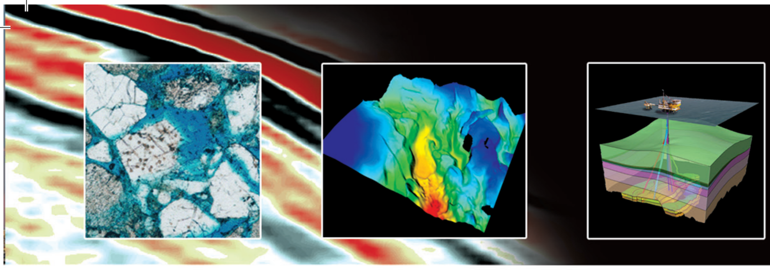

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14-16 May 2019

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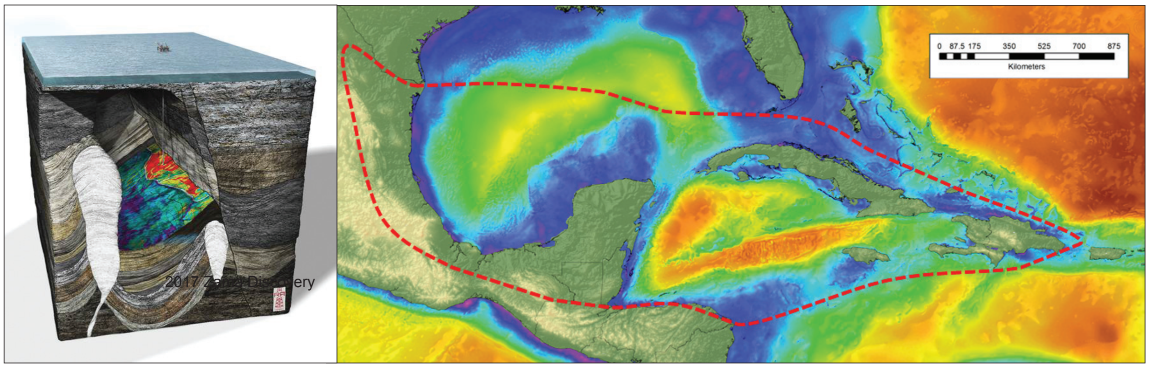

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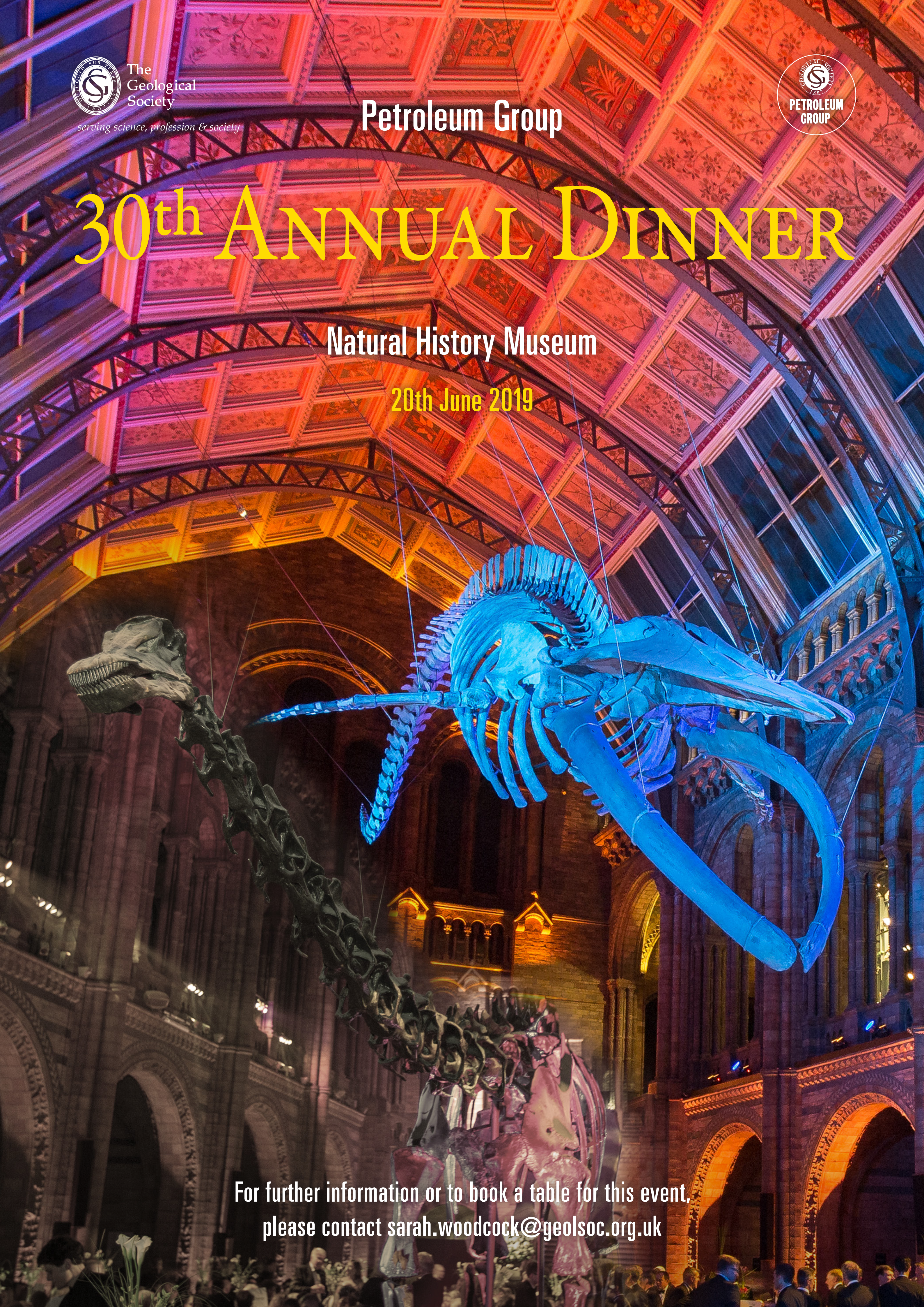
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PROGRAMME

CONFERENCE PROGRAMME

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09.00	**Keynote: The Great Gulf of Mexico: What we know, and what we don't** **James Pindell, *Tectonic Analysis Ltd***
09.30	**Common Geological Controls to the Top 20 oilfields of Mexico "the Story of Two's"** Karina Vázquez Reyes & Mark Shann, *Sierra Oil & Gas*
09.55	**Laramide compression in Mexico: the missing factor behind significant reservoir productivities?** Andrew Horbury, *Cambridge Carbonates Ltd*
10.20	**The Evolution of the Cenozoic Deep Marine Depositional Systems, Offshore Southern Mexico** Carlos Uroza, *Equinor*
10.45	**Break**
	Session Two: Mexico Regional Tectonics **Chair:** Mark Shann, *Sierra Oil and Gas*
11.15	**The Early stages of opening the Gulf of Mexico- Shaping the margins** G. Messager, *Equinor*
11.40	**Kinematic constraints on the opening of the Gulf of Mexico – Inferred driving mechanisms** E. Blanc, *Equinor*
12.05	**Tectonic and sedimentation history, petroleum systems and plays of Eastern Mexican basins: an overview** Sergey Drachev, *3GeoAmericas LLP*
12.30	**Lunch**
	Session Three: Reservoir Distribution **Chair**: Adrian Neal, *Badley Ashton*
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14.00	**Reservoir distribution in deep-water Salina del Istmo Basin, offshore Mexico** Malcolm Francis, *Western Geco*

14.25	**Provenance and Morphology of the Oligo-Miocene Veracruz Deep-water Fan System in the Western Gulf of Mexico** Daniel F. Stockli, *The University of Texas at Austin*
14.50	**Paleogeographic and Depositional Reconstruction of Oxfordian Aeolian Sandstone Reservoirs in Mexico offshore areas: comparison to the Norphlet Aeolian play of the Northern Gulf of Mexico** John Snedden, *The University of Texas*
15.15	**Break**
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15.45	**Untapped Petroleum Systems Revealed in the Mexico GOM Superbasin** Neil Hodgson, *Spectrum Geo*
16.10	**Source Rock Predictions, Reducing Conditions, Anoxia and Pyrites of the Caribbean** Mark Cowgill, *CGG*
16.35	**The Oil and Source rocks of the Patuca and Mosquita Basins, Honduras** Chris Matchette-Downes, *CaribX (UK) Limited*
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17.00-18.30	**Wine Reception**
18.30	**Conference Dinner, The Cavendish Hotel**

Day Two

08.30	**Registration**
08.55	**Welcome**
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09.00	**Keynote: The Zama Discovery: Subsurface Uncertainty in Exploration and Appraisal** **Iain MacEwen, *Premier Oil***
09.30	**Structural Evolution of the Salinas Sureste Basin: Regional Tectonics, Structural inheritance, and implications for Petroleum Exploration** Alissa A. Henza & Enrique Novoa-Cancela, *Equinor*
09.55	**The Importance of the Deep Charge Focus in Sureste Basin, Mexico. Case of study: Zama Light Oil Discovery** Karina Vázquez Reyes & Mark Shann, *Sierra Oil & Gas*
10.20	**Poster Overview**
10.45	**Break**
	Session Five: Mexico – Sureste Basin (Continued) **Chair:** Aruna Mannie, *Premier Oil*
11.15	**Integrated Seal Analysis in the Sureste Basin, Mexico** Brian O'Sullivan, *Premier Oil*

11.40	**Salt-Carbonate interactions in the Sureste Basin, SE Mexico; depositional models and analogous for Cretaceous carbonate breccias** Peter Gutteridge, *Cambridge Carbonates*
12.05	**The Sureste Basin of Southern Mexico: "Future Opportunities and Key Challenges Ahead"** Mark Shann, *Subsurface Director Sierra Oil and Gas*
12.30	**Lunch** earthmoves
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14.00	**Structural evolution of a salt diapir and associated normal faults in the Sureste Basin, Mexico** Marc Giba, *DEA Deutsche Erdoel AG*
14.25	**Miocene Compressional Tectonics in the Campeche Salt Basin SE Mexico** Ian Davison, *Earthmoves Ltd*
14.50	**Mexico offshore: New Insights into Structural Evolution and Salt Deformation through structural Restoration, Campeche Basin** Malcolm Francis, *Western Geco*
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	Session Seven: Compressional Tectonic Regimes **Chair:** Mike Hohbein, *Ophir Energy*
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16.10	**Tectonic, structural, and stratigraphic controls on hydrocarbon prospectivity in the Mexican Ridges deep-water fold-belt, western Gulf of Mexico** Jack Kenning, *University of Houston*
16.35	**Geological Interpretation and Petroleum Implication of the North of Yucatan Platform, Deep Gulf of Mexico** E. Miranda Madrigal, *Basin Research Group, Imperial College London*
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17.00	**Wine Reception** earthmoves

Day Three

08.30	**Registration**
08.55	**Welcome** **Conference Committee Chair:** Jonathan Hull
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09.00	**Keynote: The Source rock provinces of the Caribbean by recourse to biomarker and stable isotope data assemblages from produced oils, shows and seeps** **Chris Matchette-Downes, CaribX (UK) Limited**
09.30	**Determining basement terrane boundaries in the modern Caribbean plate and their impact on regional hydrocarbon systems** Sean Romito, *University of Houston*
09.55	**Regional to basin scale influence of strike slip tectonism on the evolution of the western Caribbean Margin: implications for petroleum play systems in Patuca and Mosquitia** Andrew Long, *Subterrane Ltd*
10.20	**Prospective Cuba offshore identified from new 2D seismic data** Shi Kuitai, *BGP Multiclient*
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	Session Nine: Northern Caribbean Basins **Chair:** Matthew Bowyer, *Cairn Energy*
11.15	**Tectonostratigraphic history, age calibration, and structural interpretation of a mega 3D seismic survey in the deep-water portion of Trinidad and Tobago** Rick Jowett, *BHP*
11.40	**New constrains on the tectono-sedimentary evolution of the San Pedro Basin (south-eastern Dominican Republic offshore margin): Implications for its hydrocarbon potential** J.M. Gorosabel-Araus, *University of Madrid*
12.05	**Eocene platform and basin development on the upper Nicaragua Rise** Simon F. Mitchell, *The University of the West Indies*
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13.30	**Keynote: The Mexican fold and thrust belt: structure, timing and tectonics** **Elisa Fitz-Díaz, Instituto de Geología, Universidad Nacional Autónoma de México**
14.00	**Structural sections through Oaxaca-Cuicateco-Veracruz Basin and the Chiapas Foldbelt** Rod Graham, *Consultant*
14.25	**Paleo-Canyons and Contemporaneous Oil Seeps near the Palaeocene/Eocene Boundary, Tampico-Misantla Basin, Eastern Mexico** Stephen P/J/ Cossey, *Cossey and Associated Inc*
14.50	**Break**
	Session Eleven: Burgos and Perdido Basin **Chair:** Jonathan Hull, Indpendent
15.20	**Improved stratigraphic resolution of the Frio to Wilcox Groups in the Mexico Perdido Trend** Guy Harrington, *Petrostrat*
15.45	**The Cenozoic Burgos Basin- Insights into Provenance and Sediment Routing Evolution, Drainage Basin Reconstruction, and Tectonic Controls** Daniel F. Stockli, *The University of Texas at Austin*
16.10	**Finish**

Poster Programme
Integration of multi-source surface data to enhance reservoir knowledge in Mesozoic fractured carbonates analogues of Mexico Antonio G.L. Palombo, *CGG*
The Regional Tectonic Evolution of the Gulf of Mexico – Constraints from Multi-Satellite Gravity Data Peter Webb, *Getech Group plc*
Answering key questions on the petroleum geology of the southern Gulf of Mexico using a fully integrated well database Edward Jarvis, *CGG*
Zama Discovery: From Depocenters to Paleo-Currents: Combination of Seismic and Borehole Image Datasets Phil Gabbard, *Talos Energy Inc*
The integration of reprocessed Full Tensor Gradiometry, gravity and seismic data to understand salt distribution and basement structure in the Veracruz and Sureste basins, Mexico. Sean Goodman, *Bridgeporth Ltd*
Geology and Hydrocarbon Potential of Mexico: some results from regional mapping Ian Davison, *Earthmoves Limited*
Regional Play Types of NW and Central Cuba Ian Davison, *Earthmoves Limited*

Oral Presentation Abstracts (Presentation order)

Session One:
Mexico Regional Overview

KEYNOTE: The Greater Gulf of Mexico: What we know, and what we don't

James Pindell[1,2], Brian W. Horn[2]
[1]*Tectonic Analysis Ltd.*
[2]*ION E&P Advisors, Houston, TX*

This talk addresses the paleotectonic and paleogeographic evolution of the Greater Gulf of Mexico, covering the Gulf itself along with the Jurassic and Laramide events in Mexico and the progressive collision of the Antilles Arc with southern and eastern Yucatan and then the Bahamas Platform. An integrated evolutionary model for Gulf opening, supported by aeromagnetic and regional seismic reflection data sets, is set within the framework provided by Atlantic opening kinematics and the history of Caribbean-North American relative plate motion. For the Gulf of Mexico, we will review the extent of oceanic crust, image the sub-salt section, discuss pros and cons of various rift models, assess early subsidence history and some aspects of ongoing debate, timing of salt deposition in relation to basement tectonics, and some pertinent aspects of Cretaceous and Tertiary depositional history. For the Caribbean story along the southern and southeastern Gulf of Mexico, we document first arrival of flysch deposition into the Gulf margins, the timing of arc–continent collisions, and the opening of the Yucatan Basin which played an important role in the collision of the Cuban Arc with the Bahamas. We summarise what we can be confident about, what we shouldn't be confident about (but sometimes are), what is widely believed but is demonstrably wrong, and what remains unexplained. This talk is an appraisal of where we stand today and where we could continue to investigate.

NOTES:

Common Geological controls to the Top 20 oilfields of Mexico "the story of Two's"

Karina Vázquez Reyes & **Mark Shann,**
Sierra Oil & Gas

Many times, there are clues in the past that can provide a good perspective to the future and so an analysis of the Top 20 oilfields in Southern Mexico is revealing in that they share some important geological components that are relatively unique to Mexico. In the simplest way they can be described under the heading of "The Story of Two's".

The Top 20 oilfields share two important source rocks: the Tithonian Pimienta/Edzna Formation shales, which, where present, volumetrically dominate the oils seen and the less well-known extent of the Oxfordian "Smackover type" shales for which evidence is seen in some of the oil-typing.

Two key reservoirs dominate 19 of the Top 20 oilfields: Late Jurassic oolite banks that form over basement highs and early salt swells and the enigmatic "breccias" of the Cretaceous which are somewhat particular to Mexico and of a complex multi-faceted but largely tectonically-influenced origin.

The reservoir exception is the 16th largest oilfield in Mexico to date, the 2017 Zama discovery in Late Miocene sandstones.

Two seals dominate: the Tithonian source rock itself often forms a seal capable of holding back significant oil columns and the Paleocene shales of Sureste are world-class, holding back 2200m of original oil column at Cantarell, the largest oil column in the world.

Lastly two trap-forming events dominate the burial and structuration for the Top 20 oilfields: the Laramide Orogeny that started in the Late Cretaceous and the Middle Miocene Chiapaneco Event.

The geological aspects of these play components are discussed in this presentation and what is interesting is that these elements are somewhat different to the US Gulf of Mexico play systems and so this may provide an additional perspective to future exploration in Mexico and across the Northern Caribbean.

NOTES:

Laramide compression in Mexico: the missing factor behind significant reservoir productivities?

Andrew Horbury[1] and Hector Ruíz[2]
[1]*Cambridge Carbonates Ltd.*
[2]*Pemex*

Mexican Mesozoic carbonate stratigraphies in themselves are not atypical of other Tethyan systems that are highly productive in the Middle East and the Mediterranean region. Similar general features such as Jurassic reservoirs often dominated by oolitic shoals and Cretaceous reservoirs dominated by rudist sand-derived shoals are common components of reservoir systems in all these areas. However, two fabrics dominate productivity in Mexico compared to elsewhere, these being firstly, an abundance of breccia fabrics and secondly, the importance of megakarstic systems, are characteristic of productive intervals in Mexico, particularly within the later Cretaceous. Detailed examination of stratigraphies in both the Tampico-Misantla and Sureste basins shows abundant evidence of intra-Cretaceous compression and uplift that is largely responsible for the generation of both of these fabrics. In the case of the Tampico-Misantla basin, compression is characterized by thick-skinned, long wavelength uplift of broad features, resulting in regional-scale angular unconformities that often indicates many hundreds of metres of stratigraphy being lost or subject to karstic processes within the Cretaceous itself. Redeposition is pronounced as wedges of breccia deposits. In the Sureste Basin, compression resulted in smaller areas of more localised uplift (shorter wavelength) than in the Tampico Misantla basin, in this case with deformation being thin-skinned, propagated through the Jurassic age Isthmian Salt. Associated with these uplifts in both areas are the development of forced regressive platforms and in-situ nucleation of shallow water carbonates directly above deeper water facies. Continued elevation may result in the karstification and sometimes complete brecciation and loss of the recently-nucleated carbonate platforms.

In a temporal sense there are three main periods of significant activity that are common to the whole area. The first major event is a mid-Cenomanian uplift that resulted in the demise of most of the extensive Albian-Cenomanian platform systems. A second event is more difficult to date but ties to the Coniacian and Santonian, whilst the final deformation is a later Campanian-Maastrichtian movement. Their recognition has been hampered by various factors including the development of many paradigms in the 1960s onwards, and also because of the often strong overprint of later deformation processes such as the Miocene Chiapaneco event in the Sureste Basin.

These processes are related to propagation of deformation verging towards the NE away from the active Pacific plate margin in Mexico, which in other parts of north America are generally termed Laramide Events. They are critical to understanding the distribution of high permeability reservoir rocks across the main petroleum basins and account at least in part for all of the major 'world class' productivities such as obtained from the breccia reservoirs in the Sureste Basin and the Golden Lane.

NOTES:

The Evolution of the Cenozoic Deep Marine Depositional Systems, Offshore Southern Mexico

Carlos A Uroza, Jonathan Marshall, Paul Whipp and Olusola Bakare
Equinor Exploration North America

The Cenozoic depositional systems, offshore southern Gulf of Mexico, were controlled by active tectonism during the Laramide and Chiapas orogenic events. Ongoing regional tectonics controlled all the aspects of the source-to-sink system, including the scale of the drainage catchments, nature of the source terrain and routing of major deep-water depositional systems into a bathymetrically complex, salt-influenced basin. Here we present an integrated depositional summary of the Cenozoic deep-water clastic systems offshore southern Mexico using observations from detailed seismic-stratigraphic mapping and attribute analysis, well data and published regional studies.

From our study, we identify four key tectono-stratigraphic stages during the Cenozoic: 1- Middle-to-Late Eocene: During this time there is an overall west-to-east thinning of the stratigraphic section into the Campeche salt basin. In the western region (outboard of the salt basin) we observe north-to-northeast trending seismic-scale channel geometries that run parallel to the edge of the present-day salt basin. To the north, down depositional dip, the transition from lower slope to basin floor is expressed by semi-continuous seismic amplitudes and geometries that are interpreted to represent channel-lobe complexes formed in an unconfined basin floor setting. In this area volcanic material WSW-ENE oriented is observed on seismic attributes. Seismic image quality is challenged within the salt basin; however, observed seismic attributes and seismic geomorphologies suggest these depositional systems were routed into the salt province, crossing at transfer zones along the segmented basin bounding fault that defined the edge of the salt basin. Current offshore well data does not demonstrate presence of a sand-prone Middle-Upper Eocene section; however, wells in the onshore Veracruz basin close to the deformation front have observed significant thicknesses of conglomeratic to coarse-grained sandstones.

2- Oligocene: In the western offshore region (outboard of the Campeche salt basin) a major north-to-northeast trending slope channel system is visualized on 3D seismic attributes. Limited Oligocene well penetrations along the Catemaco foldbelt (i.e., Piklis-1 and Ahawbil-1) encountered sand in the Upper Oligocene. Within the Upper Oligocene inside the Campeche salt basin, semi-continuous NE-oriented channel geometries record a sand-prone system being routed into this area. Northwards (about 250 km from the present-day shoreline) we can observe north-to-north east oriented weakly-confined channel geometries throughout the Upper Oligocene. In this basinal area we also observe polygonal faulting and sediment waves (associated with overbank deposits) in the Lower Oligocene, which suggest sand starvation during this time.

3- Lower Miocene: An overall depositional thinning of the stratigraphic section from west to east is observed during this interval. Seismic observations and well data demonstrate the presence of multiple sand-rich, north-to-northeast trending deep marine channel systems across offshore Campeche, both inside and outside the salt basin. From well data and source-to-sink analysis, we interpret that the clastic deposition mainly derived from the hinterland areas in southwest Mexico (Oaxaca/Xolapa/Southern Sierra Madre-Zongolica terranes and Trans-Mexican Volcanic Belt). Petrographic analysis shows that the sandstones are of lithic composition, texturally immature, and rich in volcanic content.

4- Middle and Upper Miocene: During this time an extensive sandy fairway developed in the offshore Campeche basin. Amplitude extractions tied to well control in the western region (i.e., Kunah area) show large sinuous channel complexes 5-10 Km wide trending northward. Farther north (> 250 Km from the present-day shoreline), well penetrations from the deep-sea drilling program reported medium to coarse-grained sand in the Middle Miocene, which supports the development of a major depositional system sourced from the hinterland of southern Mexico. In the Mid Miocene an episode of extensive submarine erosion produced a widespread erosional unconformity throughout the salt basin, with onlap seismic geometries and bed thinning onto it. This erosional event is associated with a major phase of Chiapanecan tectonism in the Campeche salt basin. The provenance analysis shows an important sediment input from the Chiapas area to the southeast, with sandstones mostly quartz-rich, texturally immature, and much less volcanic content. In general, there was an overall progradation of a major fluvial-to-marine depositional system between the Middle Eocene and Upper Miocene. Laramide tectonics in the Paleogene controlled the genesis of sediment source terranes and drainage catchments onshore and the routing of sedimentary systems within an evolving but initial bathymetrically suppressed salt-influenced basin. Throughout the Cenozoic, the fault system that defines the western edge of the Campeche salt basin has been critical in controlling the routing of deep water depositional systems. Chiapanecan tectonics since the Middle Miocene induced salt evacuation and controlled the development of multiple depocenters in the Campeche salt basin, and subsequently the routing of the sandy systems into a bathymetrically complex salt basin.

NOTES:

Session Two: Mexico Regional Tectonics

The early stages of opening of the Gulf of Mexico- shaping the margins

G. Messager[1], E. Blanc[1], N. Rodrigues[2], J. Demichelis[3], J. Skogseid[1], J.-A. Hansen[1]
[1]*Equinor ASA, Exploration Research, Fornebu, Norway,*
[2]*Equinor ASA, Exploration Research, Trondheim, Norway,*
[3]*Equinor ASA, Exploration, Houston, United States*

Recent gravimetric and magnetic anomalies map covering the Gulf of Mexico (GoM), combined with regional 2D and local 3D seismic data provide means of identifying crustal kinematic markers and tectonics domains. A detailed map of the tectono-stratigraphic domains composing the margins bounding the Gulf of Mexico was built from detailed structural interpretations of several extensive 2D seismic datasets spanning the whole region. This approach allows the reconstruction of the margins architecture and their variabilities in terms of crustal thicknesses, structural styles, syn-rift to syn-break-up seismostratigraphic units. The map of tectonic domains provides constraints on the early stages of GoM rifting. The restoration of the original configuration of its conjugate margins is also complemented by the identification of two large Magnetic Anomalies, one in northwestern GoM (Houston Magnetic Anomaly) and in southeast of GoM (Campeche Magnetic Anomaly) which are interpreted as originating from a single late Triassic-early Jurassic volcanic construction.

