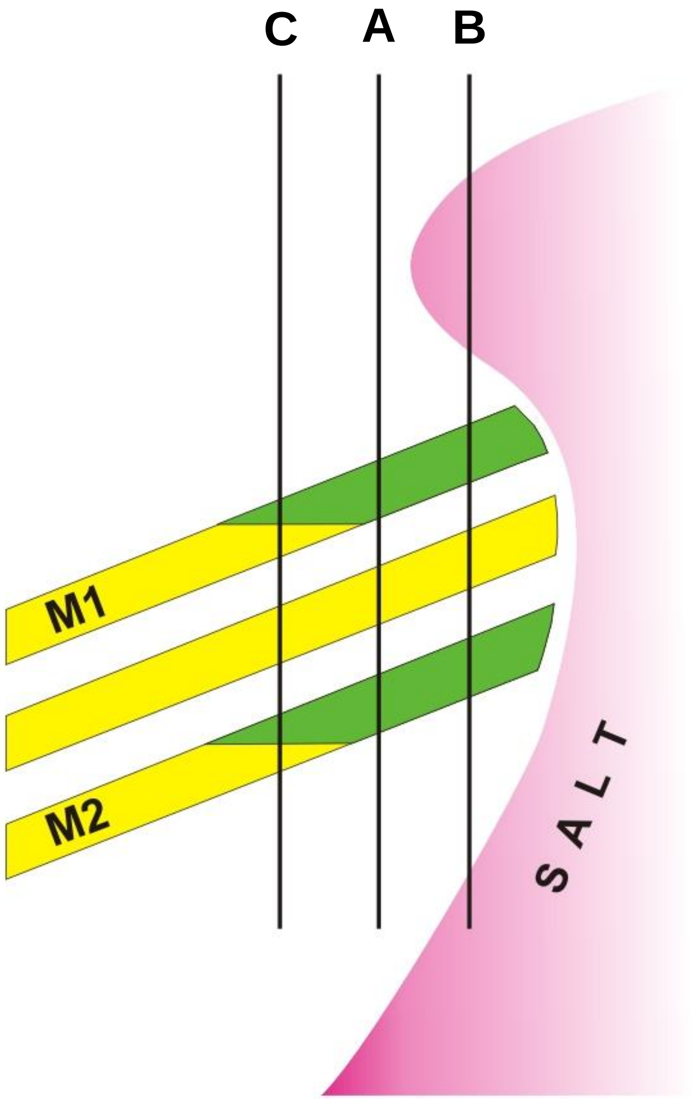


Presenter's notes: Most oil was produced before 1980. Its production was around 2MMBO per year for a long time. It dropped after 1980, to about 200 KBO in 1998, when 3D seismic was acquired. The production increased slightly after that, then decreased again. However, it is not dead. We are drilling more wells with new ideas.

Type Section – From 30 to 3 Miocene Sands



Presenter's notes: This is the traditional type cross section. It works very well for wells away from the salt, but not that well near the salt (on the right).



