# [PS]Top Seal Evaluation of Miocene Deep-Water Reservoirs, Southern Gulf of Mexico*

**Fernando Apango[1], John W. Snedden[1], Hugh Daigle[2], and Inessa Yurchenko[3]**

Search and Discovery Article #30627 (2019)**
Posted September 9, 2019

*Adapted from poster presentation given at AAPG 2019 Annual Convention & Exhibition, San Antonio, Texas, May 19-22, 2019
 DOI:10.1306/30627Apango2019

[1]Institute for Geophysics, The University of Texas at Austin, Austin, TX, United States (fer.apango@utexas.edu)
[2]Department of Petroleum & Geosystems Engineering, The University of Texas at Austin, Austin, TX, United States
[3]Bureau of Economic Geology, The University of Texas at Austin, Austin, TX, United States

## Abstract

Integration of core, 3D seismic, and well data provided by the Mexican National Hydrocarbon Commission (CNH) was used to evaluate the top seals of Miocene deep-water reservoirs within the Veracruz Trough in the Southeastern Gulf of Mexico. Deep-water well discoveries in this region have often been a mix of oil, gas, or water; raising some questions about the quality of both the source and the seal rock. Nonetheless, traces of hydrocarbons in some water-bearing reservoirs suggest that hydrocarbons were effectively generated. Therefore, the lack of economical accumulations of oil and gas in these reservoirs is probably a consequence of seal failure and/or traps that were filled to an unmapped shallow spill point. XPT pressure data from the Pemex operated Kunah-1 and Yoka-1 wells for the Upper and Lower Miocene, were used to construct 'Excess Pressure' plots to evaluate both top and internal seals. Subtle but significant pressure contrasts over small depth intervals suggested the presence of thin but effective seal rocks. To assess the seal strength for each case, mercury injection capillary pressure (MICP) laboratory measurements were performed on cuttings for those particular depths. In general, results from these measurements were concordant with our interpretations from pressure data, although in some cases the estimated entry capillary pressure for some samples was lower than expected. However, top seal capillary leakage does not necessarily equate to trap failure, as there could be a matched flowage into the base of the hydrocarbon column and leakage from the top of the column, with a commercial volume of hydrocarbons retained. In these cases, and in the presence of strong seals, spill points are the controlling factor of fluid contacts. Using 3D seismic mapping to define structural closures in both Kunah-1 and Yoka-1 wells we have identified the structural spill points for various Miocene reservoirs. There are relatively few faults in the large folded anticlines tested by the Kunah-1 and Yoka-1 wells. Seal rocks' effectiveness was ultimately assessed and defined utilizing various conventional seal classifications (Sneider, Dawson and Almon, Sales, etc.), which are primarily based on the results of MICP measurements and/or the control of the spill points. We conclude that Miocene seal rocks are effective for the observed columns of oil and gas in the southern Mexico deep-water areas but some capillary leakage is probably occurring.

# Top Seal Evaluation of Miocene Deep-Water Reservoirs, Southern Gulf of Mexico


Fernando Apango[1*], John W. Snedden[1], Hugh Daigle[2], Inessa Yurchenko[3]

[1]Institute for Geophysics, The University of Texas at Austin, Austin, TX
[2] Department of Petroleum & Geosystems Engineering, The University of Texas at Austin, Austin, TX
[3] Bureau of Economic Geology, The University of Texas at Austin, Austin, TX
*fer.apango@utexas.edu


## Overview

**Objective: Determine the cause for under-filled structures in eastern Mexico offshore Miocene reservoirs using Kunah-1 and Yoka-1 as case studies**

| Well | Reservoir | Closure (m) | HC column height (m) |
|---|---|---|---|
| Kunah | UM | 686 | 45 |
| | MM | 837 | 18 |
| | LM | 960 | 313 (compartmentalized) |
| Yoka | UM | 730 | - |
| | MM | 672 | - |
| | LM | 610 | 10 (low saturation) |

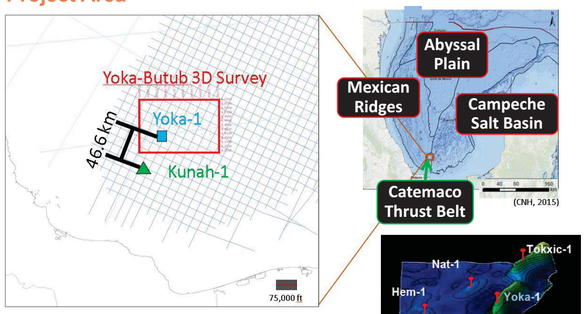
*5 wet-gas reservoirs*

*3P reserves: 1.8 bcf of gas (www.pep.pemex.com)*

Water-bearing reservoirs

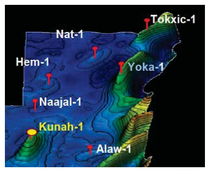
Non-commercial wet-gas reservoir

### Project Area










### Possible Causes for Kunah-1 and Yoka-1 Under-Filled Structures

**A. Top Seal Leakage**

Occurs when the hydrostatic pressure of the hydrocarbons accumulated within a reservoir overcome the capillary entry pressure of the overlaying cap rock