The work results in a new rifting model in where GoM margins evolve first from a regional crustal stretching phase clearly linked to the Central Atlantic system, second from hyper-stretching phase where faults are directly coupled with the Moho. The presence of volcanic additions correlated to the major magnetic anomalies is also interpreted as a consequence of this crustal and lithospheric thinning. The break-up of the continental crust coincides with the deposition of a set thick sedimentary wedges, all prograding basinwards onto exhumed continental mantle, locally intruded by volcanic edifices. Contemporaneous to the salt deposition, a relatively thin and faulted igneous crust appear to make the transition to the true oceanic crust.

Our mapping results suggest that the significant variabilities of the distribution of these domains spanning the margins can be explained by an along-strike, eastward migration of rifting processes and sequences throughout the Triassic until Late Jurassic times.

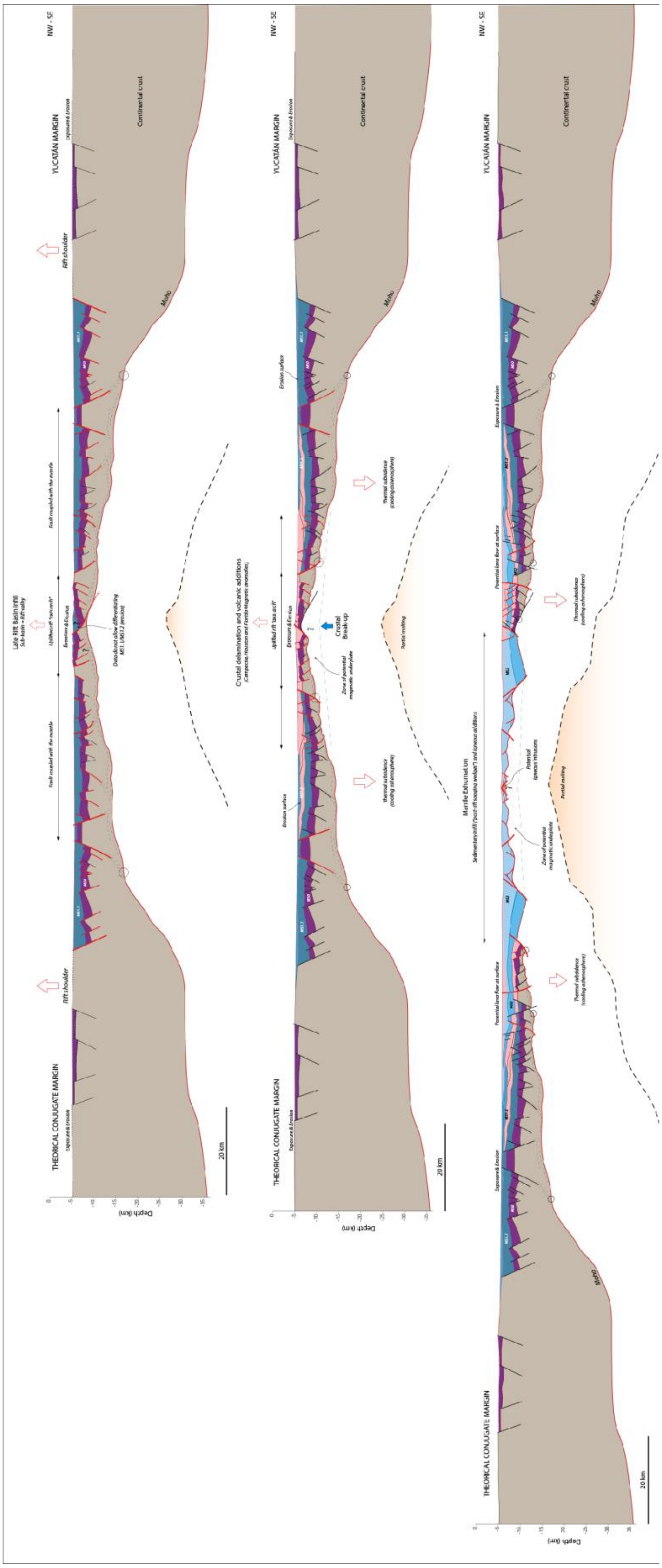


Figure: Sequentially restored section of the Yucatán margin showing crustal hyper-extension (around Late Triassic), crustal break-up (around Early Jurassic) and mantle exhumation (Early-Mid-Jurassic). Strike variabilities and diachroneities show the eastward migration of the GoM opening.

NOTES:

Kinematic constraints on the opening of the Gulf of Mexico - Inferred driving mechanisms

E. Blanc[1], G. Messager[1], N. Rodrigues[2], J-A. Hansen[1], R. Khabbaz Ghazian[1], J. Skogseid[1], J. Demichelis[3]
[1]*Equinor ASA, Exploration Research, Fornebu, Norway,*
[2]*Equinor ASA, Exploration Research, Trondheim, Norway,*
[3]*Equinor USA, EXP NA, Houston, United States*

The construction of onshore regional geological cross sections, combined with the interpretation of geological maps covering Mexico, recent gravimetric and magnetic anomaly maps and complemented with regional 2D and local 3D seismic data covering the Gulf of Mexico (GoM) provide means of identifying tectonic domains and kinematic markers. Markers were used to deduce the rotation of the Yucatán back to the time of deposition of the mid-Jurassic Louanne and Campeche evaporites in one single basin, whilst the map of tectonic domains provide constraints on earlier stages of rifting (Messager *et al*., 2019).

Two large Magnetic Anomalies, identified both northwest of GoM (Houston anomaly) and southeast of GoM (Campeche Anomaly) are interpreted as originating from a single late-most Triassic to early-most Jurassic volcanic construction, and provide additional constraints on the original configuration of the conjugate margins during early rifting stages.
Three main tectonic stages, bounded by relative changes of motion of the Yucatán peninsula are identified:

i) A first stage, spanning the Triassic and early Jurassic times, coincided with a slow southeastward translation of South America relative to north America, low strain rates over long period are likely to have led to the exhumation of continental mantle lithosphere, now preserved in NW and SE GoM. This deformation stage forms the "Atlantic rifting phase".
ii) A second stage, starting in the early-most mid Jurassic, followed a sudden shift to a broad SW-ward motion of Yucatan. It is interpreted as the result of the interference in between NW-SE central "Atlantic" divergence, with a moderate SW-ward roll-back of the Pacific subduction zone, that drove the opening of the Arperos back-arc Basin across Mexico. During this time interval, high strain rates are inferred in western and northern GoM and have led to oceanic crust spreading, while mantle exhumation and continental rifting were still ongoing in NE GoM.
Thick evaporites (Louanne and Campeche Salt) were deposited during the late-most mid Jurassic at the end of this stage, while the northern and southern proto-Caribbean oceanic domains were expanding.
iii) A third stage, during the late Jurassic, is marked by a counterclockwise rotation of Yucatan and coincides with an acceleration of the Pacific slab roll-back. This resulted in high strain rates and oceanic crust spreading in western and northern GoM, while continental mantle lithosphere was still being exhumed in NE GoM.

During the last stages of opening of the GoM, several southwards mid oceanic ridge jumps are inferred, as mere plate shape readjustments resulting from the fairly abrupt changes of plate motions, these may help explain the strong asymmetries in between GoM conjugate margins. Oceanic crust spreading in GoM ceased in the lower Berriasian (around -144 Ma) when, south of Yucatan, Chortis and the Nicaragua Rise were separated from Columbia and NW south America, as oceanic crust was laid, and the northern Proto-Caribbean domain connected with the southern Proto-Caribbean oceanic domain.

Figure 1: Conceptual cross sections across W GoM restored at -220 and -190 Ma

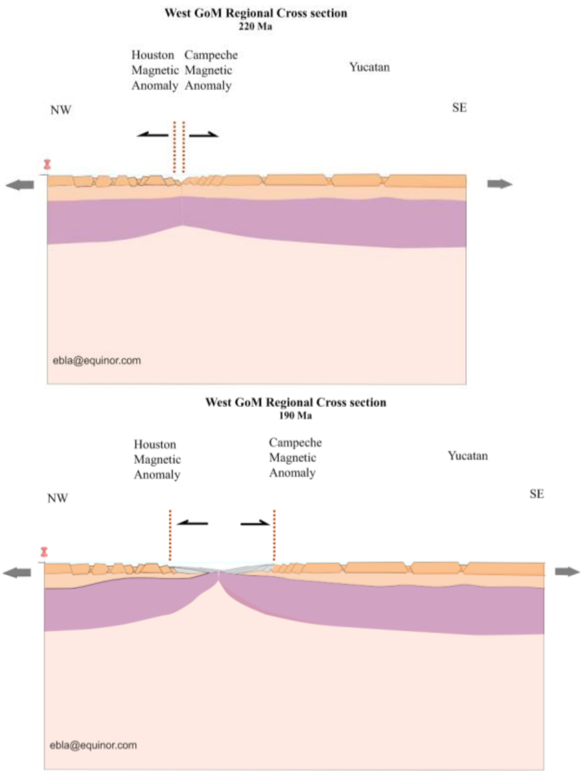
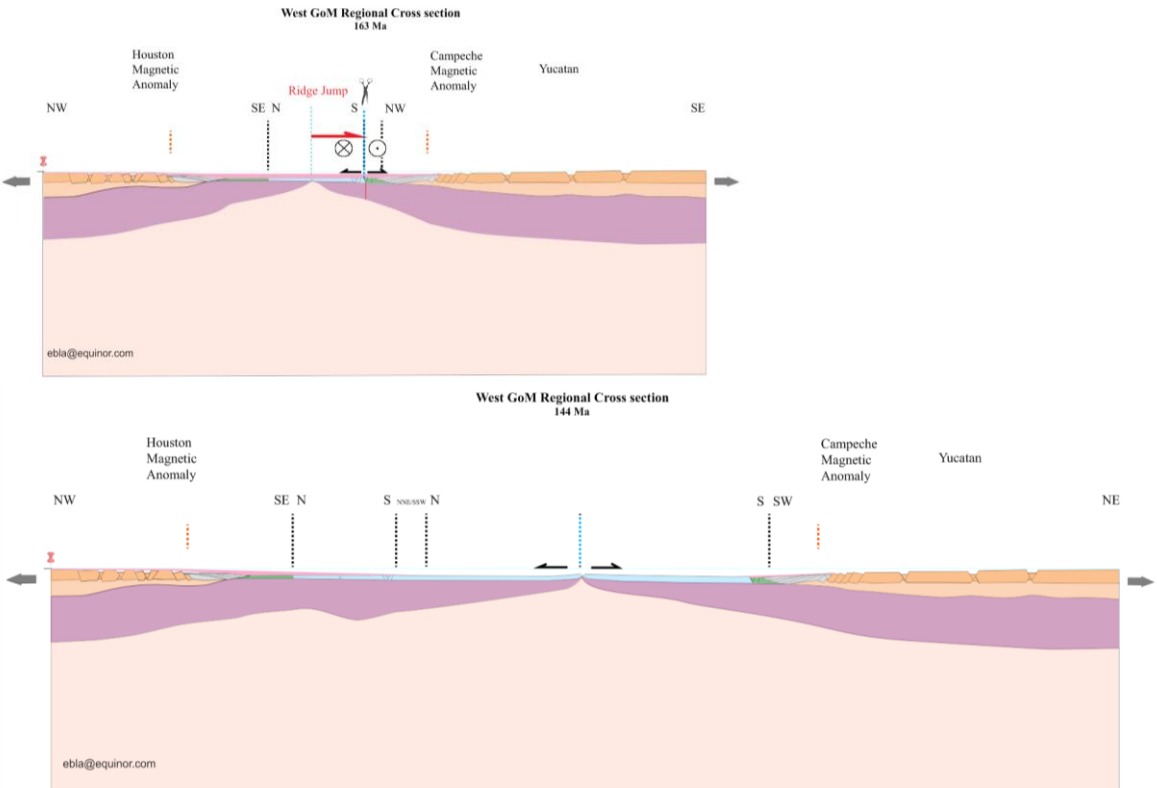


Figure 2: Conceptual cross section across S Mexico restored at -163 and -144Ma



NOTES:

Tectonic and sedimentation history, petroleum systems and plays of the Eastern Mexican basins: an overview

Ernesto Miranda-Canseco, **Sergey Drachev,** Javier Alejandro Morelos- Garcia
3GeoAmericas LLP

Eastern Mexican sedimentary basins (Fig. 1) together with the adjacent deep-water Gulf of Mexico represent one of the most prolific hydrocarbon (HC) provinces worldwide. Beginning of the crude oil production in 1901 marked a new era in Mexican history with its economy underpinned today by seventeenth largest oil reserves in the world. Tremendous, and up until very recent a sole contribution to Mexican petroleum industry has been made by the state-owned company PEMEX. However, as time of 'easy oil' has come to its end, Mexican oil production has been declining since 2005 due to lack of new reserves, specifically in the deep-water realm. This fact triggered an 'Energy Reform' that ended PEMEX monopoly in 2013 and opened the country to foreign companies to boost HC exploration and production.

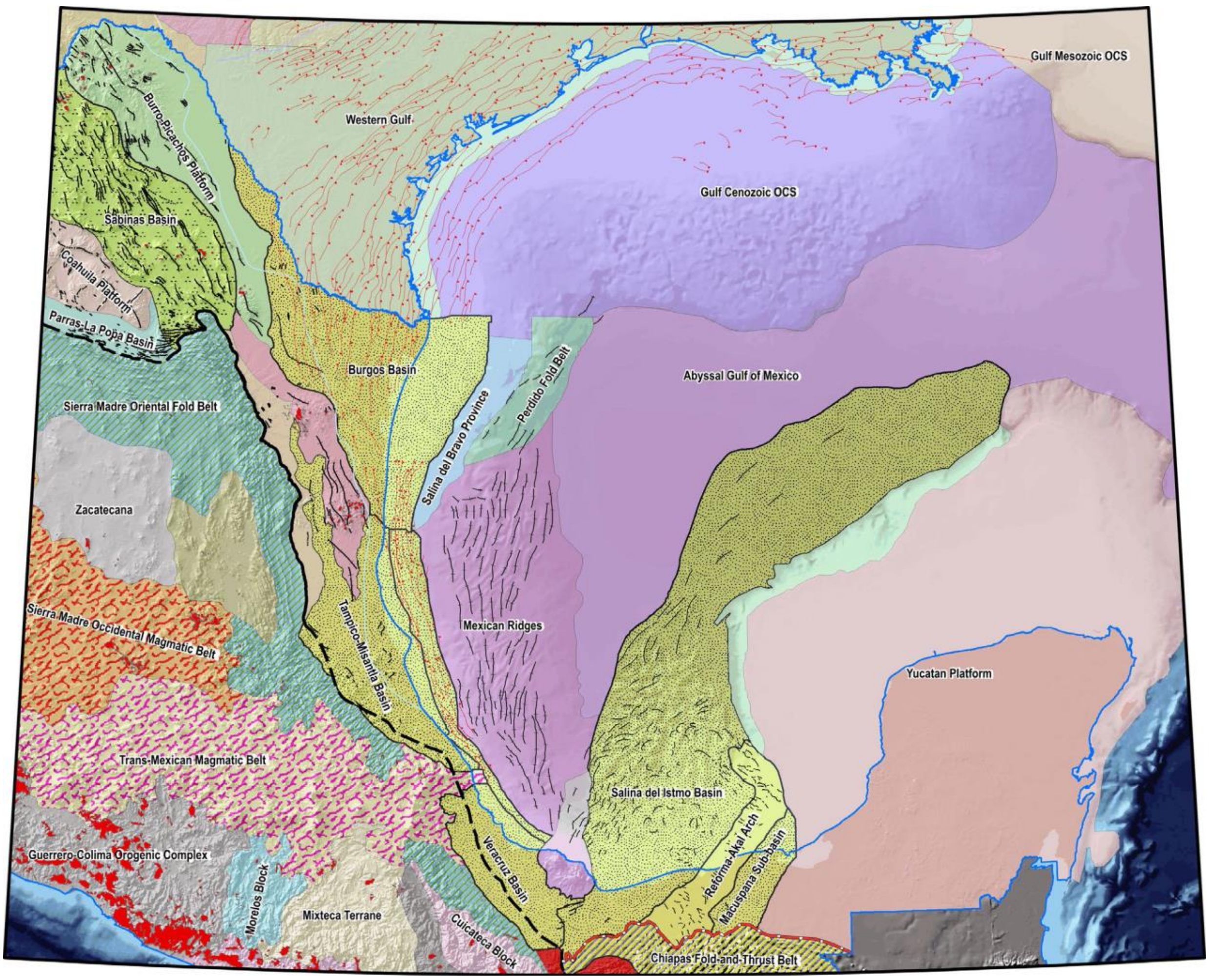


Fig. 1. Tectonic map of the Eastern Mexico and adjacent Gulf of Mexico. Based on SGM and CNH ArcGIS coverages and published data. The bold black and red lines indicate mapped (solid) and inferred (dashed) fronts of Laramide and Chiapas compressional deformations

In our presentation we review the current state of knowledge of the tectonic and sedimentation history of the Eastern Mexican basins, their petroleum systems and plays. From north to south these are: Sabinas, Burgos, Tampico-Misantla, Veracrus and Southeastern basins. For that, we mainly used data published in professional research papers and PhD/MS theses, State Geological Map of Mexico (1:250,000 scale) and data released by CNH (Comisión Nacional de Hidrocarburos) online, as well as results of our own research as a part of the PETROMEXBAS Project (https://www.3geoamericas.com/projects/). We consider main tectonic events, such as the Triassic-Middle Jurassic rifting and following opening of the Gulf of Mexico, Late Cretaceous-Early Cenozoic Laramide and Middle Miocene Chiapas orogenies, formation of major Cenozoic Sierra Madre Occidental and Trans-Mexican magmatic belts and their impact on the sedimentation and, consequently, on hydrocarbon systems and plays across the Eastern Mexican basins.

We present results of our research as a series of 12 paleotectonic-palaeogeographic maps covering the history of the region from Late Jurassic to Pliocene (Callovian, Oxfordian, Late Kimmeridgian, Tithonian, Barremian-Aptian, Albian-Cenomanian, Campanian-Maastrichtian, Paleocene, Eocene, Oligocene, Miocene & Pliocene time slices).

NOTES:

Session Three: Reservoir Distribution

KEYNOTE: Analysis of modern Mexico drainage systems: insights and predictions for post-Middle Miocene deepwater reservoir distribution and quality

Snedden, John W[1]**.,** Stockli, D. [2], Galloway W.E. [1], Fulthorpe, C[1]. and Virdell, J. [1],
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Modern Mexican drainage basins were established following the Middle Miocene Chiapanecanorogeny associated with Pacific Plate subduction. While present-day fluvial processes continue to alter the subaerial landscape, it is reasonable to use modern catchment dimensions and exposed source terrane areas for insights and predictions for the post-Middle Miocene sediment routing to the southern Gulf of Mexico offshore. This includes assessment of potential reservoir quality, which is calibrated against published well lithologic information. Seismic mapping in deepwater areas helps define trends in post-Miocene thickness, pointing to important depocenters where transported sediments were accommodated.

Hydrographic surveys identify the 10 largest drainage basins in Mexico, with four of these located in Sureste (Rio Grijalva, Rio Usumacinta, Rio Coatzacoalcos, Rio Papaloapan). These likely were important sediment pathways for post-MM reservoirs in the Salina del Istmo and southern Mexican Ridges. The Rio Guayalejo is proximal to the northern Mexican ridge exploration province while the Rio Grande/Bravo presumably routed sand to the Burgos Basin, Bravo Trough and Perdido fold belt. Other than the Rio Grande/Bravo, all Mexico rivers are less than 600 km in length and catchments much smaller than northern Gulf of Mexico drainage networks. Thus the source to sink signature is easier to discern given less mixing from multiple source terranes. The first-order global relationship between catchment area and longest river is also confirmed here.

Assessment of exposed source terranes, calibrated by well control, indicates variable contributions of quartz-rich, carbonate-rich, and volcanic-lithic rich sediments in the post-MM strata. Lithic-prone sediment contributions increase north and west. Analysis of the drainage basin size and river lengths suggests that the combined Grijalva-Usumacinta drainage basin system was particularly important for Sureste, including Upper Miocene Zama reservoirs. Higher quartz content is likely here given river access to the Permo-Triassic Chiapas massif and alongshore reworking in this wave-dominated delta that reduced lithic content by sorting and lithic grain abrasion.

Carbonate-dominated source terranes are ubiquitous in southern and eastern Mexico, including the Cretaceous carbonates of the Zongolica massif, Paleogene limestones, and other Mesozoic carbonates in the Rio Papaloapan and Rio Guayalejo catchments. This potentially means more carbonate clasts and/or carbonate cements within sandstone reservoirs.

Numerous smaller river catchments likely also played a role particularly in distributing volcanic-rich lithics from the Trans-Mexican volcanic belt and Las Tuxtlas that probably impact reservoir composition in the southern Mexican ridges. Veracruz basin wells have high lithic content that reduces reservoir quality due to ductile grain compaction and/or deleterious cementation development.

Previous work in the northern Gulf of Mexico (Snedden et al. 2018a; 2018b) validated use of first order empirical relationships for prediction of Gulf of Mexico submarine fan length and width. For Mexican rivers other the Rio Grande/Bravo, predicted lengths/widths at 0.25 and 0.50 x the longest river length indicates areas of likely fan development. These nicely overlay depositional thickness maxima indicating enhanced accommodation by sediment loading.

NOTES:

Reservoir distribution in deepwater Salina del Istmo Basin, offshore Mexico

Malcolm Francis, Clara Rodriguez, Jonathan Hernandez, Raul Ysaccis, Sebastian Villarroel, Kevin Lyons, Fred Snyder, Maxim Mikhaltsev, Mohamed El-Toukhy, Liubov Mulisheva, Sylvia Centanni, Edgar Galvan
Western Geco

The analysis is based on the interpretation of a regional (71,000 sq. km) 3D wide-azimuth, broadband depth-imaged seismic reflection volume in water depths from 250 m to 3750 m. This talk illustrates how salt and regional tectonic events controlled the distribution and architecture of deepwater depositional systems (i.e., turbidites). The turbidites identified and interpreted based on seismic stratigraphy and geomorphology represent the key Eocene, Oligocene and Miocene reservoirs in deepwater Salina del Istmo Basin, Gulf of Mexico, offshore Mexico. The presentation highlights the significance and impact of these new findings on exploration basinwards from the 2017 oil discovery (Zama-1) by Sierra Oil and Gas, Premier Oil and Talos Energy.

NOTES:

Provenance and Morphology of the Oligo-Miocene Veracruz Deep-Water Fan System in the Western Gulf of Mexico

Daniel F. Stockli[1], Julian D. Clark[2], Jesús Ochoa[2], Andrea Fildani[2], Jacob Covault[3], Lisa D. Stockli, and A. Hessler[3]
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[3]*Bureau of Economic Geology, University of Texas at Austin,*

The Oligo-Miocene siliciclastic strata around the Gulf of Mexico (GOM) host important hydrocarbon plays in Mexico and the USA. However, the extent and quality of reservoirs are difficult to predict due to uncertain provenance, sediment routing, and subsurface correlations. This study presents critical new insights from new onshore and offshore detrital zircon U-Pb and (U-Th)/He data from Cenozoic strata from the Mexico and distal USA W GOM, integrated with reflection seismic data, to delineate large-scale, basin-wide fan systems. Integrated provenance analysis of DZ U-Pb and (U-Th)/He ages and petrography from Miocene-Pleistocene strata from onshore outcrops in S and E Mexico and offshore DSDP (3, 87, 90, and 91) and industry wells in the Mexican and USA GOM are used to interpret the evolution of sediment dispersal in the W GOM. Oligo-Miocene strata in the W GOM are characterized by DZ U-Pb ages derived from the Trans-Mexican Arc (<20 Ma), Permian Chiapas, Early Paleozoic Yucatan-Maya block, and E. Paleozoic-Mesoproterozoic Acatlan and Oaxaquia basement source terranes of central and southern Mexico. The sediment sourced from S Mexico, includes up to coarse-grained sand and pebbles that were deposited ~500 km from the Mexican coastline. This interpretation is supported by DZ (U-Th)/He data confirming provenance from southern Mexican sourced terranes exhibiting Jurassic-Cretaceous, Paleogene, and Miocene tectonic exhumation. In combination, the DZ U-Pb-He data indicate predominant sourcing from a tectonically-active hinterland along the active subduction margin, including Zongolica/Sierra Madre del Sur, Permian Chiapas massif, and recycled Jurassic Todos Santos Fm.