Old Concept - all wells penetrated the same two or three Miocene sands

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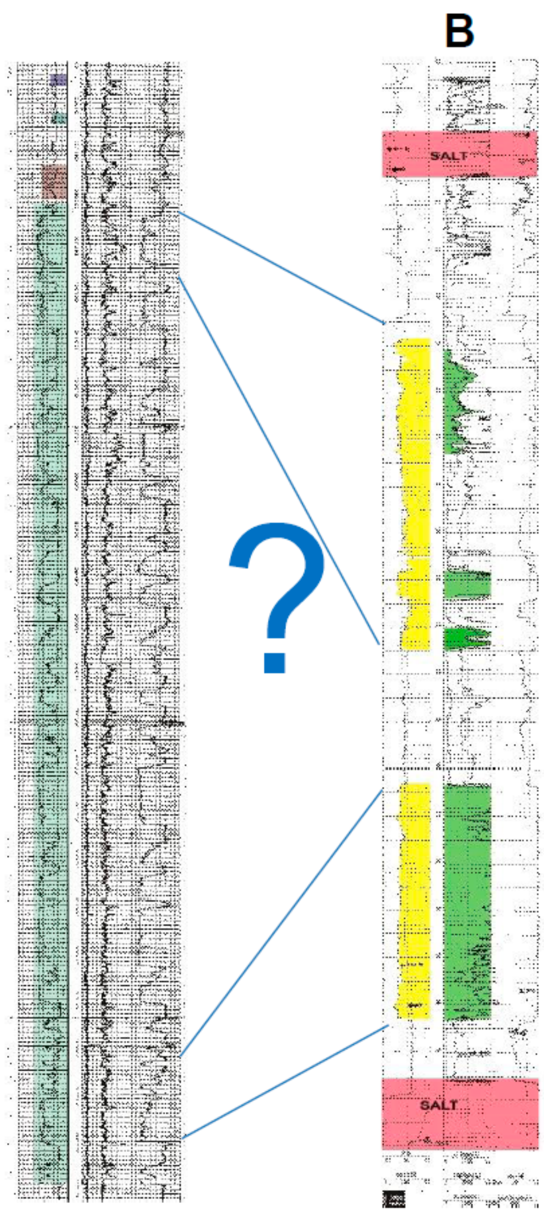
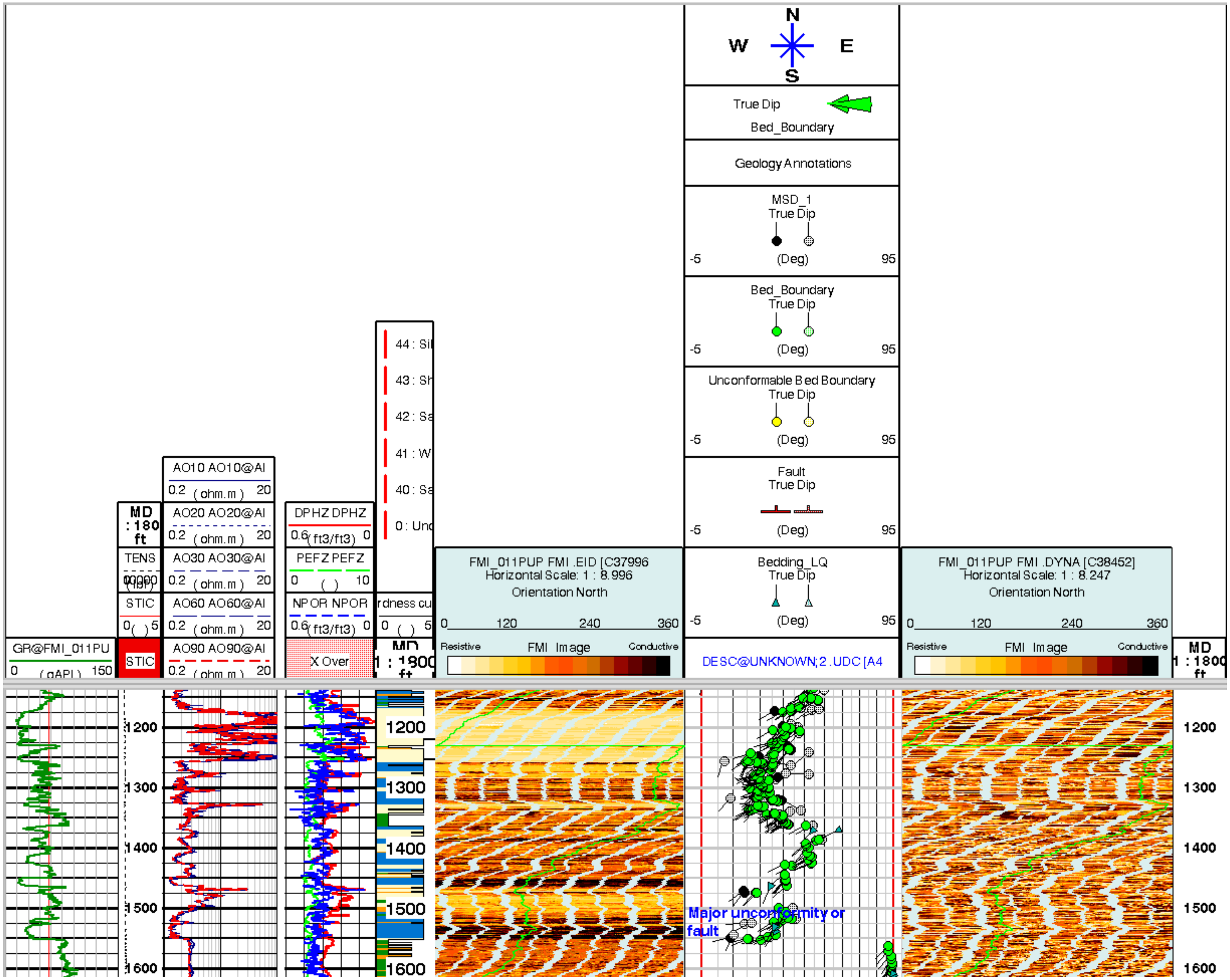
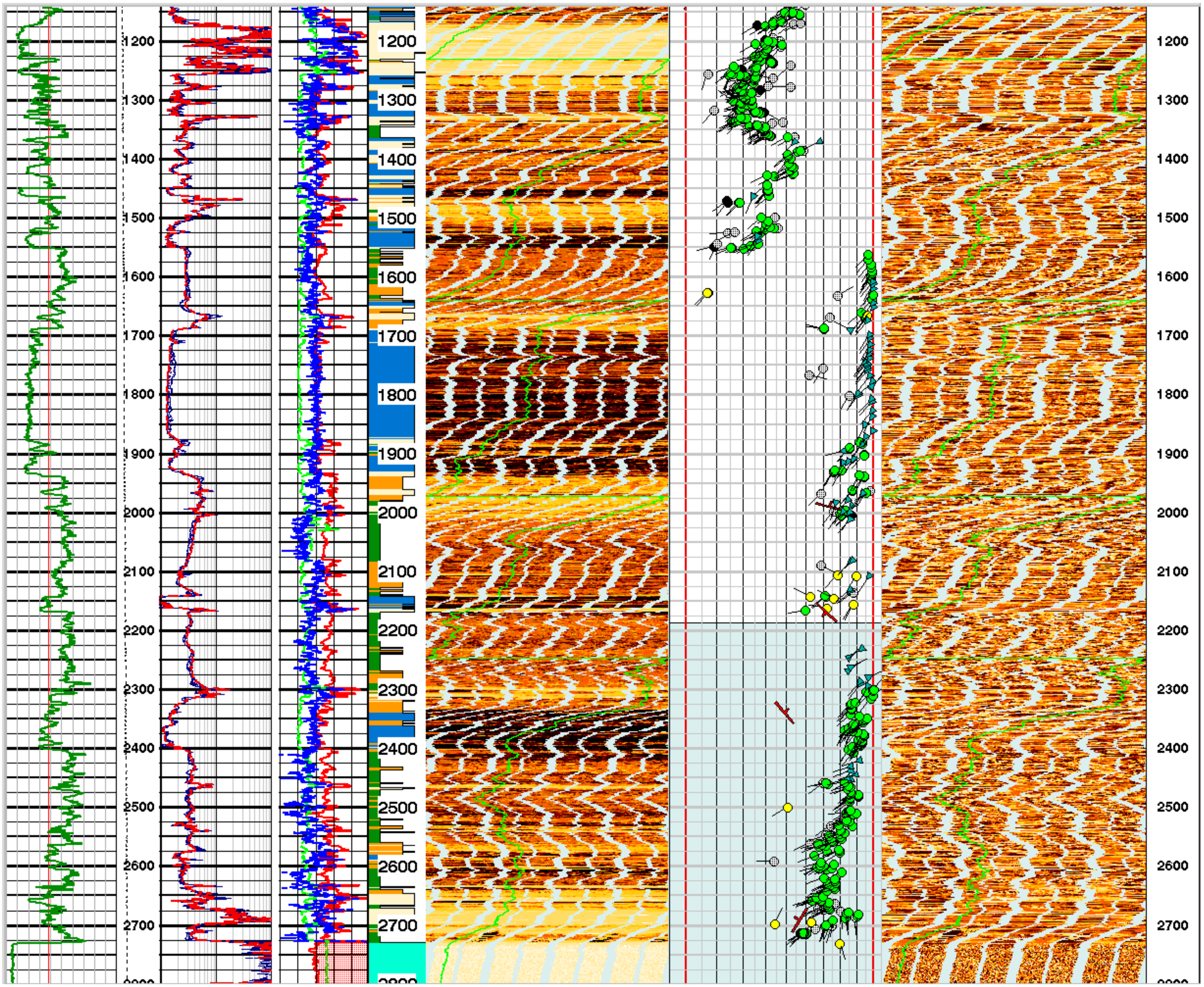