**B. Unmapped Shallow Spill Point**

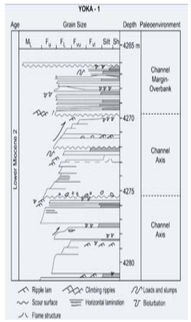
This would imply that the closure for any given reservoir is smaller than what it was originally interpreted. Spill points limit the height up to which a HC column can build up to before migrating into the next structure

**C. Late Trap Formation**

Relative to hydrocarbon charge. The assessment was based on the tectonic history of the studied area, complemented with an analysis of stratal terminations and geometries

## A. Top Seal Leakage Analysis

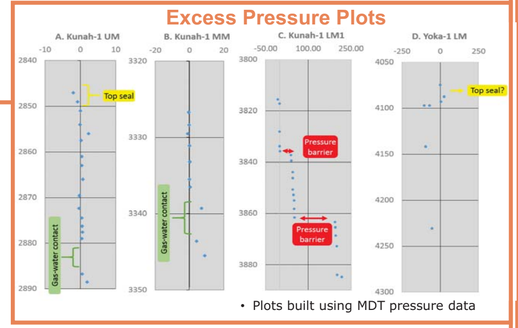
### Core Description




From the core description of reservoir and seal rocks performed at Mexico's National Hydrocarbon Commission (CNH) core laboratory we interpreted that:

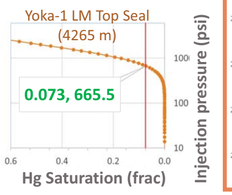
- Inter-bedding between fine-grained sandstones and thin mudstone packages was consistent for both Kunah-1 and Yoka-1 Miocene intervals
- For all Miocene reservoirs the interpreted paleo environment were deep-water channels
- Top seals and intra-reservoir seals are predominantly silty shales

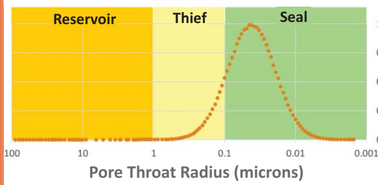
### Excess Pressure Plots




- Plots built using MDT pressure data

### MICP Analysis



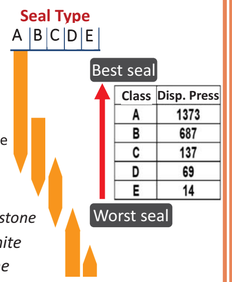




- MICP measurements were performed on cuttings sampled from CNH's core lab. Samples were available every 5 m. Pemex MICP data was also used
- Effective seals typically have pore throat radiuses below 0.1 microns

### Sneider's Classification of Seals

- Used to ultimately assess the sealing capacity of the different cap rocks. Relies on the displacement pressure estimated from MICP measurements
- Sneider determined that displacement pressure or leakage of hydrocarbons through the seal rock is likely to occur at a 7.5% non-wetting phase saturation

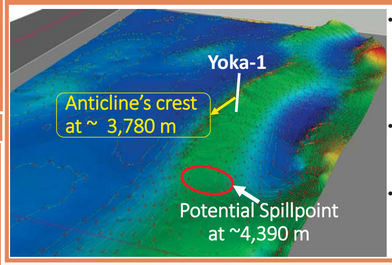
| Well | Reservoir | | Sneider's Top Seal Classification |
|---|---|---|---|
| Kunah | LM1 | UM | A |
| | | MM | A |
| | | Top Seal | C |
| | | Intra-reservoir | D |
| | | Intra-reservoir | D |
| | | LM2 | C |
| | | LM3 | B |
| Yoka | | UM | A |
| | | MM | - |
| | | LM | B/C |



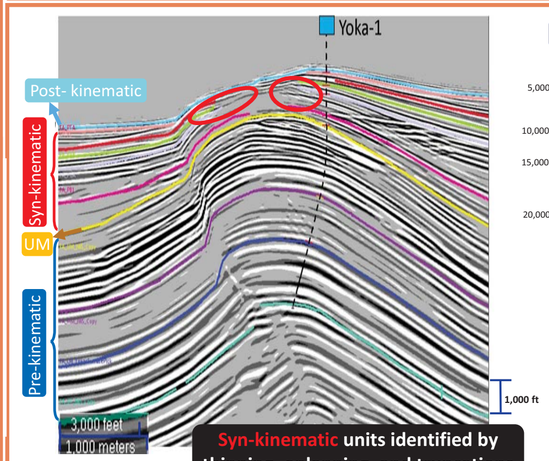

| Class | Disp. Press |
|---|---|
| A | 1373 |
| B | 687 |
| C | 137 |
| D | 69 |
| E | 14 |