Reflection seismic data show an extensive submarine fan system sourced from the southern Mexican hinterland that extended across a large area of the deep-water GOM basin into US waters. While evidence for significant deep-water clastic systems in the southern GOM has been documented previously, we demonstrate the extent over an area of ~3×10^5 km^2, comparable in areal extent to the Pleistocene Mississippi fan. The Oligo-Miocene fan systems were sourced from the S Mexico hinterland and fed via the paleo-Papalopan and Grijalva-Usumacinta river systems and several prominent large-scale (5-10 km-wide) sub-marine channel belts, mapped in 2D and 3D seismic data, which emerge from the southern sector within structurally active slopes and extend across a relatively low-relief basin floor. These primary conduits supply a series of compensating fan systems, comprising smaller-scale channels, which connect downdip to multiple lobe deposits (typically 10 – 50 km wide).

In exploring the size and northward extent of the Veracruz fan, DZ U-Pb-He double dating showed that Miocene strata in the outer portions of the central US GOM shelf, inboard of the Sigsbee Escarpment, were derived from S Mexico. Wells farther north, however, show a clear Laurentian U-Pb-He signature and derivation from US drainage systems (incl. the paleo-Mississippi). These new interpretations for Oligo-Miocene fan systems extending north into US deep-water are consistent with new mapping of seismic stratigraphy and regional isochore trends. The Pliocene in the W GOM is characterized by an increasing influx of sediment from E Mexico (i.e. Sierra Madre and Mesa Central), spilling over the Mexican Ridges, but not from the Rio Grande/Bravo system. In stark contrast, the Pleistocene marks a major provenance reversal with sediment in the central W GOM no longer being derived from S and/or E Mexico, but from dramatically enlarged basin-wide fans from the Mississippi and associated US river systems. This tectonically and climatically-induced Pleistocene provenance shift is paralleled by a compositional switch from mainly quartz, potassium feldspar, and lithic carbonate grains through the Neogene and a sharp decrease in plagioclase and lithic volcanic grains after the Miocene.

These results indicate a major clastic input from southern Mexico initiating in the Upper Oligocene, peaking in the Middle Miocene and terminating by the end of the Miocene. While the large influx of Oligo-Miocene clastic detritus appears incompatible with the relatively limited scale of S Mexico drainage systems, the provenance and size of the Veracruz fan strongly argue for the importance of tectonics and climate as significant factors in the volume of sediment released from these relatively small drainage areas.

NOTES:

Paleogeographic and Depositional Reconstruction of Oxfordian Aeolian Sandstone Reservoirs in Mexico offshore areas: comparison to the Norphlet aeolian play of the Northern Gulf of Mexico

Snedden, John W. [1], Stockli, D. [2], Virdell, J. [1], Apango, F. [2], Norton, I. O. [1]
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[2]*Department of Geological Sciences, The University of Texas at Austin*

Oxfordian aeolian sandstone reservoirs are important producers in the Ek-Balam block near Cantarell Field in the Akal trend of offshore Mexico. However, only limited data have been published documenting paleoenvironmental interpretations, subsurface reservoir quality, or source terranes from which these sandstones are derived. We conducted a new analysis including sedimentological core description, detrital zircon U-Pb geochronology, and plate tectonic restoration to reconstruct the paleogeographic map for this area and the Gulf of Mexico basin as a whole and allowing direct comparison with the previously-studied deepwater Norphlet play of Desoto and Mississippi Canyons of the US Gulf of Mexico (GoM).

Our Oxfordian reconstruction of the northern GoM indicates dryland systems, including aeolian erg (arid sand sea) and fluvial-wadi paleoenvironments covered over 58,000 km^2 - comparable in size to the modern Namib Desert. In the northern GoM, aeolian erg reservoirs host giant oil discoveries at Appomattox and Ballymore. In Mexico, our reconstruction shows the Ek-Balam field area of the Bay of Campeche is part of a smaller aeolian depositional system located in a reentrant on the southwest side of Yucatán. Here Oxfordian age sandstone of the Bacab Fm. are roughly time-equivalent to the Norphlet Fm. of the northern GoM. Like the Norphlet of the northern GoM, Bacab reservoirs consist of medium- to fine-grained sandstone, dominated by large-scale cross-bedding (Figure 1), interpreted as aeolian dune deposits. Published dipmeter data show unimodal dips of $\geq$25 degrees in multi-meter thick sets indicative of westerly to northerly wind orientations (Figure 1), complicated by post-depositional tectonic rotation. Oxfordian paleowinds may have reworked fluvial-wadi deposits derived from the exposed Yucatán platform area into north-south to locally east-west oriented transverse dunes (Figure 1). Preliminary detrital zircon U-Pb provenance work indicates that the Mayan (Yucatán) block and Carboniferous I-type granites are the primary source terranes for the Oxfordian sandstones in the Balam 101 well. Surprisingly, Permian-aged zircons, a signature of the Chiapas highland terrane and a dominant age component in Jurassic Todos Santos Group sandstone in S Mexico, are largely absent. Petrographic work indicates quartz content in the Oxfordian sandstones is quite high (>90%) likely due to derivation from this older granitic basement terrane.

Observed macroporosity at Ek-Balam is remarkably high, considering current depth of burial (>4500 m) and Jurassic age of the reservoir. Published reports of chlorite clays and carbonate cement dissolution, key elements of deep porosity preservation and development in the US GoM Norphlet and Tuscaloosa plays, imply that Oxfordian sandstone may be viable reservoirs over a larger area and at greater depths than currently thought. Seismic mapping on the Yucatan margin further north suggests a frontier exploration province may be present with similarity to the deepwater Norphlet play area. In this area, our reconstructions and seismic mapping indicate favorable proximity to this Northern GoM play area, as well as kinematic similarity in structurally defined trap styles, top seal, and reservoir discontinuity due to salt rafting.

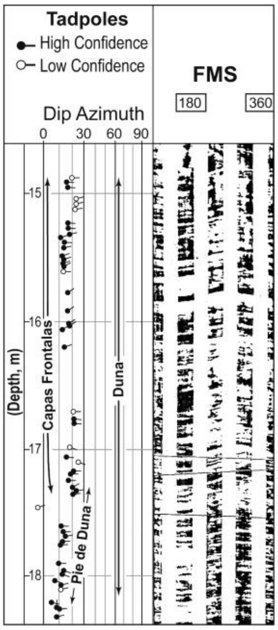

Figure 1. Bacab Formation in Ek-Balam field area of Mexico. Formation micro-scanner images and dip azimuths for Oxfordian-age sandstones of the Ek-Balam Field, Mexico. Spanish: Duna = Dune in English. Depths are disguised, but are in the 4000-5000 m range. Modified from Ramisa-Roca and Duran Arnabar (1994).

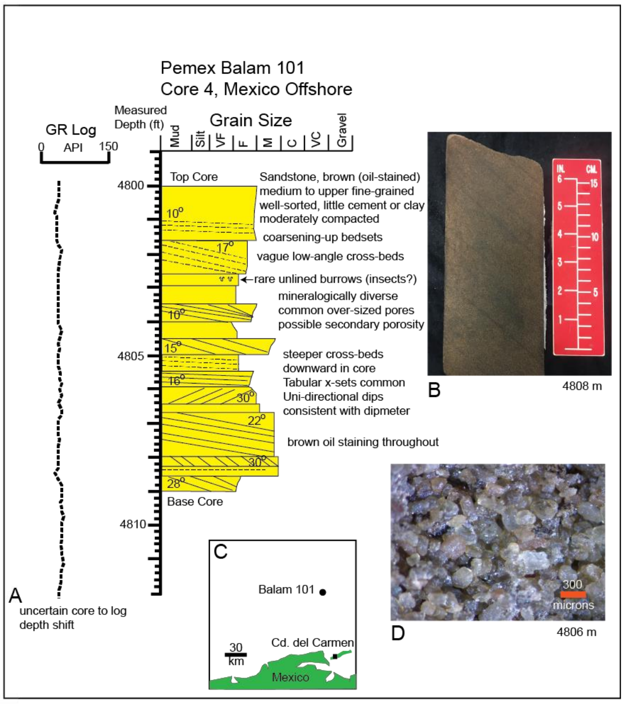

Figure 2. Bacab Formation in Balam 101 well of Mexico, (A) Core description; (B) Core photograph, 4808.3 m MD; (C) Location of Balam 101 well; (D) Magnified view of Bacab Formation Sandstones, Balam 101 4806 m MD.

Roca-Ramisa, L., and Duran Arnabar, R., 1994, Geological and Geomechanical Reservoir Characterization: The Ek-Balam Field Study in Mexico: *Congresso Brasileiro de Petroleo*, 1-28.

NOTES:

Session Four:
Petroleum Systems

Untapped Petroleum Systems Revealed in the Mexico GOM Superbasin

Karyna Rodriguez, **Neil Hodgson**
Spectrum Geo

After nationalization of oil exploration in Mexico in 1938 and the formation of PEMEX, exploration has proven extraordinarily successful in the many offshore and onshore basins such that Mexico is now the fourth largest oil producer in the Western Hemisphere. However, since 2007 production has been declining in mature fields and new fields have been slow to come on stream.

To revitalize the economy and exploration, in 2013 Mexico introduced new reforms, inviting participation from international exploration opportunities, which has very successfully generated a lot of interest in the country. A new Petroleum Agency, the CNH (Comisión Nacional de Hidrocarburos), has been formed to regulate exploration activities, holding successful License rounds, and seeing the first international exploration wells drilled. Indeed the 2017 Zama discovery of Talos Energy has highlighted the remaining potential of the already extremely prolific Sureste Basin.

The Sureste Basin is the most explored, with 61 BBOE recoverable from 480 discoveries including super giant discoveries like the 1976 Cantarell Field – one of the largest accumulations of oil in the world, helping offshore Mexico to become a powerhouse of production, sustaining Mexico's economy. Despite the discovery of oil, and the huge number of offshore structures identified on early seismic, much of the area, including the deep water part remains frontier for oil exploration.

To the northwest of the Sureste Basin, the Salinas, Cordilleras Mexicanas, and Perdido Basins lie in an arc stretching all along the East Coast of Mexico. A regional grid of modern long offset 2D seismic with excellent image across all basins has been closely examined. In each basin, extraordinary play systems are developed, each tapping into the proven hydrocarbon source, and mostly revealing good Direct Hydrocarbon Indications (DHI's) on seismic both 2D and 3D, newly acquired in Mexico and presenting information that Pemex did not have in the past. Many undrilled structures bearing such DHI's that significantly reduce risk for explorers are observed indicating that the "low hanging fruit" are still there to be picked in this Super-Basin. The next creaming curve of discoveries will come from modern seismic used to reduce and constrain risk in the unexplored deep water, generally in clastic plays in which experience drawn from other basins in which combined traps have been successfully explored will prove invaluable. Wide and full azimuth seismic will also help opening up sub-salt plays and deeper Jurassic targets, often left untested when the Cretaceous target was successful, should be identified and drilled successfully with modern technology and drilling practices.

That's not all as in this Super-Basin lies the untouched potential of the Yucatan margin of the eastern Mexico basin. Here unique geology and heat flow influenced by Chicxulub and diapiric movement show oil in a variety of plays from Cantarell to Norphlet analogues and pre-salt plays that have never been targeted. Additionally, north of the Campeche Basin, abundant tight clusters of oil slicks have been interpreted associated with the Sigsbee Knolls. It is clear that these slick clusters are closely related to salt diapirism and indicate that a thermogenic hydrocarbon system is present in the Campeche basin that is mature for oil and is generating oil in large volumes. Geochemical sampling from the Chapopote asphalt volcano indicates that at least some of these oils are generated from Jurassic source rock (Naehr et. al, 2007).

Any one of the above untapped plays in this superbasin can bring its own new Creaming curve to the Mexican Pantheon of prolific basins. The message to Mexico is clear – "The arrival of new seismic datasets has re-invigorated exploration allowing risk reduction of new and existing plays and identification of a new suite of prospectivity. You are already a Super-Basin but your exploration has barely begun".

NOTES:

Source Rock Predictions, Reducing Conditions, Anoxia and Pyrites of the Caribbean

Alexandra Ashley[1], David Gold[1], Simon Otto[1], **Mark Cowgill[1]**, John Watson[1], Simone Agostini[1], Paul Valdes[2], Peter Allison[3], Alexandros Avdis[3]
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[3]Imperial College, UK

The tectonic development of the Northern Caribbean since the Jurassic has been dominated by the relative movements of the North and South American Plates, the influence of tectonic blocks such as the Yucatan, Chortís, and North Cuba terranes and the development of the Yucatan Platform, the Caymen Trough and the Nicaraguan Rise. In such active settings source rock and reservoir facies development is driven by interrelated processes, including tectonics (uplift, faulting and volcanism) and climate.

In order to facilitate prediction of the quantity and characteristics of reservoirs and source rocks in the Caribbean we demonstrate our unique approach to combining global palaeo-Earth Systems models (incorporating the UK Met Office HadCM3) and paleotidal models (Imperial College, UK, ICOM) with regional focussed drainage studies in Nicaragua and Honduras and detailed stratigraphic interpretations in Jamaica and Honduras. This novel combination of known and modelled datasets provides an integrated understanding of the palaeogeographic evolution of the Northern Caribbean. We focus on restricted and open marine environments, oxic, dysoxic and anoxic marine conditions, drainage systems and sediment supply pathways to predict likely reservoir and source facies in the northern Caribbean.

Our global approach provides quantitative palaeoenvironmental information for key late Mesozoic and Cenozoic time slices which are then verified in the more focussed regional and country-specific datasets. Detailed biostratigraphic, sedimentological and geochemical analyses from outcrop, onshore shallow coreholes, and on- and offshore Jamaica have been undertaken to revise and update the sequence stratigraphic framework of Jamaica, tie depositional cycles to third-order sequences and identify the major source rocks and reservoir facies in the Cretaceous and Cenozoic. We here demonstrate the correlation between predicted and known source and reservoir sequences from global to local scale. The results presented here also illustrate the relationship between marine anoxia and the development of Type II / Type IIs source rocks, the influence of reducing conditions and the occurrence of pyrites within the Jurassic to Eocene across the Caribbean from Jamaica through Cuba and into Nicaragua.

NOTES:

The oils and source rocks of the Patuca and Mosquitia basins, Honduras

Chris Matchette-Downes
CaribX (UK) Limited

The Patuca basin is an elongate Miocene aged basin on the northern flank of the Upper Nicaraguan Rise as it descends through a series of smaller downthrown sub-basins into the Cayman Trench to the north. The broader and older Mosquitia basin lies to the south across the Mosquitia High which forms a shallow broad feature separating the two basins.

No wells have been drilled within the Patuca basin, however flanking wells drilled in the 1960's & 70's and a recent and extensive seabed coring, seismic, high resolution bathymetry, FTG, satellite work program and regional geology provide sufficient context and information to determine the nature and likely origin of hydrocarbons found in the core samples and adjacent wells.

The Mosquitia basin has a proven petroleum system evidenced through the drilling of Main Cape #1 at the toe of a large structure by Union Oil in 1973 which recorded over 100bbls of 31º API oil from 3 drill stem tests. An adjacent well Coca Marina #1 drilled in 1969 also encountered oil shows and 770m of rich Eocene aged source rock, the Punta Gorda Formation. This interval is believed to be the time equivalent of the Litchfield-Chapleton Formation, also a thick and robust source unit encountered in the Content #1 well onshore Jamaica. Punta Gorda source rocks have also been penetrated in several wells to the south in Nicaragua, however biomarker data from seeps and cores indicates a second distinctly different source is also present.

This second source is likely, based on maturity considerations, other biomarker data and the regional petroleum geology to be Upper Cretaceous in age and is perhaps more regionally extensive than the Eocene source which appears best developed in the inter block basins which characterise the Nicaraguan Rise.

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Session Five:
Mexico – Sureste Basin

KEYNOTE: The Zama Discovery: Subsurface Uncertainty in Exploration and Appraisal

Iain MacEwen, Oliver Cheshire, Pablo Zapico-Palmero, Aruna Mannie
Premier Oil

In July 2017 the joint-venture partnership of Talos Energy, Sierra Oil & Gas and Premier Oil discovered the Zama Field in Block 7 of the first licencing round (RD1.1) in the Sureste Basin, Mexico. Subsequent press releases put the discovery at between 1-2 billion barrels of oil in place and were accompanied by images of an obvious amplitude driven prospect with an impressive flat spot (Figure 1). This paper discusses the pre-drill risks and uncertainties, the well results and the subsurface uncertainties which will be evaluated with an appraisal campaign in 2018-2019.

The legacy full stack 3D seismic data sets that were available for purchase as part of the RD1.1 data package were of various vintages and quality. On these data a clear cross-cutting reflector (CCR) interpreted to be a flat spot was difficult to define and a laterally continuous amplitude anomaly less clear. The pre-award risk was increased by recognising that the column height defined by the interpreted flat spot was >850m; a very large column against a fault that looked to be active at present day and a trap that required a combination of salt and fault seal. There were doubts as to whether the CCR was a flat spot or a rotated channel edge, which is not uncommon for the Upper Miocene slope depositional systems. These technical uncertainties perhaps go some way to explaining why, despite 39 companies expressing an interest in RD1.1 and visiting the initial data room, there were only 4 bids on block 7.

Post award, the partnership reprocessed the legacy data through a modern processing flow incorporating FWI and tomography to better define the velocity model and used Kirchhoff Pre-stack time migration (KPSTM) and Pre-Stack Depth Reverse Time Migration (RTM) to obtain amplitude compliant pre stack gathers, angle stacks and the best possible structural image. These data were used to define the chance of success of the Zama prospect and the pre-drill resource estimate. With the closest well 17km away and with very sparse well data in the footwall of the Comalcalco fault near Zama there was a large range in pre-drill reservoir parameters, and thus resource range. Despite the clarity of the CCR on the new data, it was not flat, with a variation in excess of 200m across the prospect. Thus, its origin was still uncertain; was it a flat OWC with an inaccurate velocity model, a dipping OWC created by hydrodynamic flow within the aquifer or the edge of a channel.

The discovery well proved the presence of 30° API oil in good quality, high net to gross sandstones of Upper Miocene age. The post-discovery resource estimate came in near the top end of the pre-drill estimate, primarily due to the high net to gross of the 335m gross oil bearing reservoir. The seismic data underwent a second phase of reprocessing incorporating the velocity control of the Zama-1 well.

Despite the discovery well, the reprocessing using the well data and the clear image of the trap and interpreted flat spot there is still large uncertainty in the GRV and reservoir properties of the Zama field. To reduce this uncertainty the partnership are undertaking a 3 well appraisal programme lasting from late November 2018 to Q3 2019 with key targets being to penetrate the OWC, collect water samples and gain more information on reservoir heterogeneity with extensive wireline logging, sample collection and whole core acquisition.

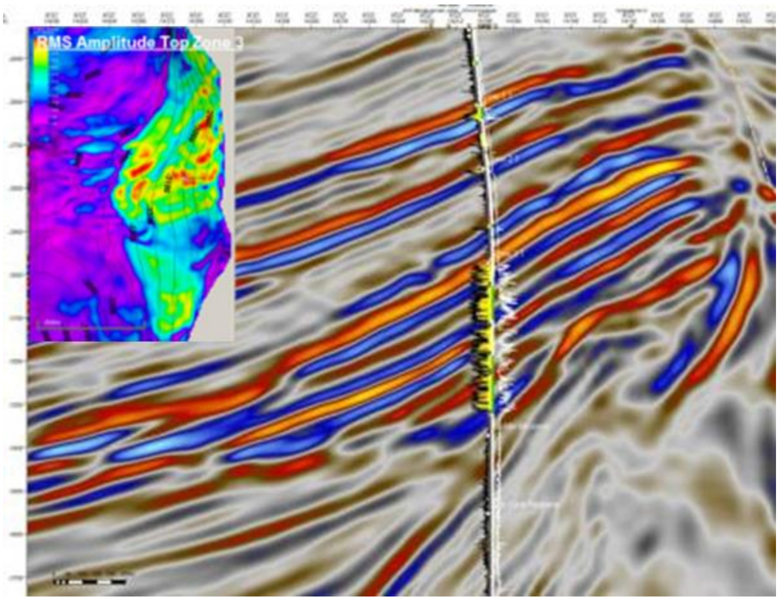


Figure 1: Zama discovery showing clear ‘flat spot’ and amplitude anomaly on the 2016 reprocessed data.

NOTES:

Structural Evolution of the Deepwater Campeche Salt Basin: Regional Tectonics, Structural Inheritance, and Implications for Petroleum Exploration

Alissa A. Henza, Enrique Novoa-Cancela
Equinor US

The deepwater Campeche salt basin is commonly considered to be the conjugate of the Northern Gulf of Mexico (GOM) salt basin. Unlike its northern GOM counterpart, the Campeche basin has undergone multiple phases of deformation during the Cenozoic due to plate-scale tectonism within and surrounding southern Mexico. These deformational episodes have resulted in a complex structural fabric that is influenced by the structural inheritance of pre-existing tectonic elements and extensive detachment levels created by both salt and shale. To better understand the evolution of this basin, we have integrated observations from 2D and 3D seismic, well data and published onshore studies to establish genetic links between onshore and offshore deformation since the opening of the GOM during the Mesozoic.

Observations on seismic data in the deepwater (> 500m water depth) Campeche basin reveal the spatial distribution of structural styles and timing of fault activity. Faults formed during the Mesozoic and early Cenozoic (Eocene and older) have influenced the accommodation of more recent (Middle Miocene to present day) tectonic and gravity-driven deformation. We observe multiple thrust faults throughout Western Campeche with Paleocene and Eocene-age growth stratigraphy. This stratigraphy corresponds with an episode of onshore uplift (e.g., Ratschbacher et al., 2009; Witt et al., 2012). Many of these early thrust faults were reactivated during the Miocene, corresponding with the onset of Chiapanecan orogeny onshore (e.g., Meneses-Rocha, 2001; Witt et al., 2012) In addition, we observe deep, high-angle faults below the autothchonous salt that we interpret to be normal faults that formed during the opening of the GOM. The seaward-most of these fault systems corresponds with the edge of the salt basin. On the seafloor, the present-day boundary of the salt basin is commonly defined by a series of strike-slip faults. The seismic data reveals that these boundary faults are commonly transpressional faults in southern Campeche and have a smaller compressional component in the north.

Two major detachment intervals are present in the Campeche basin. The Mesozoic-age (Louann-equivalent) salt generally serves as the deepest detachment level for deformation. Regional restorations and thickness differences within the Cretaceous and Paleogene age strata indicate that the salt became mobile early and has created structural relief throughout the Cenozoic. In addition, a Middle Eocene shale interval acts as a detachment level within the Cenozoic stratigraphy. This ductile interval results in disharmonic deformation between Paleogene and Neogene strata in western Campeche and the relative impact of this mechanical unit varies spatially.

The structural complexity and deformational history of deepwater Campeche have influenced both the tectonostratigraphic evolution and the petroleum system. The multiple phases of deformation during the Cenozoic have affected charge access over time by segmenting and redistributing hydrocarbon drainage catchments; trap integrity by reactivating trap-bounding elements multiple times during the Cenozoic; and paleo-topography on the sea floor which controlled the deposition of potential reservoirs. In addition, the Cenozoic deformation has controlled the maturation of source-rock intervals by creating a complex burial and uplift history that can vary over the scale of a deepwater lease block. Therefore, understanding both the regional and local structural evolution is crucial for any integrated analyses within this basin.

NOTES:

The importance of the Deep Charge Focus in Sureste Basin, Mexico. Case of study: Zama Light Oil Discovery

Karina Vázquez Reyes and **Mark V Shann**
Sierra Oil & Gas

Zama-1 is a 30º API oil discovery in the offshore Sureste Basin, Mexico with approximately 2 bnbbl STOOIP and up to 900 mmbl of recoverable oil. Worldwide, this was the largest shallow-water discovery in 2017 and the first successful wildcat drilled post-Mexico energy reform.

The reservoirs comprised Late Miocene stacked sands, with the main zone presenting a clear DHI flat spot at ~3,500m depth with a three-way structural trapping geometry against a large Pliocene-Pleistocene fault (Premier Oil website).

Petroleum charge is interpreted to be from the well-known Tithonian source rock that is extensive across the offshore Sureste Basin. This is a world-class source rock that has expelled multiple billions of barrels of oil across Sureste Basin, with average characteristics such as >5% TOC, HI 600 and around 70-200m thickness (Roman y Holguin, 2001).
Based on this published information, plus proprietary seismic interpretation, a 3D charge model was built for the Zama salt mini-basin. This was used to simulate the generation, migration and accumulation of Tithonian oil into the Late Miocene Zama sands.

Three key elements to understand the petroleum system working in Zama are: deep charge focus, fetch cell size and implied potential migration losses plus the Miocene trap timing and associated seal capacity. Three main objectives are presented in this paper: -
(1) to demonstrate the importance of the deep charge focus
(2) to understand the charge UEP (ultimate expelled potential)
(3) to estimate potential migration losses from the fetch cell mapping, plus charge timing vs. trap formation.

This work confirmed the substantial thickness of Tithonian source rock that must underlie the Zama salt mini-basin given the 2 bnbbl STOOIP discovered and this has regional implications to the overall source richness offshore Sureste.

This paper also re-enforces the importance of deep migration focus that is a recognized key prospect-risk-element in many parts of the world, for which some examples will be shown. Deep charge focus also featured in the pre-drill exploration risk assessment for Zama.