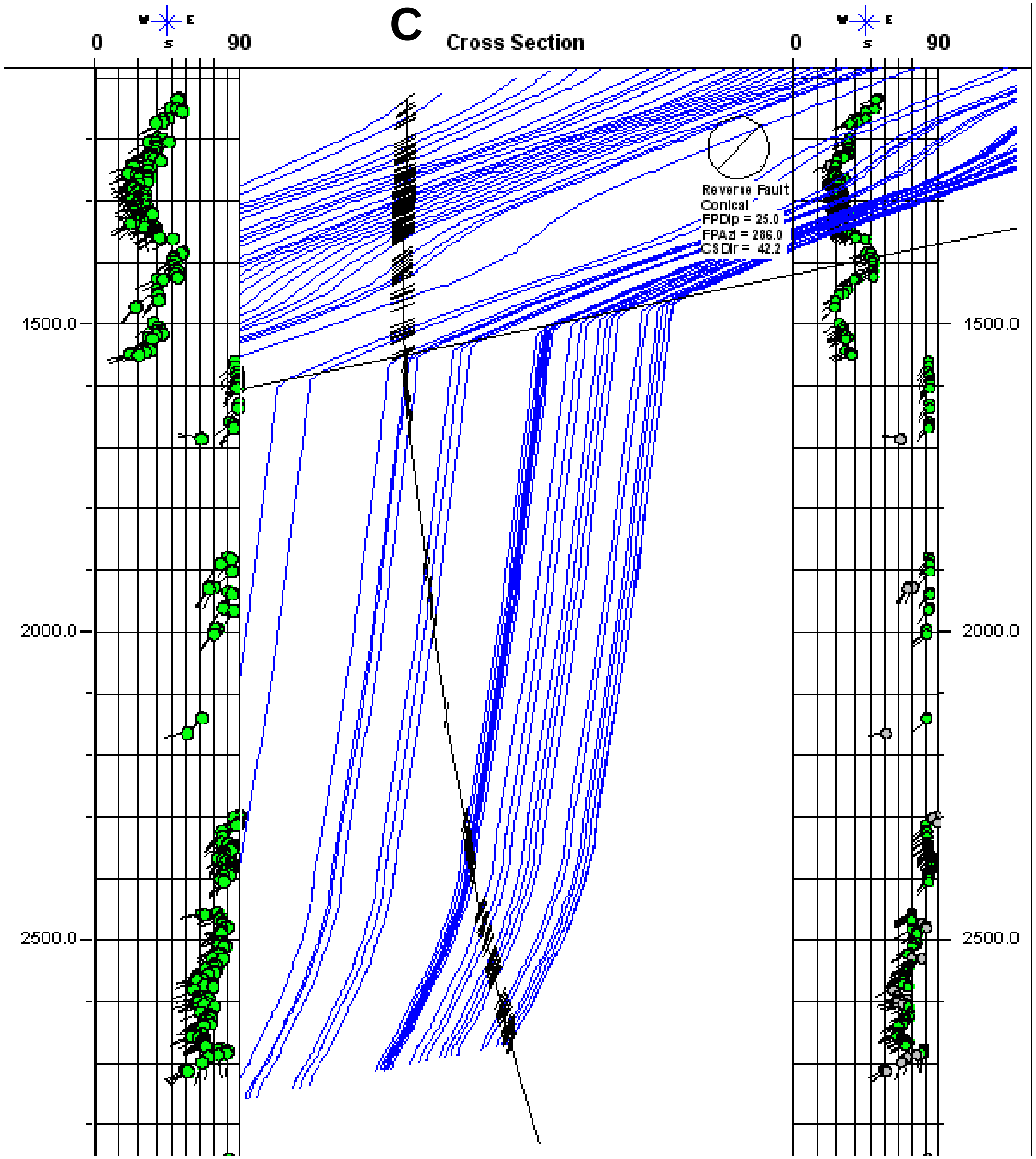
Presenter's notes: There is not clear correlation between wells away from the salt and well near the salt. Thicker sand beds in the wells near the salt dome indicates steep beds.