- **Data suggests moderate to good quality seals.**
- **Under-filled traps are not likely due to top seal leakage**

## B. Unmapped Shallow Spill Point Analysis




- Spill points for the Yoka-1 structure were interpreted on structural contour maps generated using the Yoka-Butub 3D seismic volume
- For Kunah-1, we had to rely on Alcocer's (2012) interpretation
- At least for Yoka-1, no shallow spill points were found



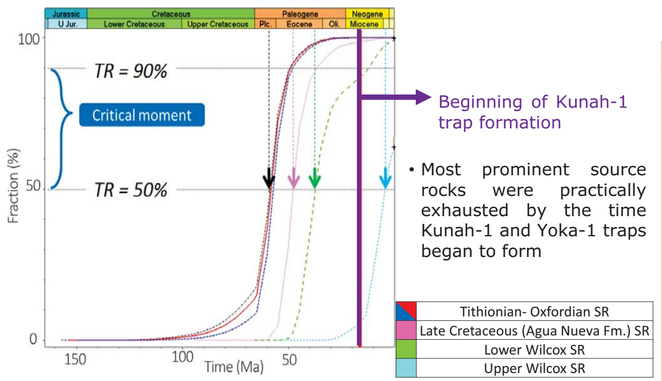

**Syn-kinematic units identified by thinning, onlapping, and truncations**

From our local analysis:

**Kunah-1**: The trap began to form during the Upper Miocene

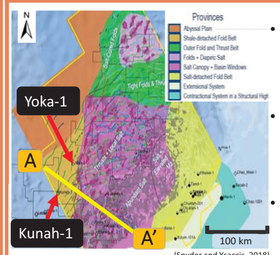
**Yoka-1:** A phase of intense deformation started during the Early Pliocene. Trap volume has been increasing ever since.

### Source Rocks' Transformation Ratio Over Time

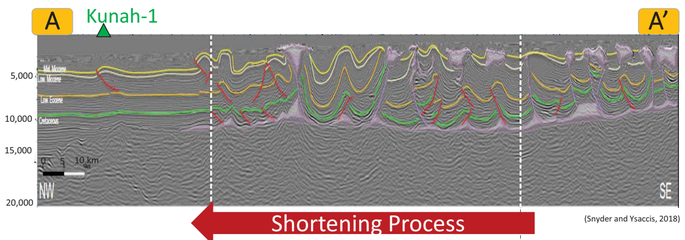



- Most prominent source rocks were practically exhausted by the time Kunah-1 and Yoka-1 traps began to form

## C. Late Trap Formation / HC Charge Analysis




- Structurally complex setting around this area due to salt tectonics and the shortening process this region has undergone
- Snyder and Ysaccis (2018) proposed that there has been an age progression in the shortening process from SE to NW
- From their regional analysis, they also proposed that units from Upper Jurassic to Lower Miocene are pre-kinematic



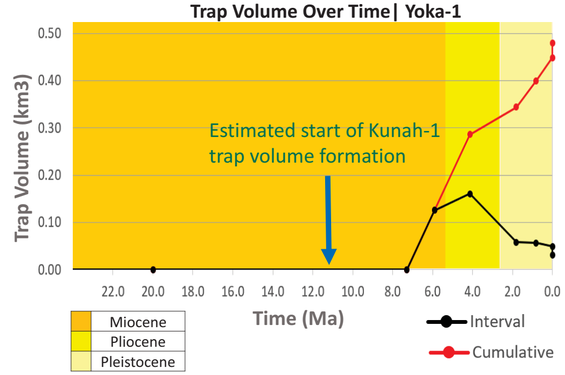

**Shortening Process**

**YOUNGEST**
*Shortening was late Miocene to Recent*

**YOUNGER**
*Main shortening was middle Miocene to Recent*

**OLDER**
Paleogene to middle Miocene shortening

### Trap Volume Over Time| Yoka-1




## Conclusions

- Rocks capping most reservoirs have a considerable sealing capacity
- Spill points are relatively deep in all cases
- Fluid contacts appear to be controlled by late trap formation relative to hydrocarbon charge
- Timing of the different petroleum system elements is the greatest risk for the assessment of new prospects around the study area