NOTES:

Integrated Seal Analysis in the Sureste Basin, Mexico

Brian O'Sullivan
Premier Oil

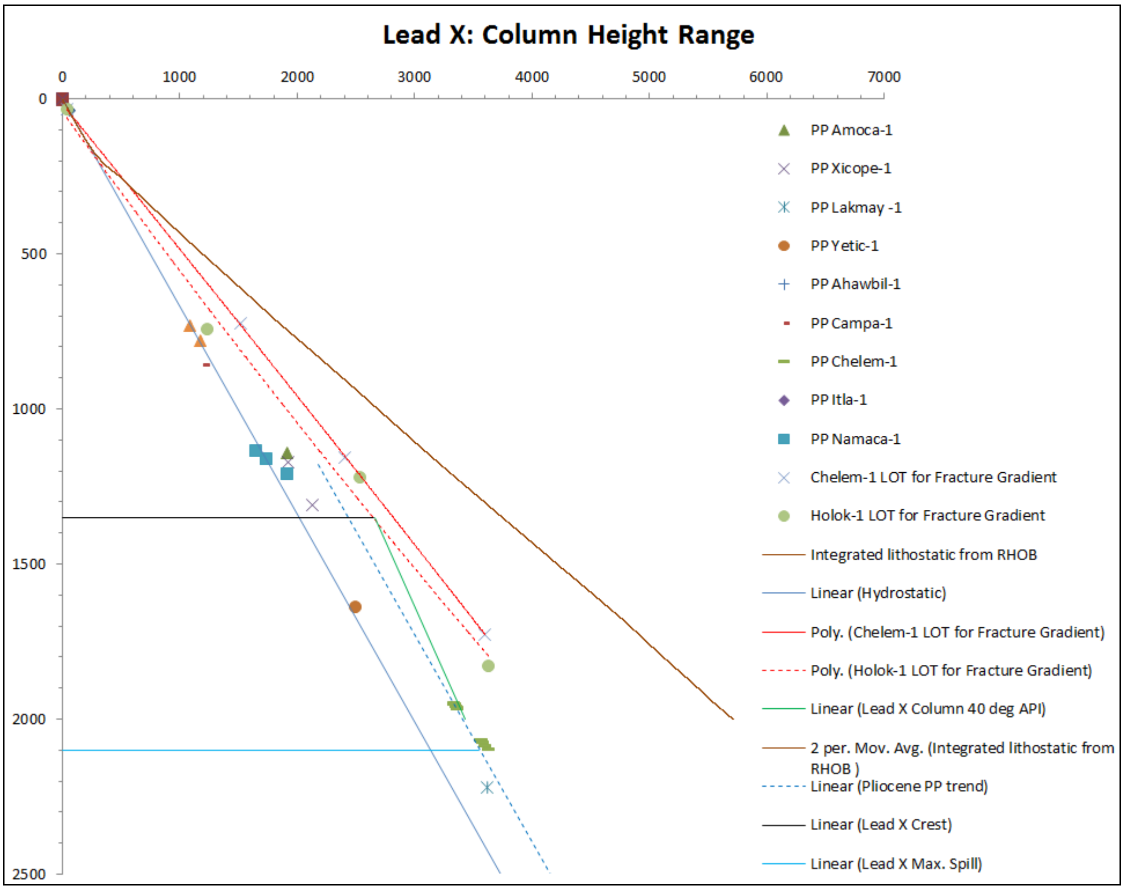
Seal effectiveness and capacity is a key control on the hydrocarbon habitat of the Sureste basin, where column heights can range from tens of metres in the western parts of the basin, to c. 2200m at Cantarell in the east. This was further demonstrated in 2017, where a c. 850m oil column was intersected by the Zama-1 exploration well. A seal analysis of the basin was conducted as part of Round 2.4 and 3.1 screening, which aimed to understand the distribtuion of and controls on column heights in the basin, as well as reasons for trap breach or seal failure.

An integrated approach was taken, where top and lateral seals were looked at holistically, with pressure as the dominant factor controlling mechanical or capillary seal strength. These parameters were then integrated with the geometry of the trap (Sales, 1997) both to describe the columns in proven accumulations, as well as predict a better constrained range of column heights for leads and prospects.

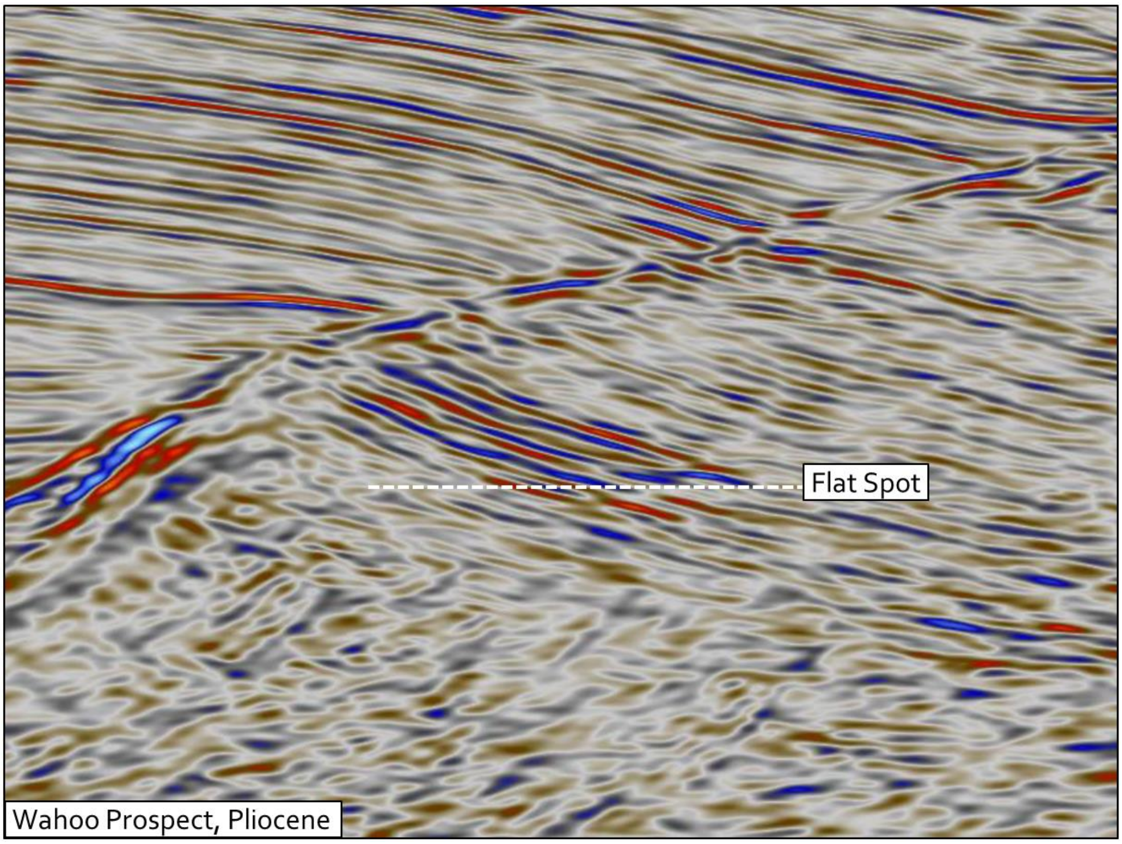
Premier Oil's interests were in the Miocene and Pliocene plays. The Miocene is a well drilled and understood play in the Sureste, with some high quality data aquired by Pemex in their legacy wells. Formation pressures typically ramp below around 1500m, or the Mid Miocene Unconformity (Xicope), but despite this barrier, column heights vary widely. All wells reviewed showed evidence of charge, which is reasonable in such a hydrocarbon rich basin. Mechanisms proposed for breach or short columns include mechanical failure or faulted crests (Holok) and geometry; where 4-ways with excess closure can lack a pressure valve, or silty topseals limiting capiliary sealing capacities (Lakach).

Long columns are sometimes helped by structures cresting above the fluid retention depth (Cantarell). Zama is a protected trap, with the thick Miocene sands regressed relative to the overlying shale. The pressure here may be valving via laterally continuous sands to a higher point in the pressure cell, or via the active bounding fault, allowing excess pressure to periodically bleed off. Either way, the Zama seal is enhanced by the shale-sand pressure differential. The nature of the lateral seal is uncertain. Footwall traps like Zama tend to occur in close proximity to salt, and are likely to be at least partially sealed on remnant evaporites where the fault grades into an incomplete vertical salt weld (Rowan, 2004, 2012). A bend in the bounding fault at this location is observed which would localise strain to facilitate a pressure valve. This may have been a necessary mechanism to allow later gas entering the trap to pass through the top. Seeking such trap geometries conducive to long columns and consequent resource density was key to screening for further material prospects.

The Pliocene, despite its youth, has managed to get buried deeply enough for significant accumulations, as proved by Pemex, and latterly ENI, at the AMT (Amoca-Mizton-Tecoalli) fields. Pliocene pressure profiles differ from the Miocene, in that fields and discoveries are near normally or mildly overpressured. Mechanical failure is much less of a concern in this play, while 4-ways are uncommon, and soft, clay rich top seals are available. Large counter regional listric growth faults set up the structures in the Comalcalco sub-basin, and footwall traps were identified within large closures. The integrated seal concepts were used to estimate potential column heights for these propects, and despite being different plays, the Pliocene prospects look remarkably similar in terms of trap configuration, geometry and DHI to Zama in the Miocene. In terms of potential seal capacity, pore pressure is the dominant factor, irrespective of stratigraphy.



Lead X: Column Height Range
0
1000
2000
3000
4000
5000
6000
7000
0
500
1000
1500
2000
2500
PP Amoca-1
PP Xicope-1
PP Lakmay -1
PP Yetic-1
PP Ahawbil-1
PP Campa-1
PP Chelem-1
PP Itla-1
PP Namaca-1
Chelem-1 LOT for Fracture Gradient
Holok-1 LOT for Fracture Gradient
Integrated lithostatic from RHOB
Linear (Hydrostatic)
Poly. (Chelem-1 LOT for Fracture Gradient)
Poly. (Holok-1 LOT for Fracture Gradient)
Linear (Lead X Column 40 deg API)
2 per. Mov. Avg. (Integrated lithostatic from RHOB)
Linear (Pliocene PP trend)
Linear (Lead X Crest)
Linear (Lead X Max. Spill)



Flat Spot
Wahoo Prospect, Pliocene

NOTES:

Salt – carbonate interactions in the Sureste Basin, SE Mexico; depositional models and analogues for Cretaceous carbonate breccias

Peter Gutteridge[1], Andrew Horbury[1], Yohann Poprawski[2],
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[2]*freelance geologist, Geologic-diffusion*

Cretaceous carbonate breccias form important reservoirs in the offshore of the Sureste Basin in SE Mexico. These breccias comprise thick deposits of very coarse cobble to boulder-sized clasts that were derived from shallow water platform interior settings. A number of different breccia types are present. Detrital breccias were deposited by various mechanisms including debris flows, grain flows and turbidites are interbedded with pelagic carbonates implying deposition in a basinal setting. Many of occurrences of these breccias are remote from possible detrital sources such as carbonate platforms located over the Yucatan and Chiapas basement blocks. Similarly, the extreme coarse grained nature of the sediment implies very proximal deposition. Breccias often also contain evidence of karstification and collapse brecciation.

Movement of the underlying Callovian salt influenced carbonate sedimentation throughout the Mesozoic and a model for salt – carbonate interaction is presented whereby carbonate platforms were initiated over salt highs. During the early stage of growth, these platforms had low energy facies and slumping down their flanks. These developed into mature carbonate platforms either by further uplift of the salt high grew or by upward growth of the platform above wave base. Facies include peritidal platform interior carbonates with bioclast grainstone shoals at the platform margins. Associated slope deposits include bioclastic and lithoclastic carbonate breccias and turbidites. Further growth of the salt structure leads to exposure of the carbonate platform associated with karstification and collapse brecciation. Salt may also be withdrawn at any time during this cycle causing collapse of the carbonate platform leaving behind a body of collapse breccia enclosed by basinal facies.

A possible analogue for this system is provided by the Bakio salt diapir and associated Albian carbonate breccias in NE Spain. A carbonate platform developed over the growing salt diapir during TSTs. Progradation of the platform during HSTs stimulates growth of the diapir and causing uplift and karstification of the platform and shedding of carbonate breccias down the flanks. These flank deposits are steeply-dipping and may be further rotated during later diapir growth; if encountered in vertical wells this may give the impression of a thick breccia deposit. This model of the interaction between syn-depositional salt movement and carbonate production allows proximal carbonate breccia reservoirs to be generated in basinal areas.

NOTES:

The Sureste Basin of Southern Mexico: "Future Opportunities and Key Challenges Ahead"

Mark Shann
Subsurface Director Sierra Oil and Gas

The Sureste Basin of Mexico is a story of split exploration maturity, with more than 139 discoveries in the onshore and shallow water area of the Sureste Basin in a series of stacked prolific plays, but less than nine exploration wildcats in water depths > 500m, despite the presence of wide seabed oil seepage indicating a regionally mature world-class source rock being present across the deep-water Campeche Slope.

With the 2014 opening of Mexico's oil industry, widespread state-of-the-art seismic imaging of this under-explored deep-water extension to the Sureste Basin has now been acquired and is in the hands of IOC's that hold substantial exploration well commitments over the next few years.

This paper discusses the play potential present, including and beyond the Late Miocene Zama giant oil discovery of 2017 from the perspective of Sierra Oil & Gas, who hold six large blocks offshore Sureste, a company founded in 2014 to focus solely on Mexico.

Both the classic US-GOM style salt-deformed slope clastic systems are present, as well as significant carbonate potential for which there are few specific reservoir analogues outside of Mexico, so a resume of Mexico's extensive breccia and underlying oolites is very relevant. 19 of the 20 largest fields in Mexico are carbonate.

Subsurface challenges originating in Sierra's dry hole analysis relate to charge timing, sub-salt deep structural imaging and column height prediction, given the high relief nature of many of the undrilled salt related structures.

NOTES:

Session Six: Salt Tectonics – Sureste and Campeche Basins

KEYNOTE: Diapirism, contraction and extension in the shelf and deepwater provinces of the southern Gulf of Mexico

Mark G. Rowan
Rowan Consulting, Inc.

The Upper Jurassic to Recent evolution of the southern Gulf of Mexico (GoM) was dominated by salt diapirism, long-lived contraction and, in proximal areas, late extension. Both gravity-driven deformation and orogenic contraction were detached on the Campeche salt, which was deposited during the latest stages of crustal rifting, just prior to oceanic spreading. Counter-clockwise rotation of Yucatan about a pole located near western Cuba resulted in a dominantly transform margin, with a possible basement high, along the western edge of the southern and central Bay of Campeche.

The Late Jurassic to Cretaceous was characterized by gravity gliding due to basinward tilt of the margin as the newly formed oceanic crust cooled and subsided. Although tilt might be expected to have been toward the west (oceanic crust), published maps show Upper Jurassic normal faults curving from E-W trends in the onshore Salina del Isthmo to NNW-SSE trends along the Yucatan margin, suggesting convergent movement. It is likely that the directions of translation were complex due to the interaction of the arcuate carbonate margin, the patterns of thermal subsidence and the possible basement high along the transform margin.

The Paleogene to middle Miocene was dominated by orogenic contraction. Although it was directed generally toward the NE, the shape of the salt basin in front of the foreland-propagating Chiapas thrust sheets resulted in rapid advance of the deformation above the salt and a consequent overall arcuate belt of deformation that was superimposed on the earlier structural architecture. Deformation was ongoing during the Paleogene, slowed during the early Miocene, and increased again during the middle Miocene Chiapaneca event.

The late Miocene to Recent has been characterized by gravity spreading driven by sediment progradation from the Chiapas Mountains into the Bay of Campeche. The resulting linked system of proximal extension and distal contraction was, again, superimposed on earlier structures. Movement was toward the NNW but divergent, controlled in part by the distribution of the salt detachment as well as a Paleogene shale detachment.

The structural styles resulting from this complex evolution vary greatly across the region and can be divided into five provinces from proximal to distal: 1) the Reforma-Akal domain; 2) the greater Comalcalco extensional domain; 3) a polygonal central domain; 4) a curvilinear outer domain; and 5) the Catemaco shale-detached foldbelt.

1. The Reforma-Akal domain experienced little Upper Jurassic to Cretaceous deformation, probably because it was in the early translational province between more proximal extension and distal contraction. The relative lack of early deformation resulted in the development of simple linear folds and thrusts trending NNW-SSE during the orogenic event. There was little extensional overprint because the domain formed a mostly undeformed raft between the Macuspana and Comalcalco extensional systems.

2. The Comalcalco domain is characterized by complex array of late extensional structures. These were overprinted on a combination of established diapirs, salt sheets/canopies, and early contractional structures. Extension was dominated by counter regional fault systems, some detached at the Campeche salt level and others detached on the shallow salt. Pre-existing diapirs widened and collapsed, with upper Miocene to Recent depocenters sinking into the diapirs.

3. The central domain comprises a complex polygonal array of folds, thrusts, squeezed diapirs, and pop-up structures. Deformation commenced during the Late Jurassic, generating structures with highly variable orientations due to the convergent movement. This pattern influenced all subsequent deformation events, so that each phase of shortening, whether gravity-driven or tectonic, was accommodated by reactivation of structures with equally variable orientations, with strike-slip deformation and vertical-axis rotation of mini basins prevalent. Most structures extend away from or link diapirs, with the diapirs having been initiated by contraction and squeezed throughout their history.

4. The outer domain is also characterized by folds, thrusts, and squeezed diapirs, but with three key differences. First, individual structures are more linear, but form an arcuate belt trending N-S in the west to ENE-WSW in the north. Second, many of the structures are disharmonic due to the presence of a Paleogene shale detachment in the west. Third, there was no to minimal early deformation, with most or all of the shortening occurring since the late Miocene. Diapirs were triggered relatively late and thus required enough erosion of the fold crests or thrust hanging walls to allow salt to break through.

5. The Catemaco foldbelt, outside the western limit of the salt and above oceanic crust, contains linear folds detached on the Paleogene shales. These were active during the late Miocene to Recent, and the shortening was linked to the salt-detached deformation by oblique ramps climbing up-section from the basinward limit of salt.

The structural styles and evolution described here have important ramifications for various elements of the petroleum system. This includes: the timing of trap formation and modification/amplification; the nature of three-way truncation traps beneath shallow salt; the evolution of sediment fairways, for example from unconfined to moderately confined in the west; local variations in thermal history and source-rock maturity, such as for the shallow Upper Jurassic to Cretaceous carbonates above pop-up structures; hydrocarbon charge scenarios where the deformation is decoupled; the distribution of geopressure and pressure-protected traps; and the likelihood of seal against vertical and thrust welds.

NOTES:

Structural evolution of a salt diapir and associated normal faults in the Sureste Basin, Mexico

Marc Giba[1], Markus Mohr[1], Mathias Stumpfe[1], Christoph Schneider[2], Oliver Cheshire[3], James Clark[4]
[1]*DEA Deutsche Erdoel AG*
[2]*Wietze Laboratory DEA*
[3]*Premier Oil plc*
[4]*Sapura Energy Berhad*

The structural evolution of salt diapirs and associated deformation is a key aspect which needs to be understood when exploring for hydrocarbons in salt basins. Structural traps often exist at flanks and on top of salt diapirs as well as along faults related to salt diapirs. The development of salt diapirs also has a major influence on sedimentation with phases of vertical salt movement usually related to non-deposition of sandstone reservoirs on top of salt diapirs but with sandstone fairways mainly located in mini-basins in between salt diapirs. The structural evolution of salt diapirs has therefore important implications for reservoir deposition and for the migration history of hydrocarbons.

In this study we investigate the detailed temporal evolution of one specific salt diapir located in the Sureste Basin in the southern Gulf of Mexico. In this basin, salt deposition started in the Mid Jurassic with salt diapir development assumed to have commenced shortly after initial deposition (Pindell and Kennan 2009). In Late Jurassic to Cretaceous times, carbonate sedimentation prevailed followed by deposition of mainly basinal shales in the Paleogene and sands and shales during the Neogene and Quaternary.

During the Miocene, compressional structures developed in the Sureste Basin and salt diapirism and mini-basin development accelerated. Within mini-basins, thick accumulations of siliciclastic sediments occurred throughout the Mid Miocene-Recent. During the same time, counter regional listric normal faults also developed. A gravitational origin of faulting is generally assumed with the detailed timing of fault movement not yet determined.

The analysis of salt diapir evolution is based on 3D seismic data and wells near the salt diapir. Salt interpretation is done on seismic data with the top of salt readily identifiable. Flank and feeder of the salt diapir have less reliable interpretations due to poor seismic imaging close to the salt diapir. The interpreted salt diapir geometry is very complex with a deformed diapir shape and normal faults atop (see figure 1). A large listric normal fault, which offsets the seabed, passes into the diapir and several active antithetic faults also exist above the salt diapir.

The development of normal faults in the vicinity of the salt diapir was analysed using fault displacement methods. For this purpose, displacements along the fault surfaces were measured on late Neogene horizons. Backstripping of displacements then allowed the reconstruction of the fault development through time (Childs et al. 1993).

For the development of the salt diapir, detailed biostratigraphic analysis is used to determine the ages of identified hiatuses and condensed sections. Several condensed sections observed in wells can be correlated with local unconformities near the salt diapir identified on seismic data. Unconformities near the salt diapir are interpreted to reflect vertical movements of the salt diapir. Detailed mapping and dating of unconformities is therefore used to reconstruct the temporal evolution of the salt diapir.

The combination of unconformity and fault displacement mapping is then used to decipher the interplay between salt diapir development, normal faulting and sand deposition. The results of the study indicate that Neogene activity of the salt diapir mainly occurred during Early to Late Miocene times. Normal faulting started in the Pliocene and resulted in the development of a large listric counter regional normal fault and associated antithetics. Normal faulting is still ongoing and it is assumed that extension accommodated by the normal faults in the Pliocene to Recent section is balanced by widening of the salt diapir at depth.

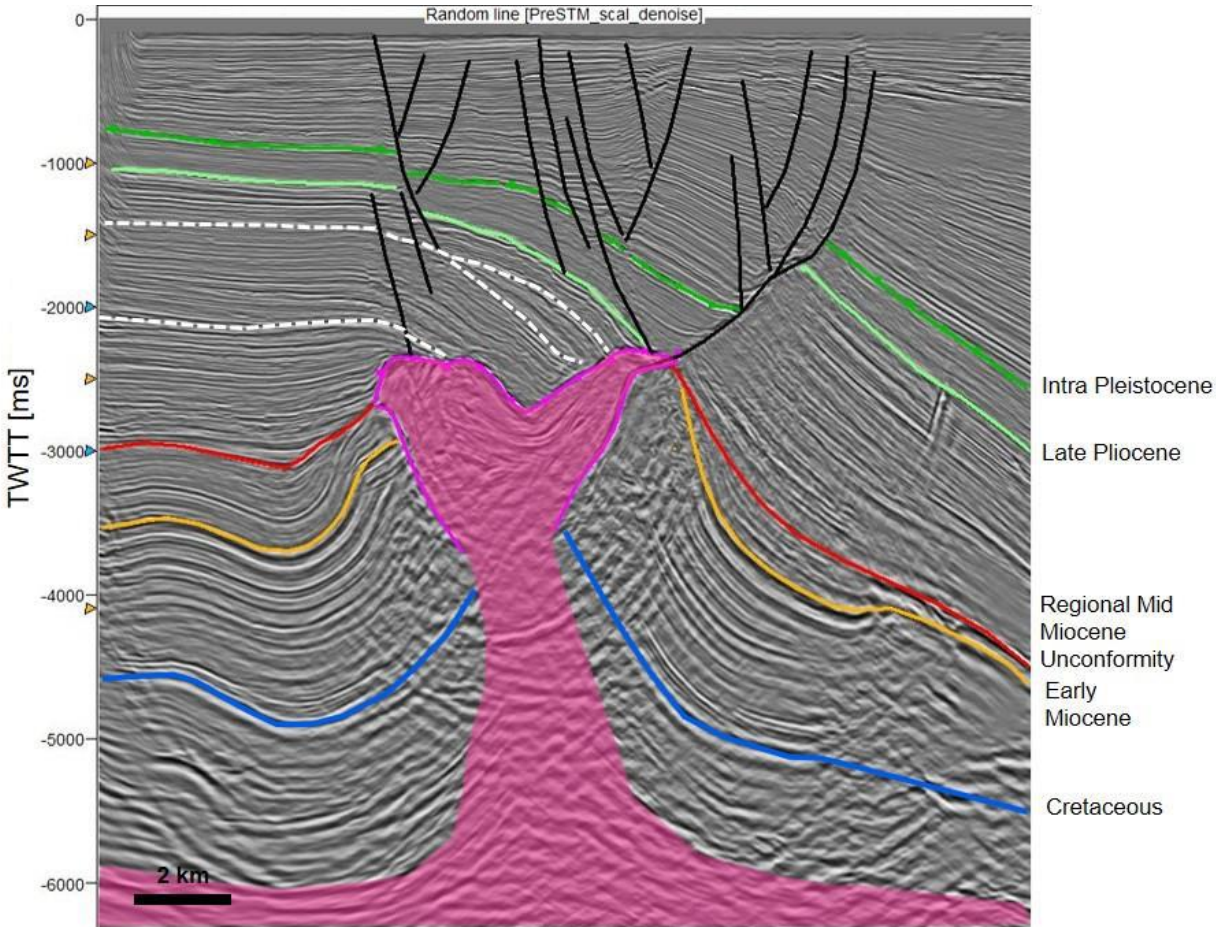

Figure1: Seismic section showing the studied salt diapir (pink) and associated normal faults (black). Interpreted seismic horizons are dated using biostratigraphic markers from nearby wells. Selected unconformities are shown as dashed white lines.