Presenter's notes: This is a typical FMI display. From left to right, the columns are: GR, depth, resistivity, porosity, lithology, image, dips, image again.



Presenter's notes: Overview of the FMI log from Well C. Low dips on the top, steep dips below. There is a major unconformity around 1550'.



Structure Modeled in StrucView –

confirmed new geologic model that beds were much steeper than previously imagined

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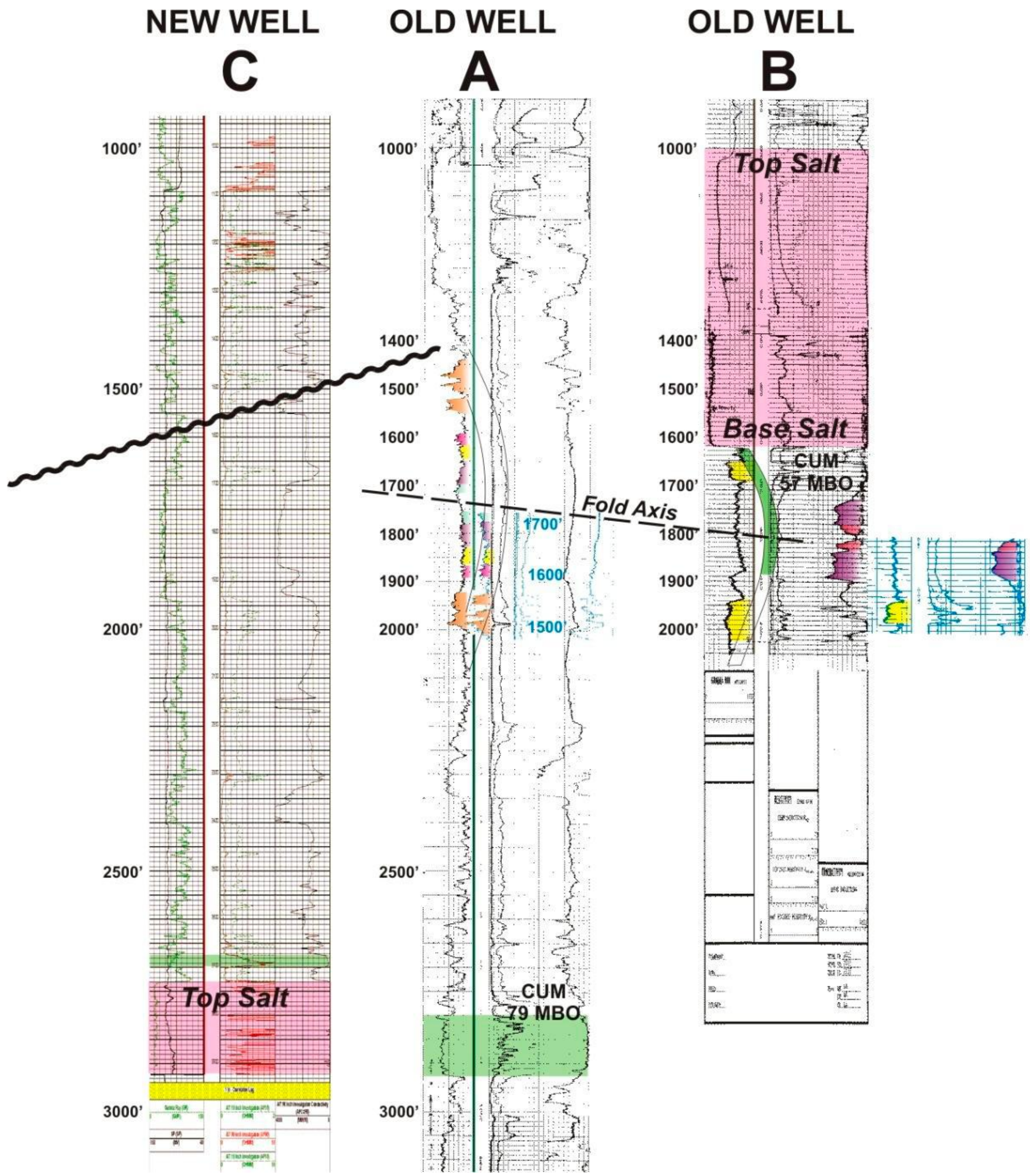
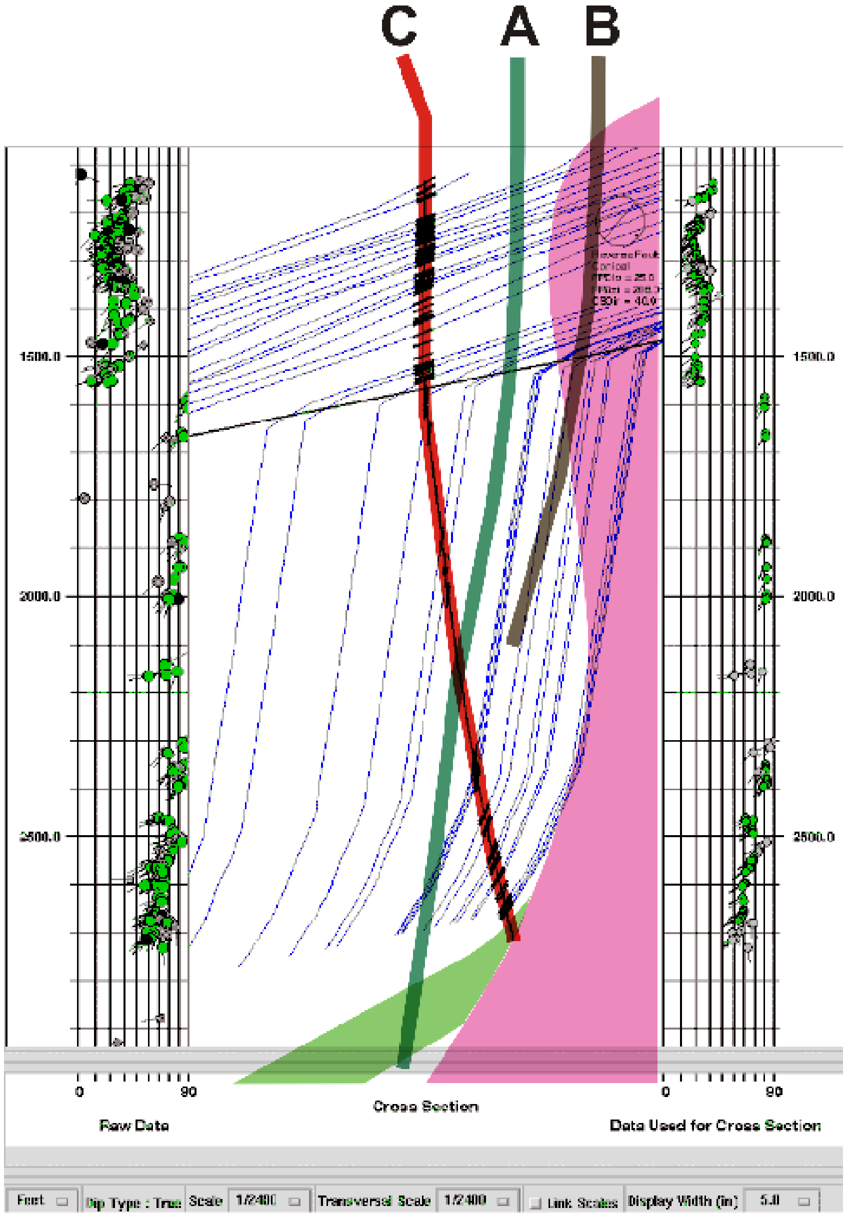