NOTES:

Miocene Compressional Tectonics in the Campeche Salt Basin SE Mexico

Ian Davison
Earthmoves Ltd.

The Campeche Salt Basin is interpreted to have been deposited in Bajocian times, at the end of the main extensional rift phase, with the base salt being a fairly continuous flat surface across most of the deepwater salt basin. However, rifting continued around the shallow edges of the basin up to the end of the Kimmeridgian (ca. 150 Ma) and in the ultradeepwater along the frontal edge of the salt basin in North Campeche. The main extension direction is still not clearly defined in the shallow water, but is expected to be approximately NW-SE from plate tectonic reconstructions; and the overall present day basin tilt is also towards the NW.

The salt basin and the sedimentary cover have been compressed since the Mid-Miocene (ca. 20 Ma) up to the present day by NE-SW directed shortening (Chiapaneco event) associated with formation of the Cocos Spreading Ridge and subduction of this ridge below Mexico. Mid-Miocene compression produced intense squeezing of pre-existing diapirs leading to extrusion of a vast allochthonous salt canopy in mid to late Miocene times in the onshore and shallower (<2000m) offshore area of the salt basin. These salt sheets have been continually deformed to the present day by subduction-related stresses and became folded, producing attractive sub-salt anticlinal traps. However, the structures at the top of the salt sheets are discordant with the folding at the base salt sheet level making seismic imaging difficult.

In areas where the salt was deeply buried, Miocene compression produced salt-cored anticlines, and caused the folding and overthrusting of Mesozoic carbonate slabs which were uplifted several kilometres and laterally displaced up to 20 km. Some of the overthrusted carbonate slabs became exposed at the seabed soon after the onset of the Mid-Miocene compression. Fracturing and karstification of the exposed carbonate sheets will have significantly enhanced the reservoir potential of the previously deeply-buried Jurassic carbonates. However, no exploration wells have been drilled to test this play type so far. The salt can be diapiric in the anticlinal cores where the overburden lid was sufficiently thinned by erosion so that the compressed salt broke through, and extruded at the surface. Salt dissolution led to collapse of the overlying carbonates which may have further enhanced the Mesozoic reservoir quality.

A NW downward tilt to the basin was produced during Cretaceous thermal subsidence which has been enhanced by Tertiary sediment loading. This has produced NW directed downslope sliding with large extensional counter-regional faults producing NE-trending Pliocene-Recent minibasins in the hanging walls. The counter regional faults developed on previously extruded allochthonous salt sheets which reached seabed soon after the Mid-Miocene compression initiated. Up to 4 km of strata was deposited in less than 2 million years within these minibasins, with deposition of key Mio-Pliocene reservoirs of the Magallanes, Cinco Presidentes and Orca Formations. Such rapid sedimentation implies a significant increase in denudation some 2 Myr ago. This is probably due to enhanced uplift during a compressive phase along the Pacific subduction zone perhaps due to subduction of larger volcanic complexes along the Cocos Ridge. Although the cause is still not clearly understood. Finally, gravitational toe folding was also developed in the Pliocene to Recent (0-2 Ma) along the frontal edge of the salt basin. The complex interplay between NE directed thrusting, and NW directed downslope tilting and sliding led to the large arcuate fold pattern observed at the present day.

NOTES:

Mexico offshore: New Insight into Structural Evolution and Salt Deformation through Structural Restoration, Campeche Basin

Malcolm Francis, Sebastian Villarroel, Sylvia Centanni, Mohamed El-Toukhy, Edgar Galvan, Jonathan Hernandez, Kevin Lyons, Maxim Mikhaltsev, Liubov Mulisheva, Clara Rodriguez, Fred Snyder, Raul Ysaccis
Western Geco

The aim of this study is estimation of the shortening experienced by the sedimentary column mainly in the Salina del Istmo Basin, offshore Mexico, a 2D restoration program was used, focused on the geometrical response to the last contractional event (NW-SE). A special caveat to be considered are the high structural complexity and in- and out-of-the-plane movements and different stress field orientations that make this 2D approach viable only for the mentioned contractional pulse.

A complex structural deformation history characterizes the Mexican portion of the Gulf of Mexico deep-water area. The basin opened during Lower to Middle Jurassic. Extensional grabens were created following rotational movement of the Caribbean, North American, and Cocos plates. Two main contractional pulses can be recognized in this portion of the Gulf of Mexico. Studies suggest that the first phase was caused by the Upper Oligocene to Lower Miocene Laramide Orogeny and was characterized by a southwest – northeast orientation. This tectonic period was responsible for creating faults, ramps, and detachment surfaces along salt and, in some cases, along the Eocene shales. In other cases, the shales formed anticlines that were completely decoupled. This relationship between coupled and decoupled structures can define different trap timing in distinct parts of the area. The subsequent contractional phase was related to the compressive event of Middle Miocene to Pliocene and is characterized by a southeast – northwest orientation. This phase represents the last folding and faulting recognized on seismic data and, thus, this orientation was used for the structural restoration.

NOTES:

Session Seven: Compressional Tectonic Regimes

Evolution of kinematically linked structural systems above a contiguous salt and shale detachment surface in the Western Gulf of Mexico

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The Gulf of Mexico Basin has a complex post-rift evolution owing to gravitational collapse and translation above a number of detachment surfaces including Middle-Late Jurassic Louann Salt (autochthonous/para-autochthonous and allochthonous detachment surfaces) and Middle Tertiary shales. The deepwater foldbelts at the distal end of these gravity systems are important exploration targets in the region. In the western Gulf of Mexico, where the Louann Salt Basin joins the Mexican Ridges there is a switch in structural style from one of salt-detached deformation to shale-detached deformation. At a time when exploration is expected to extend southward through this area, we use new interpretations based on the latest seismic processing to give an overview of the structural styles and their evolution.

In the North of the study area near the US-Mexico border, deformation is primarily salt-involved with two key features; (1) the Perdido Foldbelt, an Oligo-Miocene age toe-of-salt foldbelt detached on the deep Louann Salt, and (2) the Sigsbee Salt Canopy produced during the Eocene-Recent as salt was evacuated from an outer-marginal trough. Shale-detached deformation becomes more prominent southward through the survey and mainly comprises foldbelts around the periphery of the Sigsbee Salt Canopy. Of great surprise, is the distinct lack of an updip extensional shale detachment posing interesting questions about the mechanics of foldbelt development.

Clues lie in the close stratigraphic relationship between the shale detachment and the base of allochthonous salt. Well data indicate that the shale detachment sits within sediments equivalent to the Late Eocene Claiborne Group. Progressively southward, the duration of salt canopy emplacement shortens from Eocene-Miocene to a focused pulse in the Late Eocene contemporaneous with deposition of the Claiborne shales, producing a single detachment surface. Our restorations show that the shortening recorded in the shale-detached foldbelts is driven by extensional collapse at the head of the salt canopies.

Toward the southern limit of the Louann Salt Basin where shale-deformation is more prominent there are examples of the opposite dynamics with updip shale-extension strongly influencing contractional salt deformation. In conclusion, the western Gulf of Mexico displays a complex variety of salt and shale tectonic deformation which our work shows to be kinematically linked along a contiguous detachment surface.

NOTES:

Tectonic, structural, and stratigraphic controls on hydrocarbon prospectivity in the Mexican Ridges deep-water fold-belt, western Gulf of Mexico

Jack Kenning and Paul Mann
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The Mexican Ridges fold-belt (MRFB) is a 600-km-long, submarine, passive margin, fold-thrust belt that trends parallel in water depths of 500 to 3000 m along the eastern continental margin of Mexico. The MRFB formed by late Miocene gravitational gliding and spreading along multiple detachments following up-dip gravitational failure along the Quetzalcoatl extensional system in the shelf and coastal area of eastern Mexico. The MRFB is detaches on Paleogene shales deposited above a substrate of either thinned continental crust or late Jurassic oceanic crust that post-dated the separation of the Louann salt body of the northern Gulf of Mexico (GOM) and the Campeche salt body of the southern GOM.

A 20,000 km grid of 2D depth-converted industry seismic data, tied to two wells, was used to map the underlying structure, shale-based detachments, and the regional structural geometry of the MRFB in order to assess its along-strike, hydrocarbon prospectivity. A fundamental control on the structure of the MRFB is the basin-ward slope angle of the top Cretaceous shelf that underlies the up-dip areas of the northern and southern MRFB: steeper dips of the northern MRFB correspond to a wider (200-260-km) fold-belt run-out and greater amount of up-dip extension (>30-km) along the primary listric fault trend. Shallower dips of the southern MRFB correspond to a narrower (200-115-km) run-out and more limited up-dip extension.

A second fundamental control on the structural style of the MRFB is the presence, map-view shape, and thickness of mass transport deposits (MTDs) of Eocene and Oligocene age. In the area of greatest run-out in the central MRFB, seismic characterization and mapping has identified the detachment shales as a delta-shaped, 500-1500-m-thick wedge of stacked MTDs that form at least two detachment surfaces within the fold-belt. Deposition of these regionally extensive MTD events is interpreted to be a result of the Paleogene Laramide orogenic activity that produced thrusting, folding, and uplift along the adjacent Sierra Madre Oriental orogenic front.

In areas of the northern MRFB where composite MTDs are up to 1500-m in thickness, the overlying style of the fold-belt displays: 1) shorter wavelengths (2-7-km), 2) larger amplitudes (350-1,050-m), and 3) tighter inter-limb angles (50-105°). The presence of thicker, mechanically weaker, MTD shales relative to overburden thickness in the north is interpreted to have resulted in faster gravitational spreading and could partially explain observed differences in fold geometry and distribution, with smaller closures for potential hydrocarbon traps. Area-depth strain (ADS) analysis of fold structures with thicker underlying detachment shales in the northern MRFB suggest that a combination of flexural flow and parallel to bedding pure shear is the dominant mechanism for detachment fold growth across the entire fold belt - in line with previous study in the southern MRFB.

Our observations from seismic indicators, structural geometry, and hydrocarbon seep data suggest that: 1) MRFB MTD shales are over-pressured, with overpressure distribution interpreted as a primary control on detachment, as has been suggested in the analogous Niger Delta, 2) over-pressured clay-rich MTDs thicker than 150-m likely form regional seals for hydrocarbons generated in the underlying Mesozoic section, 3) despite the presence of thicker detachment shales in the northern MRFB, there is still good hydrocarbon prospectivity in overlying fold-belt Miocene reservoirs where locally thrust faults are present that cut through the Paleogene shale MTDs, acting as potential migration pathways.

NOTES:

Geological Interpretation and Petroleum Implication of the North of the Yucatan Platform, Deep Gulf of Mexico

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Basins Research Group (BRG), Imperial College London

The Gulf of Mexico (GOM) is one of the most important and intensely explored petroleum provinces of the world. Today it is one of the most active and successful provinces in the world due to discoveries of new Deepwater plays. Time-migrated 2D seismic reflection data, wells drilled by the Deep Sea Drilling Project (DSDP), in addition to published data, were used in this study for the geological interpretation of an area that includes part of the Deep Gulf of Mexico basin and the northern portion of the Yucatan Shelf (Figure 1).

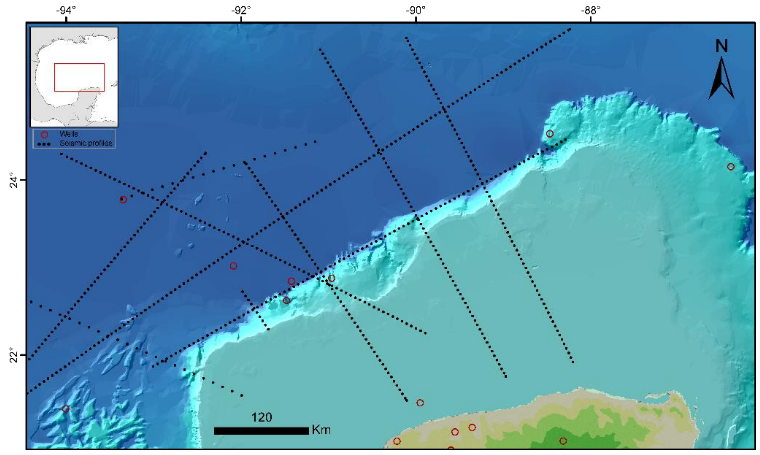


Figure 1.- Location map of the study area in the northern part of the Yucatan Platform.

In the regional framework, the boundaries of the oceanic and transitional crust were defined as well as the distribution of the autochthonous salt. The limits and characteristics of portions of four structural provinces have been defined: Platform of Yucatan, Isthmian Salt, Abyssal Province and Mexican Ridges Fold Belt.

The Isthmian Salt province is subdivided into four subdomains with (1) rotated blocks, (2) synthetic growth faults and rollover systems, (3) diapirs and folds, and (4) thrust and compressional diapirs, each characterised by their structural styles. The previous allowed to define the tectonic evolution and its impact on the sedimentation.

The integrated stratigraphic interpretation allowed the definition of the paleoenvironments of the Syn-rift, Jurassic, Lower-Middle Cretaceous and Upper Cretaceous sequences, in which the paleoenvironmental evolution can be appreciated; from the rifting stage, with predominance of continental and restricted shallow marine environments, to the progressive marine invasion, accentuated by thermal subsidence, caused the flooding of big basement blocks and the development and evolution of a broad platform with associated slope and basin facies. In this interpretation, a new delimitation of the north edge of the Middle-Upper Cretaceous platform and its implication on facies distribution was established.

Paleoenvironmental interpretations of the Paleogene and Neogene provided information on the stages of highest and lowest deposition of sediments in the area, as well as the probable sources of sediments supply and their lithological characteristics. The fact that at the Neogene level there is sandy sedimentation to the abyssal zone in the Sigsbee plain is noteworthy.

With all the information that was acquired during this process of data integration, analysis and interpretation, the presence of the elements (source, reservoir, seal, and overburden rocks) and processes of a petroleum system (formation of traps and evidence of generation and migration) were determined. These results are of major interest for the oil exploration in this portion of the Gulf of Mexico.

NOTES:

Session Eight: Northern Caribbean Regional Tectonics

KEYNOTE: The source rock provinces of the Caribbean by recourse to biomarker and stable isotope data assemblages from produced oils, shows and seeps

Chris Matchette-Downes
CaribX (UK) Limited

Whilst the present day Caribbean comprises of fragmented crustal blocks of varying dimensions spread over a large area it is possible to determine from the generated oil's biomarker and isotope data common source rock characteristics across the region.

In this review, data from the analysis of oil seeps, produced oils and shows collected over decade have been compared and contrasted to determine the likely age and palaeoenvironment of deposition of the precursor source rocks.

Late Jurassic to Miocene source rocks are present variously throughout the Caribbean region, the youngest though not yet mature.

The dominant source rock creation periods are the; Late Jurassic which generated oils with marl to carbonate signature found along the north coast of Cuba, USA (Smackover Fm.), Mexico, Belize and the north coast of Jamaica; the Lower Cretaceous limey mudstones of the south Florida basin and carbonate rich sources found in southern Mexico and Guatemala.

Aptian aged source shales have been identified in Honduras and may occur elsewhere within the region. The Turonian aged La Luna source rocks of Venezuela are perhaps the best known from the wider Caribbean region, but equivalent aged source rocks are thought also be present in Honduras and perhaps Nicaragua. There are also Cretaceous aged source rocks inferred from oils data from Cuba, Dominican Republic, Jamaica, Trinidad, Barbados, St. Lucia, Saba Bank and elsewhere in Nicaragua. In Mexico produced oil from the Sierra de Chiapas region is tied to Cretaceous carbonates and evaporites.

Tertiary source rocks are equally ubiquitous, with oil seeps and shows containing the distinctive biomarker Oleanane in suitable abundance. Robust Tertiary source development is found in Honduras and Jamaica and is implicated through oils analysis in Cuba.

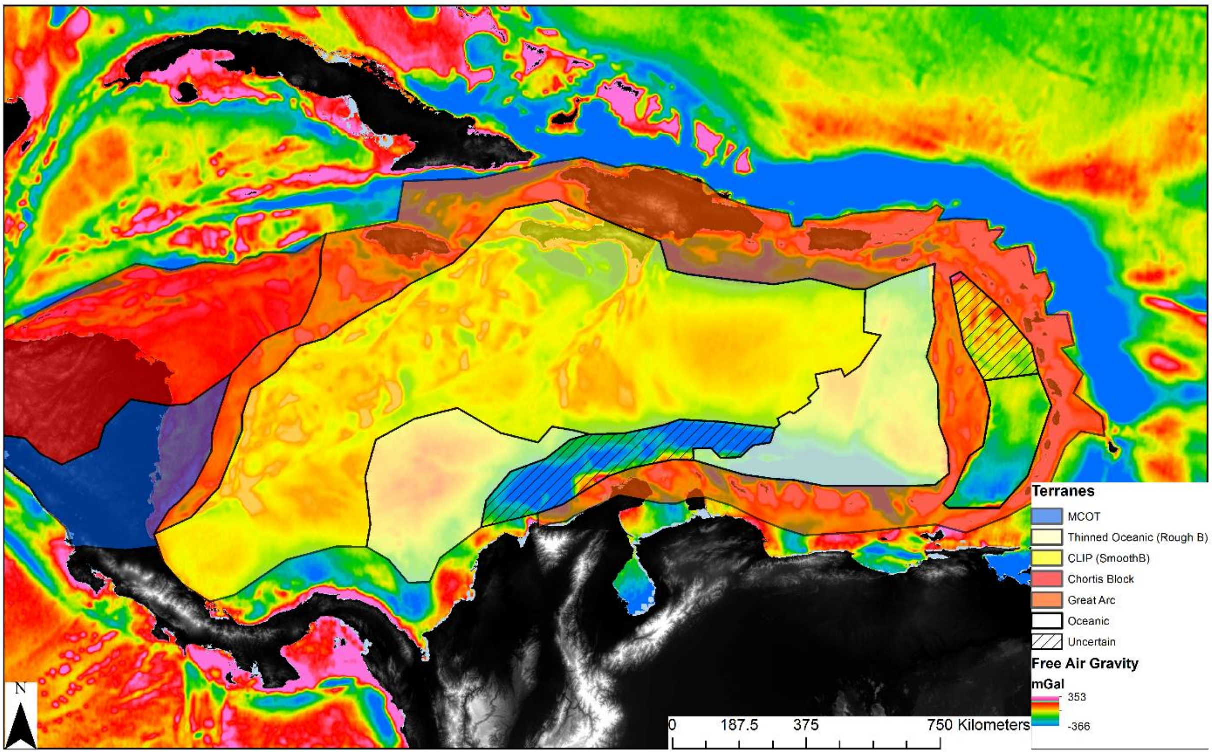
The results of the analysis of some thirty oil samples is presented temporally and spatially and is augmented with data from other sources to delineate and constrain the source systems of the Caribbean.

NOTES:

Determining basement terrane boundaries in the modern Caribbean plate and their impact on regional hydrocarbon systems

Sean Romito, Paul Mann,
University of Houston

The 3,100,000 km^2 Caribbean plate is largely submarine and formed by the late Cretaceous to Miocene amalgamation of five distinctive basement terranes we have defined from: 1) surface geology; 2) 120,000 km of marine, seismic reflection data; 3) 34 seismic refraction profiles; 4) 51 wells, and their overlying source rocks; 5) reservoir rocks, oil and gas seeps; and 6) areas of commercial hydrocarbons. In decreasing order of their areal extent, the five terranes include: 1) the Cenomanian-Turonian Caribbean Large Igneous Province (CLIP) that formed as the central 30% core of the Caribbean plate; evolved as a 12-20-km-thick oceanic plateau in the eastern Pacific Ocean; has an average water depth of 3 km; and is overlain by an extensive 1-12-m-thick OAE2 marine source rock (TOC 2.5-11.1) with associated clastic reservoirs in Miocene to recent submarine fan systems; 2) early Cretaceous-Recent Great Arc of the Caribbean, forms 23% of the plate as a 15-25-km-linear belt that surrounds the CLIP; originated as an intraoceanic arc in the eastern Pacific; is submerged at shallow depths or exposed on land; is overlain by 2.5-3-km-thick carbonate banks and clastic basins; is gas prone, and includes the 2009 La Perla 16 TCF, carbonate-hosted gas discovery offshore Venezuela; 3) the Precambrian-Paleozoic Chortis continental block covering 14% of the plate; formed as part of the 20-45-km-thick craton in southern Mexico; is overlain by 2-5-km of interbedded clastic and carbonate rocks including the OAE3 late Cretaceous source rock of late Ceonomanian-Campanian age (TOC <1-33) along with a younger source rock of Eocene age (TOC 0.85-3.74); 4) middle Jurassic-early Cretaceous oceanic crust is found in the Colombian and Venezuelan basins and covers 18% of the plate; is 3-8-km thick; has average water depths of 3-5.5 km; and is filled with CLIP-comparable OAE2 marine source rock and pelagic sediments; 5) late Triassic-early Cretaceous Mesquito Composite Oceanic Terranes covers 13% of the plate; formed as separate oceanic terranes 20-30-km-thick and accreted to the southern edge of the Chortis block; is exposed in Central America; is overlain by 0.1-0.5-km of Eocene source rocks (TOC 0.5-16.4) on the Nicaraguan Rise; and is oil and gas prone. The areas that I consider with the highest potential - and the least amount of previous exploration - are the largely submarine, basement terranes 1 and 2.



Study location and free air gravity map with terrane boundaries

NOTES:

Regional to basin scale influence of strike slip tectonism on the evolution of the western Caribbean Margin: implications for petroleum play systems in Patuca and Mosquitia

Andrew Long
Subterrane Ltd.

The Honduran Caribbean Margin lies on the eastern bound of a major regional left lateral sigmoidal strike slip fault that has influenced the evolution of the Patuca and Mosquitia basins coevally to transfer of the continental Chortis block to the Caribbean plate.

Utilizing airborne full tensor gravity gradient (ftg) and magnetics, satellite gravity and magnetics, and 2d regional seismic interpretation of Cenozoic well-tied seismic horizons, the evolution of the Mosquitia and Patuca basins are seen to have evolved separately through the Cretaceous to Eocene period as Chortis drifted south.

In mid-Eocene times, the onset of Cayman Trough oceanic spreading, and significant Chortis anticlockwise rotation (Boschman et al, 2014) influenced carbonate deposition within the Patuca and Mosquitia basins within two distinctly different palaeo-marine environments.

The Patuca basin developed syn-tectonically on the margin to the sinistral Eocene opening of the Cayman trough, and rifting proceeded eastwards towards the East Basin and further east. Correlation of seismic mapped Miocene carbonate mounds with terrain corrected vertical gravity gradient tensor (Gzz) reveals a sinistral strike slip fault system that has influenced the growth and distribution of the Patuca's carbonate mounds and sub-basins through the Tertiary rift phase.

To the south, the Patuca and Mosquitia basins are bound by a major sinistral strike slip fault mapped from satellite gravity that extends westward towards the Tela Basin, and eastwards to define the northern limit of the Pedro Fracture Zone.

The Mosquitia basin is defined by a large dextral extensional strike slip fault system mapped from satellite gravity and magnetics that extends onshore Honduras to include the Sang Sang Graben north of the Cocos River, and on trend with the Ulua Olancho basin expressed as a prominent residual gravity trough, but buried by a thick sequence of Tertiary volcanics related to prior fore-arc activity on the margins of the Pacific Trench subduction zone.

The western margin of the Mosquitia basin is defined by a dextral bounding fault adjacent to the uplifted and exposed Cretaceous marine section and older metamorphosed exposure of the Chiapas Massif interior. The Patuca anticline mapped by Mills and Hugh, 1974 lies in a transfer zone to a sinistral strike slip fault system that is linked to the Polochic—Motagua- Jocatan fault system that exposes metamorphosed Precambrian section in the west. Between the western Polochic fault margin, and the eastern bounding fault with the Mosquitia Basin, a broad region of compression is defined by a series of restraining transpressional zones on the margin of a regional left lateral bounding fault.

Within the Mosquitia basin, a number of sub basins are defined by a series of extensional dextral strike slip faults correlative between the satellite and airborne ftg-magnetics survey, and at the Base Tertiary and Eocene horizons mapped from the regional 2d seismic. A seismic defined antiformal structure mapped at Base Tertiary level correlates to a fault bound magnetic basement high in the vicinity of Main Cape-1 which suggests there may be further prospects within the southern Mosquitia hosting potential hydrocarbon prospects.