Presenter's notes: The correlations now make sense.



Structure Modeled in StrucView -

annotated by generating geologist

New well C
Old wells A,B

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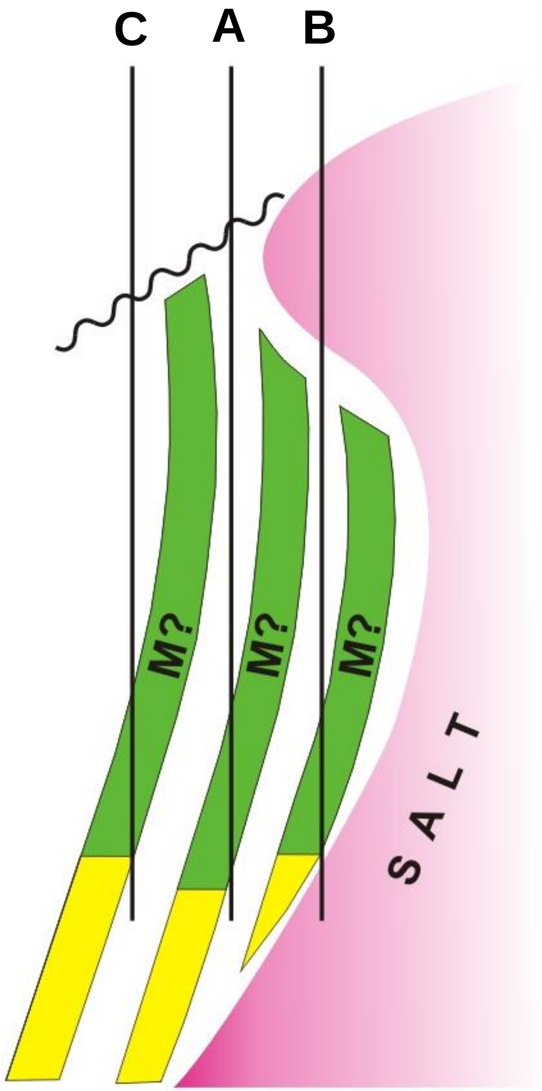

New Concept -
every well may have
penetrated different
pay sands -
any one of thirty
Miocene sands

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- ***A new idea was developed for an area of the field where thirty wells had been drilled***
- ***The area was believed by most to be fully developed***
- ***New wells were drilled with a new idea and the new geologic model was confirmed by using FMI***
- ***Twenty to thirty additional well locations may exist in this area based on the new geologic model***