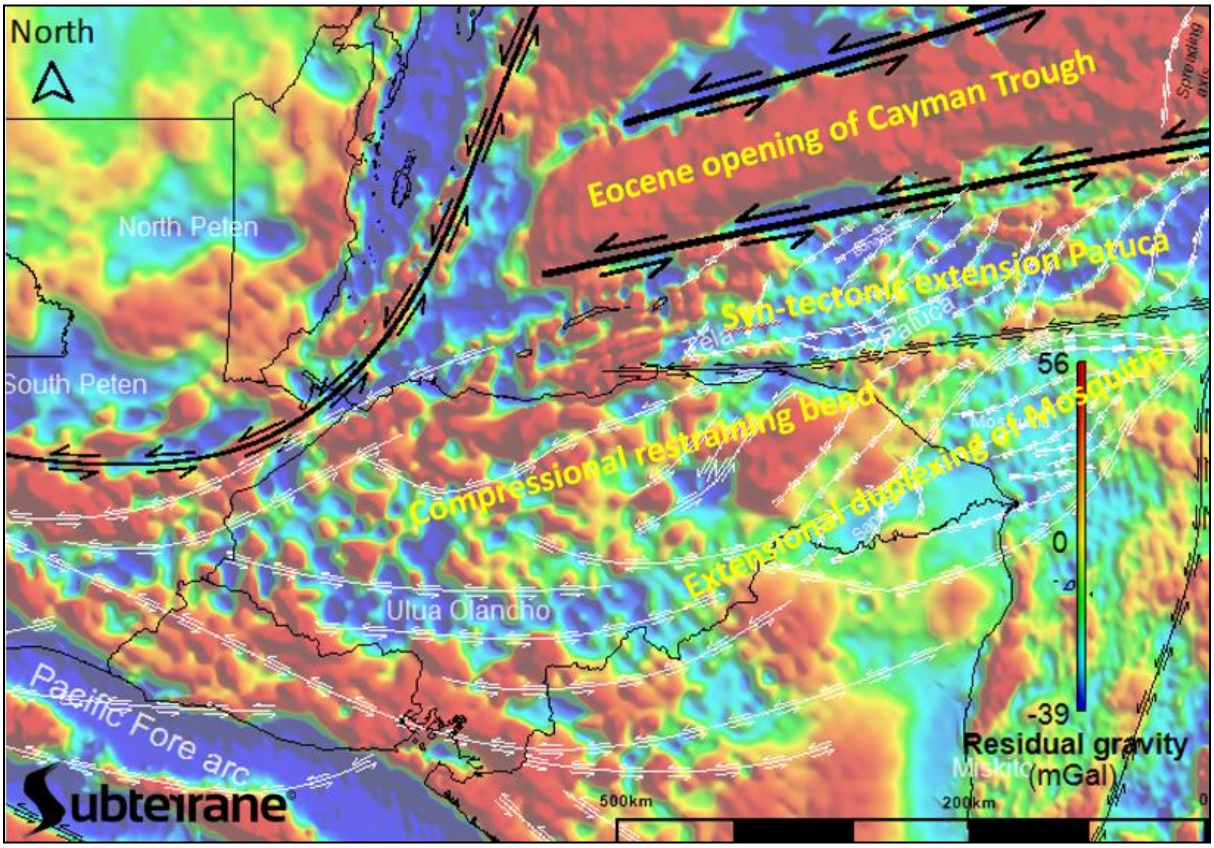


Figure 1: The Honduran Caribbean Margin: Satellite residual gravity derived from Sandwell et al, 2014, showing the main tectonic provinces defining the Patuca and Mosquitia basin systems

NOTES:

Prospective Cuba offshore identified from new 2D seismic data

Shi Kuitai
BGP Multi Client

Background

The Cuba offshore has undergone the same tectonic evolution history with the other parts in the Gulf of Mexico. Both sides have similar geology background and petroleum system, with same chances to deposit thick marine source rocks and effective reservoirs. In the history, most of the exploration efforts have been made on the Cuban northern onshore and nearshore heavy oil belt by Cuban National Oil Company (CUPET) and some international oil companies. And the huge offshore area is still frontier with good potential to find hydrocarbons.

For the purpose of revealing the petroleum potential of Cuban offshore exploration blocks, BGP in cooperation with CUPET, acquired around 27,000km high quality 2D multi-client seismic data from 2016 to 2017(Fig 1). Now, both PSTM and PSDM are available and the imaging of deep section has greatly improved. Petroleum system elements are highlighted through the seismic interpretation.

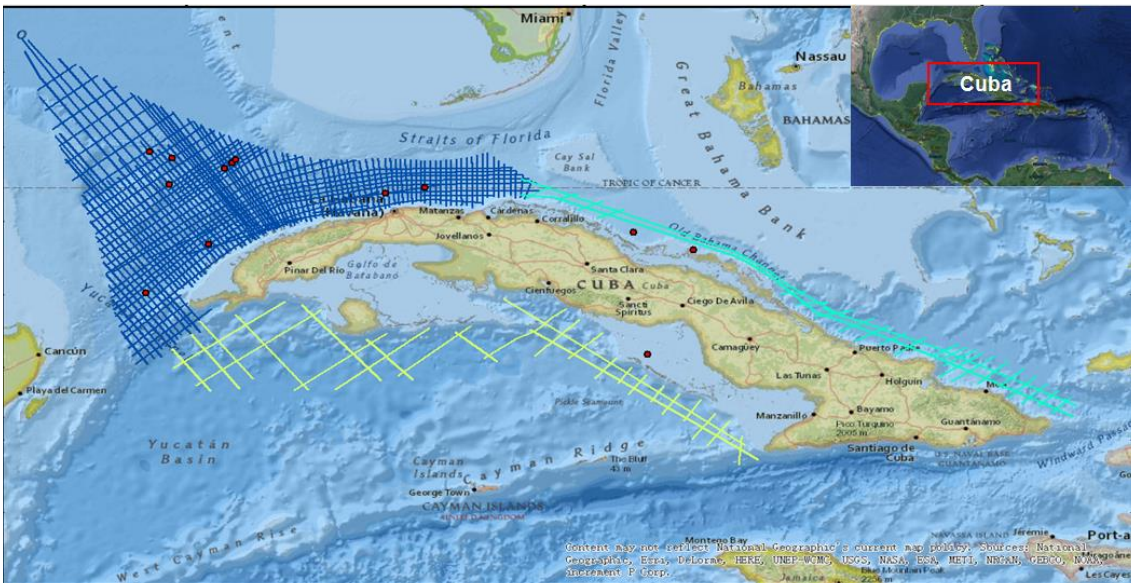


Figure1 Seismic lines of BGP Multi Client 2D seismic survey

Geology Setting

From late Triassic to middle Jurassic, rift sequence were widely developed in Cuban GoM. From the Late Jurassic, passive continental margin sequence caused by transgression was subsequently deposited. Since Late Cretaceous, Foreland basin and Thrust belt formed as the results of the northwards movement of the Caribbean Arc. Cuban offshore comprises of several geology units(Fig 2).

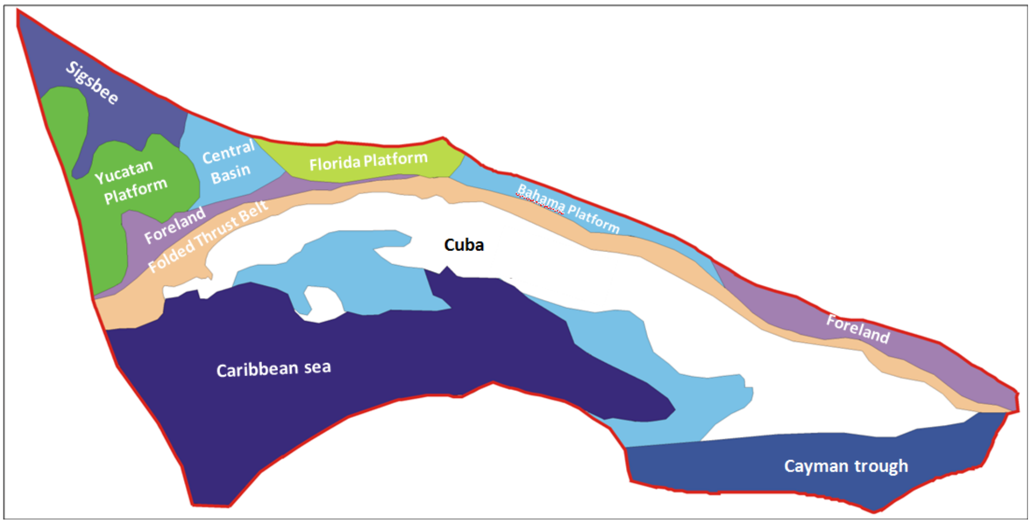


Figure2 Geological units of Cuba offshore

As revealed in the new data, thick Jurassic-Tertiary sedimentary sequences are present in Cuban GoM and NE offshore area (Fig3). Thick Jurassic-Tertiary sequences are the major exploration sections in Cuban offshore containing numerous favorable structural and stratigraphic traps. Pinch out/Anticlines/fault related trap/ Flat spot and many other geological features have been identified in the new seismic data although there are different types of focused traps in the geological units.

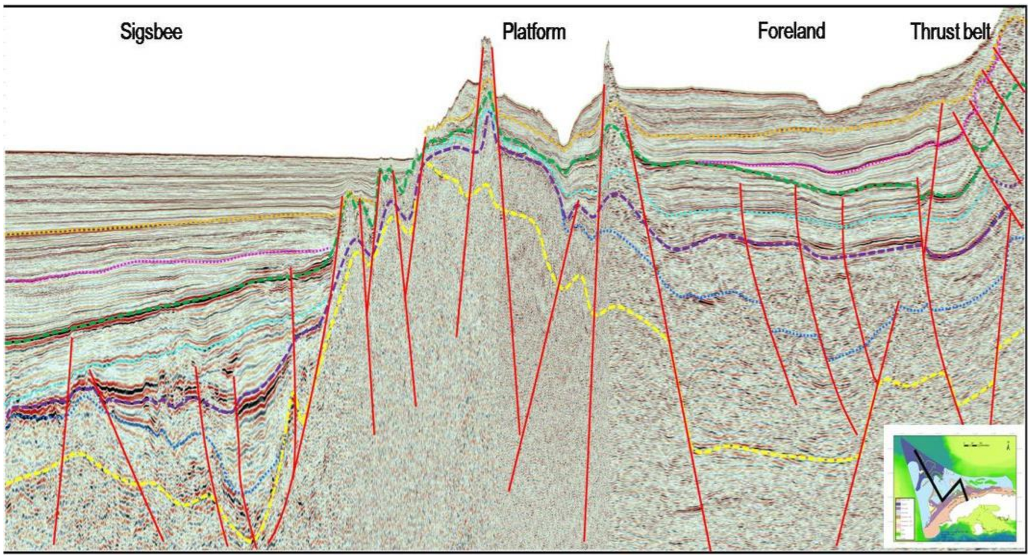


Figure 3 Sedimentary characteristics in geological units

Petroleum Potential highlighted from the newly acquired seismic data

Significant structural and stratigraphic traps have been identified in different geology units of Cuba offshore area (Figs below). Some features have never been seen before. Medium gravity oil (21-22.5°API) produced from new exploration well (drilled 2017) also increase the chances to find lighter oil in Cuban offshore. The average in Cuban fold belt is 9-13°API in oil discoveries before.

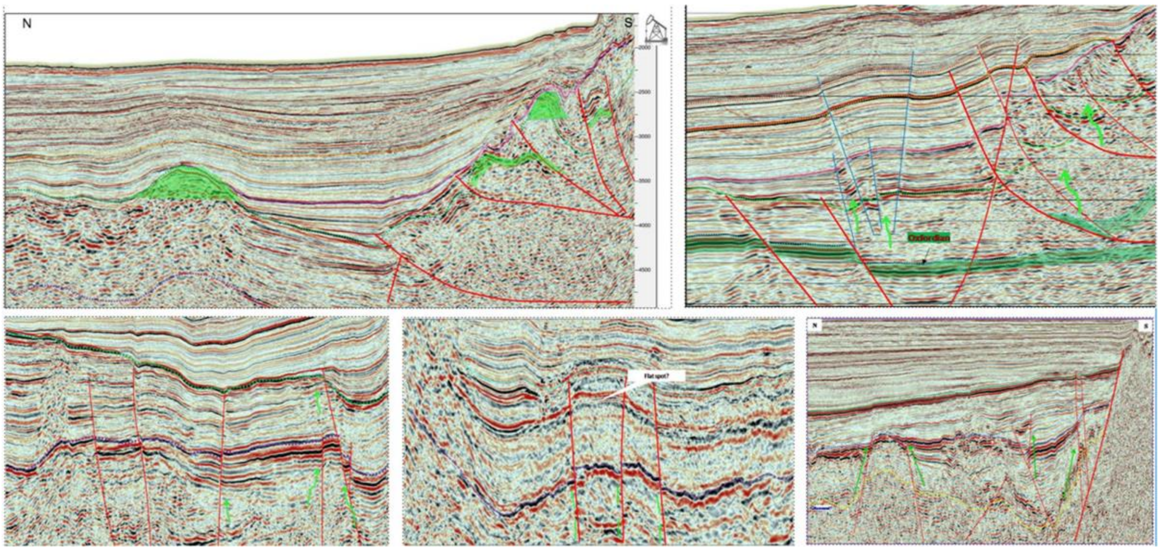


Figure4 Multiple types of plays

Conclusion

Onshore and nearshore heavy oil fields in Cuban GoM have proven an active petroleum system is present in the folded and thrust belt. But the oil fields area accounts for only about 5.4% of the total folded and thrust belt and other regions also have a high possibility of hydrocarbon accumulations, as multiple fault-related structures, that are demonstrated in the new seismic data, which are located at favorable position to capture the oil and gas generated from deep source kitchen.

Jurassic Cretaceous source rocks in the foreland and Sigsbee basins are mature, and many types of traps in the Foreland basin, Sigsbee basin and Platform margins are identified. It is easy to capture the hydrocarbons generated from deep source rocks and charge the potential reservoirs due to favorable positions. Seismic data also reveal exploration potential in deep section, although the sediments have not been tested by any drilling to date.

NOTES:

Session Nine:
Northern Caribbean Basins

Tectonostratigraphic history, age calibration, and structural interpretation of a mega-3D seismic survey in the deep-water portion of Trinidad and Tobago

Rick Jowett [1], Ken Abdulah [2], James Cai [1], Will Crane [3], Ted Lee [4], Hunter Lockhart [1], and Gavin Thomas [1]
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[2] *Formerly BHP, Currently Subsurface Clarity LLC,*
[3] *Formerly BHP, Kosmos Energy Ltd*
[4] *Formerly BHP, Northwoods Energy LLC*

BHP has acquired and processed one of the world's largest proprietary marine 3D seismic survey collected by an international oil company covering ~21,000 km^2 located in the deep-water portion of Trinidad and Tobago across nine 2016 operated licenses. The broadband survey was acquired by PGS in 2014 and 2015 utilizing two vessels simultaneously in only 11 months. The data was processed by multiple vendors with strategically targeted intermediate output volumes to allow geoscientists to gain an early advantage to frame regional geologic concepts and interpret the data. This coupled seismic acquisition and fast track processing approach has helped transform frontier explorations pace by significantly reducing the overall cycle time from acreage access to first drill in an industry top percentile 32 months. The survey covers a complex structural terrain at an oceanic-oceanic crustal boundary where the eastward advancing upper Caribbean plate converges with the subducting lower Atlantic plate forming the overlying Barbados accretionary prism. The deep penetrating pre-stack depth migrated 3D volume has illuminated evidence that supports a two-prism model for this part of the convergent margin. Age calibration of the survey was accomplished by synthetically tying 17 wells with biostratigraphy from offshore Guyana, the Columbus basin, shallow and deep-water Trinidad, and recent exploration wells within the 3D. These wells collectively sample stratigraphy from the Plio-Pleistocene to the early Cretaceous with three wells bottoming in igneous / metamorphic basement. Multi-level mapping was conducted from sea floor to basement including but not limited to the ~Top Pliocene, ~Top Miocene, Mid-Miocene, Top Cretaceous, Top Mid-Cretaceous. The interpretation has revealed the tectonostratigraphic history of the margin and has allowed identification of four distinct structural terrains within the two prism complex as follows; i) Uplifted Relic Accretionary Prism Terrain, ii) Back Thrust Terrain, iii) Vertical Shale Tectonics Terrain, and iv) Fold Belt Terrain, the latter three terrains comprising the modern accretionary prism.

NOTES:

New constrains on the tectono-sedimentary evolution of the San Pedro Basin (south-eastern Dominican Republic offshore margin): Implications for its hydrocarbon potential

Gorosabel-Araus, J.M.[1], Granja-Bruña, J.L.[1], Gallego-Mingo, A.[2], Gómez de la Peña, L.[3], Mas, R.[1], Rodríguez-Zurrunero, A.[1], Carbó-Gorosabel, A.[1]

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[2]*Cepsa E&P*

[3]*GEOMAR – Helmholtz Centre for Ocean Research*

Summary

The San Pedro Basin (SPB) is an E-W-trending bathymetric depression located the south-eastern offshore margin of Hispaniola Island. With an approximately extension of 6000 km2, SPB limits to the south with Muertos Thrust Belt (MTB). In the scientific literature, the SPB has been usually interpreted as a local "forearc basin" containing sediments from Middle Miocene to Present. Although it is located close to confirmed onshore petroleum systems (Maleno and Higuerito former oil fields at Azua Basin), several attempts of onshore-offshore stratigraphic correlations with the San Cristobal (considered as the onshore extension of SPB) and Azua Basins have shown discrepancies and therefore the SPB evolution is still unclear.

Our study has been focused on a detailed revision and synthesis of the systematic geological mapping (SYSMIN I & II Programs) together with the integration of a large volume of sub-surface geophysical data. This includes the analysis of up to 60 exploration wells provided by Banco Nacional de Datos de Hidrocarburos (BNDH) of the Dominican Republic, the processing of new 2D multi-channel seismic data from the Spanish Research Project NORCARIBE, the reprocessing of vintage seismic profiles and the interpretation of gravity and magnetic data.

Preliminary results have provided new constrains which lead us to propose a tentative new evolution model for the SPB. In the new model, the basement of the SPB is formed by the Cretaceous sedimentary and volcanic rocks, deposited in an intra and back-arc context. A subsequent change in the stress regime at the K/T limit, led to the partial inversion of the basement units favouring the deposition of Palaeocene?-Eocene sediments into a submarine foreland setting. Due to the collision between the Carbonate Bahamas Province and Hispaniola in Upper Eocene, compressional stresses were transferred to the south where Cretaceous and Paleogene sediments were deformed forming the current configuration of MTB and generating a new accommodation space where SPB was developed since Upper Eocene / Oligocene until Present. This new model agrees with outcrops from San Cristobal Basin and could have important implications for the exploration in the area. New dating places the oldest rocks of the basin in Upper Cretaceous instead of Middle Miocene, as it was traditionally considered in the scientific literature, opening a new window for potential source rocks and the rest of elements of the petroleum system.

Hydrocarbon potential of the San Pedro Basin

We have gathered all the information available from BNDH and Robertson Research Reports (1984), correlating exploration wells (*fig. 1*) and identifying potential source rocks, reservoirs and seals which should be presented in the SPB. The information extracted from these reports has been combined with onshore studies and our model in order to determine the burial history, the geothermal gradient, potential traps and the critical point. A brief review of the preliminary potential petroleum system would be as follows:

- *Source roc*k: Three potential source rocks have been detected; Upper Cretaceous shales and marls (TOC: up to 0.52%, Type III at San Pedro #1), Oligocene shales and lignite (TOC: 0.62 - 4.18%, Type III in outcrops and up to 1.05% Type III at Caño Azul #1) and Miocene shales and marls (TOC: up to 1.24 - 2.27% Type II at Cul de Sac #1 in Haiti, 1.5-1.6 Type III at Charco Largo #1).
- *Reservoir:* The limited production in Hispaniola was restricted to Upper Miocene / Lower Pliocene turbidite sandstones. However, intervals with fair to good porosities produced water during Drilling Steam Tests (DST) in Oligocene to Lower Miocene Limestones, where vugular porosities and fractures were detected in core analysis.
- *Seal:* Oligocene to Lower Miocene shales and tight limestones have been tested as regional seals at Chaño Azul #1, Maleno #1, Maleno #2, Maleno #7, San Francisco Reef #1.
- *Trap:* Structural and stratigraphic traps are expected to work in Hispaniola and have been interpreted in the San Pedro Basin.
- *Timing / Migration:* By the restoration of the basin for different periods of time, we have determined intervals for oil expulsion and potential migration pathways.

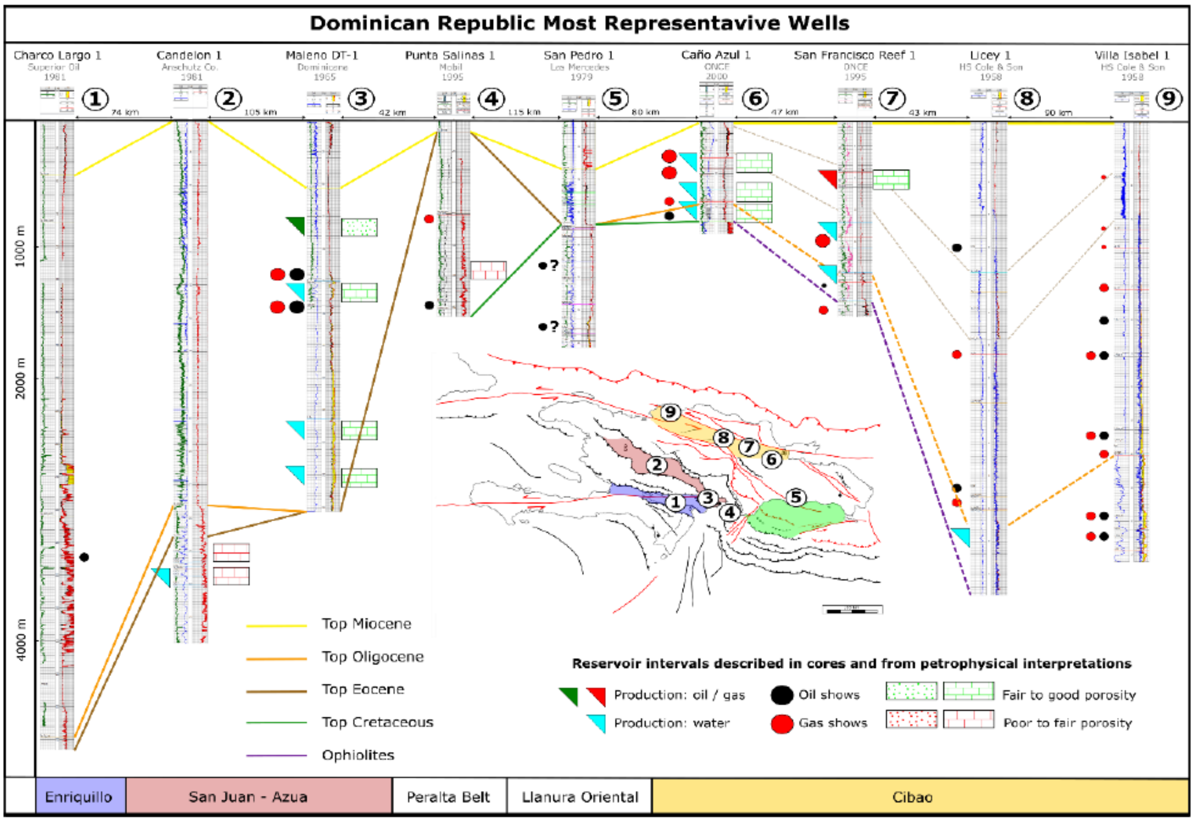

Figure 1. Correlation of the most representative wells of each basin in Hispaniola. Note the presence of oil and gas shows along the island.

NOTES:

Eocene platform and basin development on the upper Nicaragua Rise

Simon F. Mitchell
The University of the West Indies

A late Cretaceous arc comprising the Upper Nicaragua Rise (UNR, including central and western Jamaica) collided with the continental rocks of the Yucatan and Maya blocks which formed the southern margin of the North American Plate. Progressive Caribbean Plate-North American Plate collision during the late Cretaceous to early Eocene instigated a change in plate movement vectors for the Caribbean Plate from northeast-wards to eastwards and a transition into a broadly east-west extension tectonic phase that controlled Eocene sedimentary patterns across the UNR. A high-resolution biostratigraphic scheme integrating planktic foraminifers and calcareous nannofossils with platform margin and platform interior larger benthic foraminifers (LBFs) enables correlation of sedimentary successions from deep-water basins into the interiors of carbonate platforms, enabling sedimentation patterns to be investigated. Across the eastern UNR, east-west extension led to the formation of a series of blocks/platforms (Clarendon, Hanover, Pedro Bank) and troughs/basins (North Coast Belt, Montpelier-Newmarket, Walton) which were transgressed from north to south during the early and middle Eocene. Blocks/platforms saw the accumulation of thick mixed clastic-carbonate and carbonate sequences during intervals of extension, with block stratigraphies truncated by regional-scale angular unconformities (sequence boundaries) caused by tectonics. Basins/troughs, in contrast, developed thick deepening upward successions where shallow-water mixed clastic successions were succeeded by marlstones and finally chalks. The basins/troughs record progressive subsidence, with tectonic intervals represented by carbonate shedding from the margins of the adjacent blocks/platforms. Detailed studies of outcrop geology in Jamaica provide a framework across a trough (North Coast Belt) – block (Clarendon Block) – trough (Monteplier-Newmarket) – block (Hanover Block) physiography, whereas wells on the Pedro Bank and western UNR show the development of thick block/platform succession in the mid Eocene with similar unconformities to those on the blocks/platforms in Jamaica. Restricted patterns of ocean circulation across platforms and troughs during the early and mid-Eocene was probably extenuated by decreased oxygen availability driven by widespread warm climatic intervals during the Eocene, and led to the deposition of organic-rich mudstones with high TOCs. High-resolution biostratigraphy indicates that the early Lutetian was a regional interval of source-rock deposition across the UNR. Reservoir rocks are represented by transgressive clastic (sublithic arenites) in the lower part of sequences (particularly where there is volcanic basement onlap) and grainstones in basins/troughs where there is tectonic shedding. Seals are provided by shales that succeed arenites, and by marlstones. The UNR represents the formation and the subsequent tectonic breakup of a mega-carbonate platform in the Eocene and is very attractive as a hydrocarbon prospect in the Americas.

NOTES:

Session Ten:
Onshore Mexico Basins

KEYNOTE: The Mexican fold and thrust belt: structure, timing and tectonics

Elisa Fitz-Díaz
Instituto de Geología, Universidad Nacional Autónoma de México

The Mexican Fold and Thrust Belt (MFTB) is pervasive tectonic feature in eastern Mexico, from Sonora to Chiapas. Its trend is NW-SE along most of its length, although the Monterrey salient is a noteworthy feature in which the trend of the MFTB changes to an E-W orientation forming an oroclinal fold. The MFTB consists of folded and reverse-faulted mesozoic and lower-paleogene strata dominated by carbonates alternating with shale and sandstone. Middle Jurassic evaporites horizons provide detachment surfaces locally, as do the carbonaceous shale units. The geometry of the structures is largely controlled by the spatial distribution of paleogeographic elements and detachment horizons as well as the overall kinematics of the deformation which is dominated by NE-directed tectonic transport along the belt, with the exception of the Monterrey salient, where it is directed northward.

The structural style is dominantly thin-skinned in central and southern Mexico, and thick-skinned in NE-Mexico, where high-angle thrusts result from reactivation of normal faults. In general, the strain distribution in the MFTB satisfies the critical wedge theory predictions, decreasing toward the foreland. Values greater than 70% shortening are documented in the hinterland of central Mexico, and these decrease systematically to values <15% where the Gulf onlap sequences unconformably overlie the deformed strata. Exceptions to this pattern are well documented and are related to lateral variations in mechanical properties caused by facies variations-notably massive platform *vis à vis* thinly-bedded basinal carbonates.

The timing of deformation has been well constrained using Ar-Ar systematics on illite coatings generated by layer-parallel slip in the flanks of flexural folds. The results published to date suggest episodic pulses of deformation between 93-80, 75-64 and 55-43 Ma. Each of these pulses progressively affects rock units further east (toward the foreland), in agreement with critical wedge theory. Effects of subsequent shortening are accentuated on the westernmost exposures of the thrust belt and are evident on a map scale by folded fold axes, compared to generally linear or broadly arcuate axial traces of frontal folds.

Although the causes for shortening in the MFTB remain debated, this analysis indicates that orogenic wedge development took place in a retroarc setting that postdated consolidation of the hinterland oceanic assemblages, which lay offshore western Mexico during Albian time. Orogen development followed a protracted period of early Mesozoic extension that affected most of the Mexico. Initial shortening in the MFTB followed the Arperos basin closure and Guerrero superterrane accretion by ~10-15 Ma and was coeval with voluminous magmatism on the Pacific margin of Mexico, sinking of the western carbonate platforms and the development of foreland-basin sedimentation. Periods of acceleration of the North American plate to the roughly coincide with the episodes of deformation recorded in the MFTB. Thus, subduction of the Farallon slab from Late Cretaceous to Eocene time was thus the primary driving mechanism of shortening in the MFTB.

NOTES:

Structural sections through Oaxaca-Cuicateco-Veracruz Basin and the Chiapas Foldbelt

Rod Graham, Jim Granath, Jim Pindell and Maria Sierra-Rochas
Consultant

Like much of cordilleran North America, Mexican regional tectonics are very much dominated by the idea of terrane collision. These collisions are oblique in the general plate tectonic framework of Mexico and the Tehuantepec Terrain and Chortis are clear examples. The Cuicateco belt of Southern Mexico, appears to be somewhat different. We interpret the opening of a hyperstretched back-arc basin within Mexican continental crust and document its closure during Laramide and Miocene shortening which is less important in Cuicateco, but all important in the Chiapas. The evolutionary scheme is illustrated by two restored cross sections through the Sierra de Juarez and the Veracruz basin and a third section across the Chiapas fold and thrust belt.

The Cuicateco sections explore a model in which deep water sediments of the Cretaceous Chivillas Formation are thought to have accumulated in a back arc basin floored by hyper-stretched basement through which basalt lavas were extruded. These basinal rocks, together with the hyper-stretched basement beneath them were thrust onto the Cretaceous platform Carbonates of Cuicateco (Sierra de Juarez) during the latest Cretaceous and Palaeogene and drove the Veracruz carbonate platform toward the Gulf of Mexico.

The enveloping surface of the frontal Laramide folds of the Sierra de Juarez and the floor of the associated Palaeogene foreland basin now dip towards the Gulf of Mexico, not, as one might expect, back into the mountain belt. We argue that they were re-oriented by a major crustal flexure related to the underlying subducting Cocos Slab which shallowed during the Miocene (and the associated arc migrated eastward to its current location at the Gulf of Mexico margin as the Tuxtlas volcanic centre. The slab is also considered to be the most likely uplift mechanism supporting Neogene topography in Cuicateco and the young Oaxaca fault which deforms the Laramide emplacement fabrics might also be related to this late uplift.

The Chiapas history is analogous in many ways to Cuicateco, with the hypothesis of the flattening slab documented by seismicity and migrating arc volcanism. It is argued that the idea also explains the structural dilemma of a vertical transcurrent fault backing the dip slip Chiapas fold and Thrust belt

Some element of gulf-ward dip probably also existed at the Veracruz margin in Cretaceous time because the restored sections place the platform-basin transition on the western side of Cuicateco on full thickness continental crust. We argue that this might relate to the subsidence of the recently created oceanic lithosphere of the Gulf of Mexico which was welded to the continent along the Veracruz transform.

NOTES:

Paleo-Canyons and Contemporaneous Oil Seeps near the Paleocene/Eocene Boundary, Tampico-Misantla Basin, Eastern Mexico

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Abstract

The existence of numerous paleocanyons, roughly dated as forming within the age range of the Paleogene Wilcox Formation in the Gulf of Mexico have been documented by many authors (Figure 1). On the western flank of the Tampico-Misantla Basin in eastern Mexico, we have identified at least five paleo-canyons (Figure 2). These were formed at ~56 Ma (also during equivalent age Wilcox Formation deposition) when fluvial systems eroded into the subaerially exposed, unconsolidated Paleocene bathyal sediments during an extremely large fall in sea-level. These paleocanyons have not been mapped by the SGM (Mexico Geological Survey) and do not appear on geological maps of the area because previous workers had not identified the Lower Eocene canyon-fill sediments because of ubiquitous, reworked Upper Paleocene foraminifera and nannofossils.

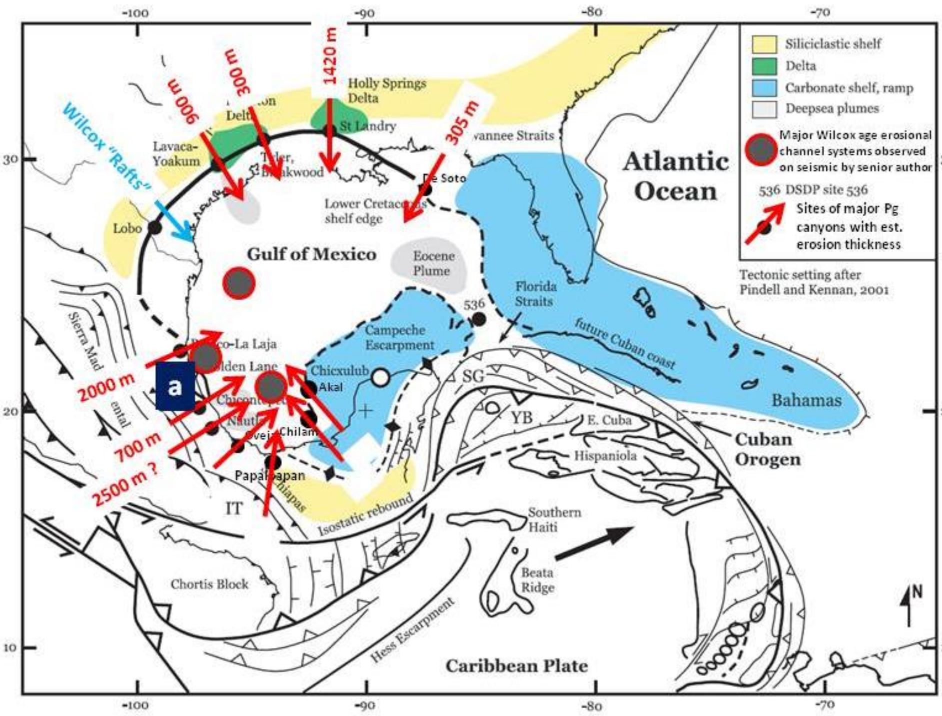

Figure 1. Paleogeographic map of the Paleogene in the circum Gulf of Mexico area, showing known paleocanyons and erosional thicknesses from various sources. Base map modified from Pindell & Kennan (2001) and Rosenfeld & Pindell (2003). Study area shown by box with letter "a". Estimated erosional thickness of Mexican canyons from Carillo-Bravo (1980) and Cantú-Chapa (2001).

Following the rapid drop in relative sea-level, a rapid rise provided the accommodation space for the deposition of hundreds of meters of coarse-grained, conglomeratic, and mud-rich canyon-fill sediments.

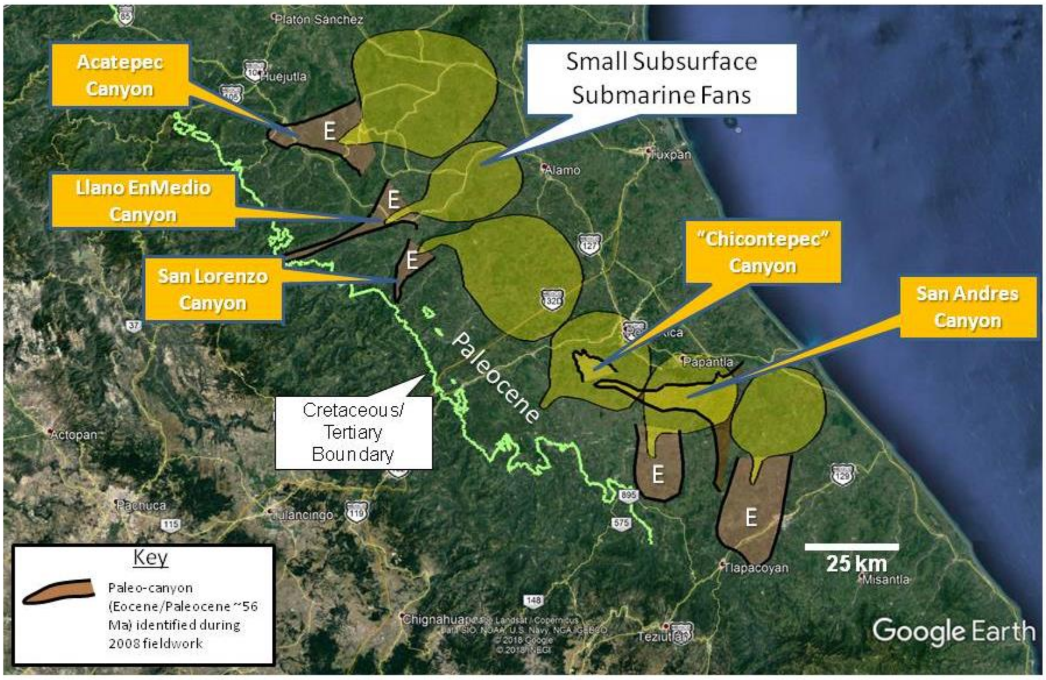

Figure 2. Early Eocene paleogeography in the Tampico-Misantla Basin, showing Paleocene-age erosional canyons and small submarine fans which later developed in front of them during the early Eocene. Modified from Vásquez et al. (2014). E = Eocene paleocanyon outcrops.

The northern (Acatepec) canyon was filled with more than 200 m of slumps, pebbly-mudstones, channel sandstones, and thin-bedded channel-levee sediments. The upper part of the sequence also contains several paleo-karsted intervals which may indicate additional large relative sea-level fluctuations. The San Lorenzo paleo-canyon contains a mass transport deposit at its base and overlies over 600 m of bathyal sediments. We have also identified two bitumen beds in outcrop, both of which overlie the ~56 ma unconformity when the canyons formed. One of the beds overlies and preserves evidence of a deep desiccation crack (80 cm deep) in the underlying bathyal sediments, on the once-exposed off-axis areas of the terrestrial canyon.

Over 15 well penetrations of bitumen beds at the Paleocene/Eocene unconformity and up to 11 meters thick covering an area of at least 14 km x 4 km have been identified in the subsurface of the basin (including one cored well). These multiple occurrences of bitumen beds are tied to a large drop in the Gulf of Mexico water level near the Paleocene/Eocene boundary which would have decreased the lithostatic pressure gradient and resulted in a breach of deep hydrocarbon traps in the basin. The pre-erosion and canyon-fill sediments were all deposited in a bathyal environment, begging the question of what caused the rapid fall and rise of relative sea-level. The Paleocene Eocene Thermal Maximum (PETM) has been tentatively identified near the base of the canyon-fill sequence in the Acatepec paleocanyon, overlying the regional unconformity on which the bitumen beds were deposited.

NOTES:

Session Eleven:
Burgos and Perdido Basin

Improved stratigraphic resolution of the Frio to Wilcox Groups in the Mexico Perdido Trend

Guy Harrington, Paul Cornick**,** Neil Campion
Managing Director PetroStrat Ltd.

Recent advances made in the stratigraphic resolution of the Paleogene Wilcox Group in the USA Gulf of Mexico (GoM) and Mexican Perdido complex using palynology have allowed for a greater understanding of its depositional history. This talk and paper presents a detailed sequence stratigraphic framework for the Wilcox Group, based on data generated from over 80 wells from both onshore and offshore USA and Mexico integrated with key outcrop sections. Detailed correlations made using palynology (which has previously been underutilized in its application) provide evidence of at least two major unconformities linked to sustained periods of significantly lower relative sea level. These breaks in deposition led to the historical establishment of the Upper, Middle and Lower Wilcox lithostratigraphic units across the US Gulf Coast. Until now linking these units to the deep water stratigraphy, such as the Wilcox 1 to 4 scheme of Zarra et al., 2007, has proven problematic. The refined stratigraphic framework now allows a greater understanding of the link from onshore to offshore and of the depositional history and sediment provenance during the Paleogene in the northern Gulf of Mexico.

NOTES:

The Cenozoic Burgos Basin – Insights into Provenance and Sediment Routing Evolution, Drainage Basin Reconstruction, and Tectonic Controls

Daniel F. Stockli[1], Timothy F. Lawton[2], Cullen D. Kortyna[1], Edgar Juarez[2], and Jacob A. Covault[3]

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The Cenozoic Burgos Basin in northeastern Mexico and southern Texas straddles the Mexico-USA border region along the Rio Grande/Bravo River and represents the largest gas-producing basin in Mexico. Despite its economic importance, fundamental aspects of the basin remain poorly understood and with those uncertainties impacting hydrocarbon exploration both in the Burgos Basin and off-shore Perdido area of the Gulf of Mexico (GOM). During Late Cretaceous-Paleogene times, the Burgos Basin was situated in a transitional tectono-sedimentary zone between the Laramide and Mexican Cordillera and the GOM. There is considerable controversy surrounding both the Late Cretaceous-Paleogene sediment routing system delivering sediment into the Burgos Basin, including dispersal pathways, catchment extent, debouchment locations as well as the controls of contractional tectonic elements, e.g. the Tamaulipas-Burro-Salado arch and inversion structures, and Gulf of Mexico-associated intra-basin normal faulting on sediment routing into the Burgos Basin. A more robust sediment-routing framework is critical to understanding sediment delivery, source-to-sink sediment transfer, evolving hinterland source provinces, and with important implications for reservoir size and quality in the Burgos Basin and the Perdido area of the GOM.

This study presents new depth-profile LA-ICP-MS detrital-zircon (DZ) U-Pb data from marine and nearshore fluvial-deltaic Late Cretaceous and Paleocene strata from the Burgos Basin in northeastern Mexico and southern Texas to determine likely sediment source terranes, delineate sediment dispersal pathways, and better predict basin reservoir size and quality. The data also provide new constraints on maximum depositional ages, stemming from first-cycle volcanic zircons, aiding basin strata correlations. The provenance data are characterized by dominant Paleogene-Late Cretaceous age modes and subordinate Jurassic, 1.4, and 1.7 Ga and minor Permo-Triassic, Silurian-Ordovician, Neoproterozoic, and 1.1 Ga age modes. Importantly, they lack DZ ages derived from the Early Cretaceous Alisitos arc and show a typical Cordilleran magmatic gap. In summary, these DZ U-Pb signatures are diagnostic of sources from the Western U.S. and argue against sourcing from western Mexico and input via the Parras-La Popa Basin routing system. Furthermore, DZ U-Pb depth-profile data from individual zircons suggest that the Burgos Basin received sediment via a paleo-River Grande river system from a mixture of recycled sedimentary, volcanic, and basement source terranes in southeastern Arizona, northeastern Mexico (Chihuahua Trough, Sabinas Uplift, and Coahuila Block) and southern Colorado/New Mexico (e.g., Colorado Mineral Belt). This interpreted catchment area is more extensive than previously thought, incorporating large portions of the southwestern U.S. and northeastern Mexico where it drained an evolving, tectonically active Laramide hinterland characterized by both first-cycle magmatic input and sedimentary recycling from uplifting inversion structures. This has important implications for the reservoir size and reservoir sandstone quality in light of sediment sourcing from a significantly larger drainage basin than previously proposed and tapping into a quartz-rich plutonic and recycled Mesozoic rift-basin rocks in the hinterland. The data unequivocally demonstrate that the Parras-La Popa drainage did not provide sediment into the Burgos Basin and that the peripheral Tamaulipas-Burro arch (forebulge) acted as an effective barrier during the entire Paleogene interval, both channelling sediment axially along it in the paleo-Rio Grande routing system and blocked sediment transfer from W Mexico into the Burgos Basin and the NW GOM.

NOTES:

Posters

Integration of multi-source surface data to enhance reservoir knowledge in Mesozoic fractured carbonates analogues of Mexico

Antonio G.L. Palombo[1], Yannick Santerre[1], Agoston Sasvari[3], Arthur Satterley,[2] Usman Muhammad[2]
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[3]*Former employee CGG Services (UK)Ltd.*

Naturally fractured carbonates account for about 85% of the total world's carbonate reservoirs (Lamarche 2012). In Mexico, a large portion of hydrocarbon production comes from naturally fractured Mesozoic carbonate reservoirs, which also outcrop in the Sierra de Chiapas. The aim of this study was to provide a surface control on the producing Mesozoic fractured carbonate reservoirs of the Reforma-Akal Uplift, Macuspana, Comalcalco and Campeche-Sigsbee Salt Basins (SE Mexico), by understanding the structural geology, the sedimentology and the reservoir geology of the analogues outcropping in the Sierra de Chiapas. This work has involved integration of sedimentological, structural, photogrammetric and satellite imagery interpretations from historical field observations, from seven outcrop locations. A conceptual reservoir model has been built based on the historical outcrop information from one selected location and from the new 3D outcrop structural interpretation.

From sedimentological point of view outcrop samples display a wide range of facies, from fine mudstones to grainy grainstones through to algal boundstones and rudist floatstones/rudstones, corresponding to a wide range of depositional environments from very shallow to very deep marine. Planktonic foraminiferal wackestones in the Caimba outcrop are potential analogues for Late Cretaceous carbonates in key cores in wells Etbakel-1 and Kach-1. Reservoir quality in the core samples is always very low, with very little observed open porosity, very similar to the carbonate rocks from producing fields in southern Mexico. Interpreted paragenesis shows the crucial importance of burial cementation processes that often lead to the complete occlusion of both primary and secondary porosity, explaining why understanding sediment fracturing is so critical.

Three main fracture sets prevail in both the satellite imagery dataset and the outcrop fracture readings: 1) N-S fracture set; 2) NE-SW fracture set and 3) E-W fracture set. Three main deformation phases are also identified on the basis of the paleostress inversion: 1) Maastrichtian to Middle Miocene NW-SE and occasionally NNW-SSE compression/strike-slip deformation; 2) Middle Miocene to Recent NE-SW compression/transpression and 3) Possibly recent NE-SW and NW-SE extension which however, is attributed to gravity slide and hence is not tectonically controlled (non-Andersonian stress). The Photogrammetry interpretation is an accurate and reliable tool which is able to reproduce most of the field observations. The reservoir model generated for this study is a conceptual sector model based on parameters obtained from the Tuxtla Autopista 10 (TXAP10) outcrop fracture network. Sensitivity analysis was performed for a range of sigma factor, matrix and fracture permeability, pore pressure, well trajectory and aquifer strength. From the reservoir model we concluded that 1) The estimated recovery per well and recovery factor ranges from 140 MBO to 730 MBO and 7.7% to 41%, respectively, for the various scenarios modelled during the study; 2) Reducing matrix permeability by a factor of 100 from our base case will result in recovery factor drop from 29% to 23.6% and most of the production will be through fractures. 3) A tight matrix fracture system will result in just 7.7% and 13.2% recovery factor for vertical and horizontal wells, respectively; 4) A horizontal well can produce 40% to 70% more than a vertical well for similar reservoir conditions; 5) Strong aquifer support or water injection pressure maintenance will result in a higher recovery factor.
In conclusion, Mesozoic carbonates reservoir analogues outcropping in the Sierra the Chiapas, are tight matrix reservoir rocks affected by intense fracturing. Hence, understanding their fracture networks is paramount to evaluate the best well design and field development plans to achieve the highest possible recovery factor in a production scenario.

The Regional Tectonic Evolution of the Gulf of Mexico – Constraints from Multi-Satellite Gravity Data

Peter Webb, Kirsten Fletcher, Sam Cheyney & David Tierney
Getech Group plc, UK

Hydrocarbon exploration often starts with understanding the regional tectonics of the area of interest. In the case of the Gulf of Mexico, numerous reconstructions have been proposed over the years to explain the region's tectonic evolution. It is now near universally accepted that the Gulf of Mexico is an extinct Mesozoic oceanic basin; however, two key indicators of ocean crust formation and tectonic history are absent:

- The bathymetric and geophysical expression of oceanic fracture zones, which are usually used to constrain the relative motions of continental plates as the ocean between them evolves.
- Linear magnetic reversal anomalies, which normally indicate the age of oceanic crust formation and can be used to estimate the rate of divergence between separating continents.

The absence of these indicators in the Gulf of Mexico means that we need to rely on other geological indicators to decipher the region's tectonic age and evolution:

- Palaeomagnetic data from the Yucatan Block of southern Mexico are consistent with a rotated block with respect to the North American continent. When the palaeomagnetic polar wander path from southern Mexico aligns with the path from North America, this indicates the age at which the Gulf of Mexico became extinct as an oceanic basin.
- Evaporites deposited in the region during the Callovian and early Oxfordian are interpreted to coincide with the latest syn-rift phase and the earliest formation of oceanic crust; they therefore give a bound on the start of the southward motion of the Yucatan Block.
- Tectonic constraints from further afield (the Central and Southern Atlantic Oceans) constrain the relative motion between the North and South American continental plates.
- Upper Triassic red beds located in Mexico and the southern United States are thought to indicate the earliest phases of continental rifting in the Gulf of Mexico region.

A commonly proposed model for the Gulf of Mexico involves a relatively long-lived phase of continental rifting (Late Triassic and Jurassic) that is followed by a short phase of oceanic crust formation in the Late Jurassic, resulting in counter-clockwise rotation of the Yucatan Block away from North America against a transform margin with eastern Mexico.

In this presentation, we use the latest advances in satellite-derived gravity data to identify lineations in the data that are interpreted as the trace of oceanic fracture zones and failed mid-ocean ridge segments (Figure 1). We use these interpreted structural features to 1) calculate best-fit poles of rotation for the Yucatan Block and 2) confirm the validity of the prevailing tectonic model.

We use gravity calculated from satellite altimeter measurements of sea surface height. Since 2010, additional data from two new satellites, CryoSat-2 and Jason 1, have significantly improved data resolution and reliability. These data are used to interpret geological structures on continental margins and in adjacent oceans, and when they are combined with a range of horizontal or vertical derivatives, they provide an excellent tool for uncovering the tectonic fabric of the Gulf of Mexico.

We combine the tectonic elements defined from the multi-satellite gravity data with our global tectonic model to produce a new model for the Gulf of Mexico. This new model corroborates a commonly proposed tectonic model involving Callovian–earliest Cretaceous rotation of the Yucatan Block about a slowly migrating pole of rotation to the northeast of Present Day Cuba (Figure 2).