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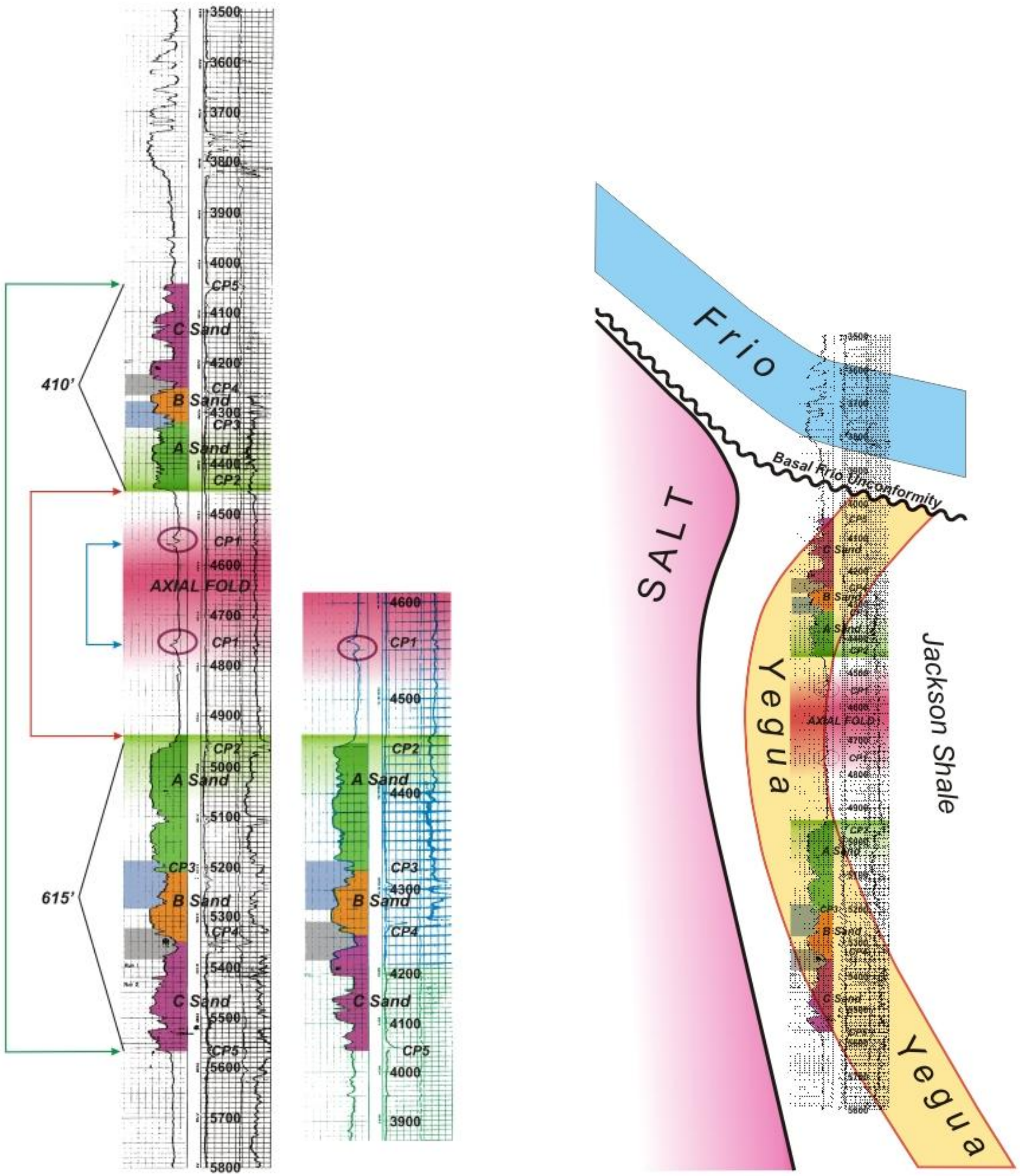

An example from Saratoga Dome Hardin Co, TX

There should be many more out there around GOM

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Summary

- There are many bypassed reservoirs surrounding salt structures remaining to be exploited.
- Structures near salt domes are complex. Many have overturned beds, unconformities and unexpected fault orientations.
- Image logs and other dipmeter type logs will help to build structural models surrounding salt domes.
- These structural models can help us to define deep sub-salt structures in offshore GOM as well as onshore shallow salt piercement domes.

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Acknowledgement

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- **Bob Davis** for providing some cool slides
- **Schlumberger** for giving this opportunity to present the result

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