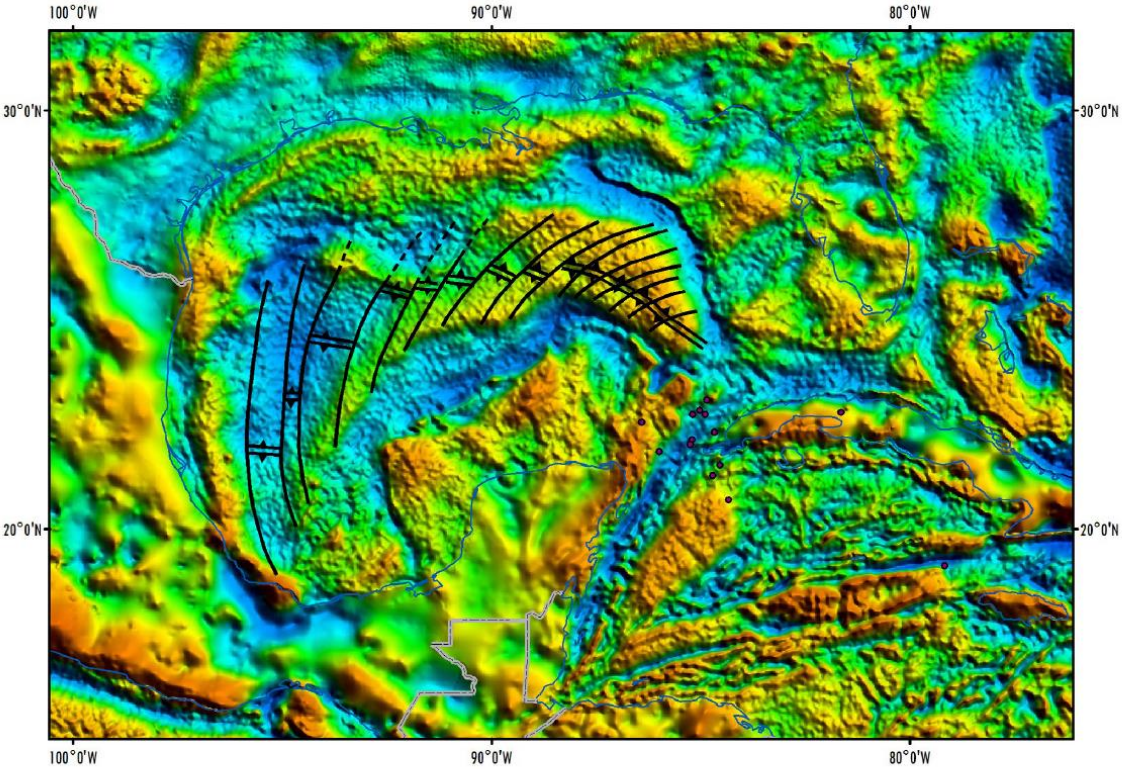

Figure 1: Gravity data for the Gulf of Mexico region, including Getech's Multi-Sat solution for offshore areas. The overlay displays the interpreted tectonic structure of the Gulf of Mexico

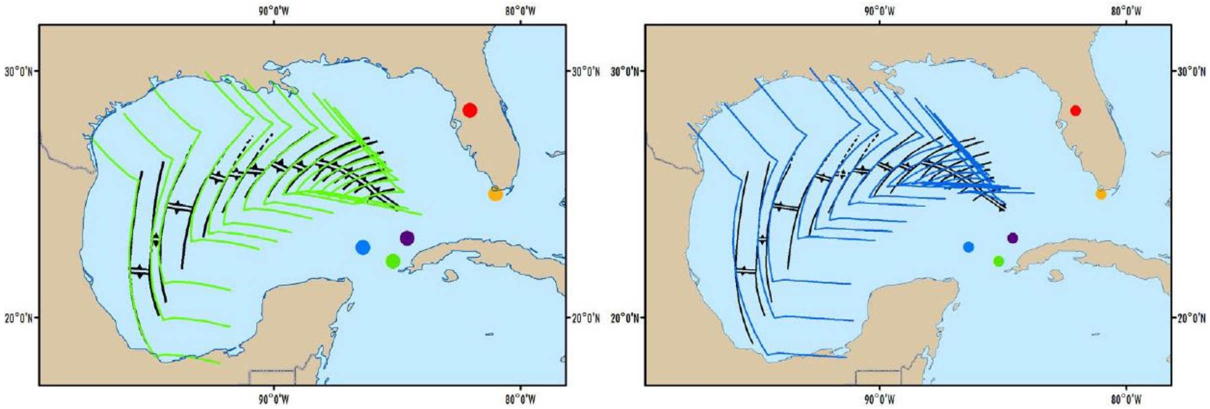

Figure 2: Interpreted tectonic fabric of the Gulf of Mexico, with predicted flowlines shown for the prevailing tectonic model of the Yucatan Block rotation and poles of rotation displayed for other evolution models.

Answering key questions on the petroleum geology of the Southern Gulf of Mexico using a fully-integrated well database

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The Mexican Gulf of Mexico (GOM) is a world class petroleum system with most current production coming from the southern basins, and particularly from the Cantarell complex where production is associated with Cretaceous breccias and fractured carbonates. Recent discoveries in Cenozoic clastics have received significant attention, with many remaining questions concerning both the established and emerging plays;

- Clastic reservoir distribution in the offshore and the relationship with sediment provenance, maturity and reservoir quality.
- The controls on light and heavy oil distribution and the influence of source rock types, timing of maturation and migration pathways.
- The nature of fracture networks (density, orientation and connectivity) in Cretaceous and Jurassic carbonates.

Although most existing studies are focused on small areas and datasets, the recent energy reforms and the availability of large volumes of historical Mexican well data facilitates a more complete review. Coupled with advances in computing, data capture and data science, new means of interrogating multi-million data points provides the potential to address these questions.

We demonstrate an approach utilizing a legacy dataset of 124 wells across both the onshore and offshore Mexican basins of the Gulf of Mexico with input file counts exceeding 37,000 (multi-million data points), including a full range of geological, engineering and well status data in variable formats and vintages. We present the results of applying data analytics approaches to stratigraphic and provenance data in determining controls on reservoir quality within Tertiary clastic sequences in the Salinas and Veracruz Basins.

Facilitated by the use of more than 10,000 petrographic and core data points in conjunction with over 100,000 petrophysical data points in uncored intervals, our initial results demonstrate regional trends for deepwater clastics. Reservoir quality is influenced by both primary (depositional facies and mineralogical maturity) and diagenetic (grain dissolution and clay authigenesis) controls. Our analysis shows that both these factors may be required in deeper, offshore reservoirs to counteract the impacts of enhanced mechanical and chemical compaction. With data extraction and data science workflows established, the addition of further wells data can be quickly accomplished to progressively upgrade and improve the models.

Zama Discovery: From Depocenters to Paleo-Currents Combination of Seismic and Borehole Image Datasets

***Phil Gabbard*[1]**, *Zbynek Veselovsky[2], Bernd Ruehlicke[2], Carsten Vahle[2], David Kosmitis[1], Michael Albertson[1], David Tett[1]*
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[2]Eriksfiord

The Talos Energy Zama #1, the first private-sector exploration well operated in Mexico in 78 years, was drilled in May-July of 2017 in Block 7, offshore Tabasco in 166m water. A gross sandstone reservoir interval of 344 meters was penetrated; the estimated reserves make Zama one of the most significant offshore discoveries globally in several years.

The reservoir section is dominated by amalgamated, very fine-grained to fine-grained, feldspathic sandstones with low clay and carbonate contents. Seismic interpretation and biostratigraphy suggest sediment may have been fed into an evolving Late Miocene mini-basin from one or more focused entry points, and deposited as a confined slope-fan complex.

In order to corroborate the seismic interpretation of depositional setting, and provide a much more detailed picture of the sedimentary system, Schlumberger's Quanta Geo borehole imaging tool was run in the Zama #1 well. Borehole images (BHI) are commonly used for detailed structural and sedimentological interpretation, thereby closing the gap between seismic and core scale. The spatially-oriented image tool used in Zama #1 offers a vertical resolution down to mm- to cm-scale; hence, it provides higher resolution in comparison to traditional wireline tools within oil-based mud environments. BHI enables the analysis of directional information such as fault trends, symmetry of sand bodies, and sediment paleo-transport within interpreted depositional systems, which is indispensable for reservoir characterization and subsequent field development.

Prior to any sedimentological interpretation, the structural tilt of the stratigraphic section needs to be compensated for. The measurement of structural tilt is based upon uniform dip intervals of strata that are deemed to represent paleo-horizontal. In Zama #1, a general NW to W structural tilt with overall ~20° dip angle is determined. There are a number of dip changes across faults and angular unconformities, hence the interval was subdivided into several structural sections.

An image facies scheme was established based on the BHI texture, dip patterns, and petrophysical log response. Image facies stacking patterns and directional measurements allowed for the interpretation of depositional systems and their change over time. Pulsed high-density turbidity flows are interpreted, characterized by a high sediment flux leading to common de-watering. Pre-existing mini-basins (likely controlled by salt-withdrawal) were rapidly filled by prograding fans, before sediment spilled over to areas with available accommodation space. Sediment discharge patterns suggest several sediment entry points, which switched over time, but may have been temporarily active simultaneously. Turbidity currents were sourced primarily from the southeast and east, but may also have received sourcing from the southwest. Reservoir units are subdivided by mud-prone quiescence intervals characterized by continued, but reduced, sediment influx (diluted low-density turbidites and hemipelagites). Above the uppermost reservoir unit, repetitive adjustments of local topography led to partly intense soft-sediment deformation including coherent, block-rotated slides, ductile deformed and partially dislocated slumps, as well as muddy to sandy debrites. Mass transport complexes were governed by unstable slopes oriented north-south, northeast-southwest, and occasionally west northwest- east southeast.

The results of this study, and subsequent BHI interpretation of the appraisal wells (currently drilling), will be critical to developing a detailed depositional model and building static and dynamic reservoir models for development planning.

The integration of reprocessed Full Tensor Gradiometry, gravity and seismic data to understand salt distribution and basement structure in the Veracruz and Sureste basins, Mexico.

Sean Goodman
Bridgeporth Ltd

A joint reprocessing and integration venture between AustinBridgeporth (ABI) and Seitel Mexico has led to an enhanced understanding of the salt distribution throughout the Veracruz and Sureste basins, both onshore and offshore Mexico. ABI reprocessed and merged 68 gravity datasets across the region, subsequently merging these with a high resolution FTG dataset.

Originally acquired in 2010, airborne FTG data was reprocessed using ABI's advanced Equivalent Source techniques, involving the integration of scalar gravity with the original FTG data. ABI's reprocessing resulted in an increase in the signal: noise, as well as the restoration of the long wavelength component of the gravity field. With the FTG's strength at short wavelengths (relating to shallower features) now combined with the strength of the scalar gravity at long wavelengths (relating to deeper structure), ABI were able to more clearly delineate the shape and orientation of salt bodies as well as the structure and depth of basement across the region.

A regional database of newly reprocessed 2D seismic data, provided by The National Hydrocarbons Commission and Seitel Mexico, was combined with the FTG and gravity data. Initial integrated interpretation along a selection of ten 2.5D models provided the input data for a 3D Earth model. By combining gravity inversion techniques with ABI's proprietary 3D forward modelling software, detailed maps of gravity-derived salt distribution and basement structure were produced across the Veracruz and Sureste basins of Mexico.

Geology and Hydrocarbon Potential of Mexico: some results from regional mapping

Ian Davison and Ian Steel
Earthmoves Limited

The prospective offshore Mexican sector of the Gulf of Mexico is now completely covered by seismic data. Systematic mapping, mainly by Pemex, has led to a much better understanding of the geology and hydrocarbon potential. This poster aims to capture the main conclusions of the geophysical mapping and combine this with remote sensing and bathymetric data to produce a comprehensive structural framework map. We make some general observations resulting from the regional mapping which are listed below.

Perdido Fold Belt

The outer Burgos Basin and Perdido Fold Belt are dominated by allochthonous salt sheets which started to extrude in Eocene times during the later stages of the Laramide orogeny. Seven individual sheets have been mapped which decrease systematically in width (measured parallel to coastline) from 52 km in the north to 37 km in the south. The thickness of the individual salt sheets also varies from ca. 6 km in the north (Corfu and Cratos sheets) to ca.2.5 km in the south. Allochthonous Salt sheets have a dramatic cooling effect on the source rocks below them, so that both the Tithonian and the Turonian-Cenomanian source rocks may still be in the oil window even when buried to a depth of 10 km.

Sand Channels in the Campeche Salt Basin

Channel have also been mapped through the offshore area, and regional maps indicate that the main sand input points are derived from the Laramide and Chiapas Fold Belts which surround the westerns and southern margins of the Gulf of Mexico. However, there is little clastic sediment input from the Yucatan peninsula in the east, as this is a carbonate platform which developed from the Jurassic through to the present day. Our map compilation indicates that the northern part of the Campeche salt basin is located some 300 km, or more, from potential sand sources. The many intervening salt structures and the general NW tilt of the Campeche Basin will have inhibited sandstone channels reaching the northern part of the basin, except in the frontal fold belt which only developed in the Pliocene along the western border of the salt basin. Hence the northern area may rely on carbonate reservoirs, but these are deeply buried and the Miocene compressional reactivation has minimal impact this area.

Mexican Ridges Fold Belt

Bathymetry maps allow detailed mapping of the anticlinal folds in most of the Mexican Ridges Fold Belt. Surge zones can be mapped where the fold belt extends farther seaward and the basal Eocene age shale decollement is more effective. Mapped surface oil slicks appear to be preferentially developed in between the surge zones where the decollement may be less effective and less overpressured, allowing leakage from underlying source rocks of presumed Cenomanian-Turonian age. Hence, these intervening areas between the surge zones may be the most prospective for oil, but the fold belt has only yielded gas so far. The updip extensional system of faults is also a locus for surface oil slicks suggesting oil has migrated updip below the detachment to the zone where the Eocene shales are not overpressured and allow leakage of hydrocarbons from below the detachment level.

Regional Play Types of NW and Central Cuba

Ian Davison[1], Ian Steel[1 &2] & Mathew Taylor[2]
[1]*Earthmoves Limited, Camberley*
[2]*GEO International Limited*

Until recently geopolitical sanctions limited exploration in Cuba. However, there is a renewed interest in Cuban exploration with a license round announced in December 2018, and an extensive offshore 2D seismic survey has been shot. Exploration and production is focused in the NW and Central Cuban foreland fold belt which has a series of heavy oil discoveries, but only 10 oil fields remain in production. Recent exploration wells in the offshore drilled by Repsol, Gazprom and Petronas have proven the existence of light oil shows and seismic data shows a variety of rift and foreland play types in the area. Recent exploration has proven three main source rock intervals in the Oxfordian, Tithonian and Aptian-Turonian. These intervals show geochemical affinities similar to proven oils in the Mexican Campeche Basin, northern-Gulf of Mexico and onshore Texas.

This poster presents an overview of structural styles and play types to provide a basin framework and outlines the prospectivity for offshore NW Cuba.

The NW Cuba exploration area has been the focus for recent exploration and exhibits a complex interplay of extensional and compressional structural systems relating to Jurassic rifting and establishment of a passive margin setting through to the early Cretaceous. Island arc collision and ophiolite obduction occurred in the Late Cretaceous with generation of the North Cuban fold belt and foreland.

In the offshore, a series of Jurassic rift zones are mapped with rotated fault blocks creating regional lows, with large basement highs topped by carbonate knolls. These form large fault-block and half-graben plays with thick growth packages of Lower to Middle Jurassic with trapping of potential Oxfordian Norphlet-San Cayetano sandstones. A thick sedimentary succession of Cretaceous limestones with some high energy marine carbonate facies is present in the offshore, and associated thin hypersaline source rocks and evaporites occur in restricted depocentres. A thick Cretaceous carbonate sequence is also observed on the adjacent Yucatan Platform and underwent downslope sliding and brecciation in response to the Chixculub meteorite impact at 66 Ma. This ‘Cantarell-type’ play has not been tested in the offshore in NW Cuba but proves an interesting hypothetical play type given the extensive presence of Cretaceous carbonates, proximity to the impact crater and later thrusting. The Yamagua-1 well found oil shows in reworked and redeposited Cretaceous chalk intervals in the breccias, however these showed poor reservoir characteristics.

Late Cretaceous to Palaeogene obduction of arc-volcanic, sedimentary and metamorphic terranes resulted in the formation of a thrust duplex play with stacked overthrusted sheets of Upper Jurassic and Lower Cretaceous carbonates and sandstones. Unfortunately most of the targets drilled to date are shallow, and the oil has been biodegraded. However, the Jarahueca oil field produced small amounts of light oil due to active oil migration at the present day, and Melbana Energy announced a 21° API oil discovery (Bacuranao) in NW Cuba in 2018. This suggests that light oil may be found at greater depths in deeper duplex traps.

Proven plays onshore are relatively untested in the offshore and interpretation of new 2D seismic and analysis of well data have highlighted a number of new plays and prospective zones ready to be tested.

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Leave the building via the nearest and safest exit or the exit that you are advised to by the Fire Marshal on that floor.

Fire Exits from the Geological Society Conference Rooms

Lower Library:
Exit via main reception onto Piccadilly, or via staff entrance onto the courtyard.
Lecture Theatre
Exit at front of theatre (by screen) onto Courtyard or via side door out to Piccadilly entrance or via the doors that link to the Lower Library and to the staff entrance.
Main Piccadilly Entrance
Straight out door and walk around to the Courtyard.

Close the doors when leaving a room. **DO NOT SWITCH OFF THE LIGHTS**.

Assemble in the Courtyard in front of the Royal Academy, outside the Royal Astronomical Society. Event organizers should report as soon as possible to the nearest Fire Marshal on whether all event participants have been safely evacuated.

Please do not re-enter the building except when you are advised that it is safe to do so by the Fire Brigade.

First Aid

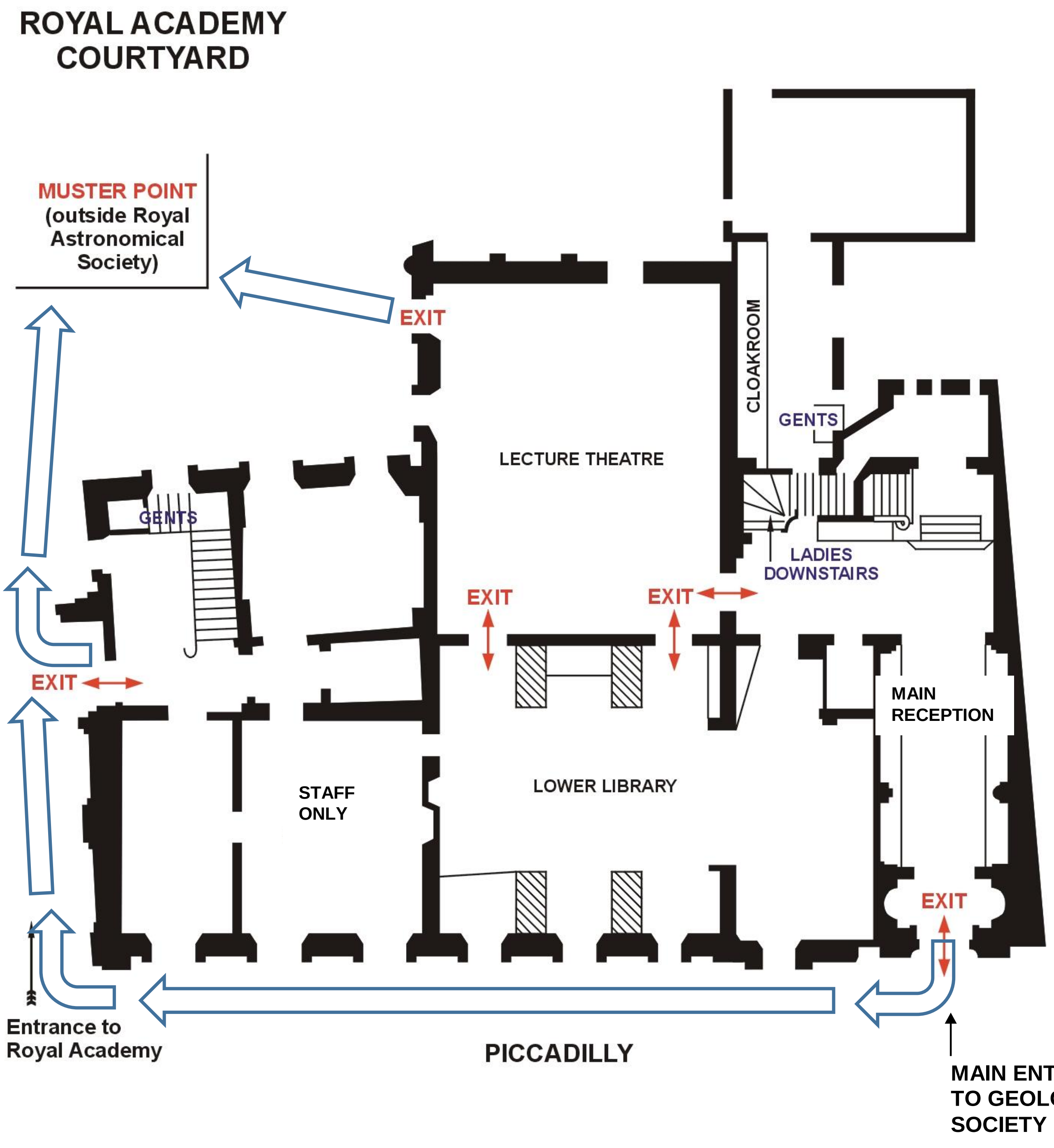
All accidents should be reported to Reception and First Aid assistance will be provided if necessary.

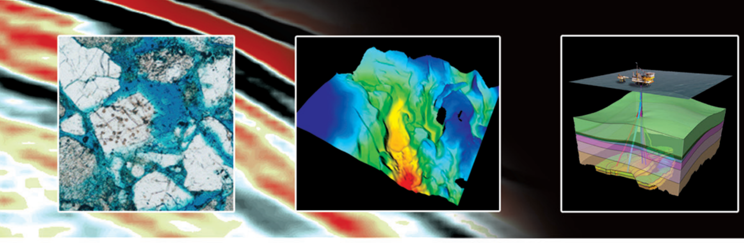
Facilities

The ladies toilets are situated in the basement at the bottom of the staircase outside the Lecture Theatre.

The Gents toilets are situated on the ground floor in the corridor leading to the Arthur Holmes Room.

Ground Floor Plan of the Geological Society, Burlington House, Piccadilly





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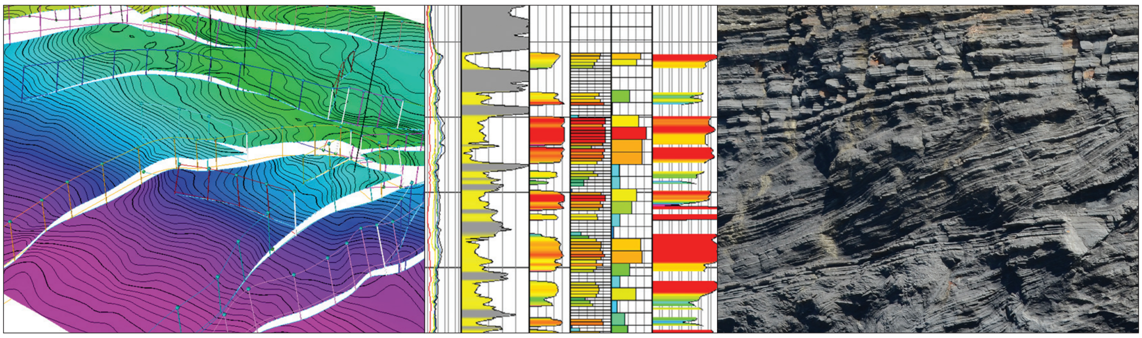
Registration Now Open

Capturing Geoscience in Geomodels

26-27 June 2019

Robert Gordon University, Aberdeen



Over recent years the construction of 3D static and dynamic reservoir models has become increasingly complex. With the availability of extensive tools and technology it is important not to forget the objective of the modelling process.

As we develop our hydrocarbon fields it is essential that 3D Static Models be built with fit-for-purpose geological models, honouring the geological, geophysical and petrophysical data that they are created from.

This two-day conference will explore how geoscience information should be used to best effect, and how to identify when geoscience data may no longer add value. Sessions will include the following themes:

- Data integration: seismic, well log, sedimentological, core dynamic data and beyond
- Capturing conceptual geology in reservoir modelling for different settings and depositional environments
- Scale: geology vs model vs data
- Uncertainty: dealing with geological uncertainty in modelling and understanding its benefits and limitations
- Embracing new modelling technology and approaches.

For further information please contact:

Sarah Woodcock, The Geological Society, Burlington House, Piccadilly, London W1J 0BG.
Tel: +44 (0)20 7434 9944 Web: https://www.geolsoc.org.uk/PG-Geomodels

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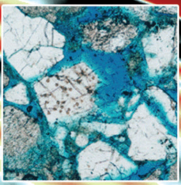
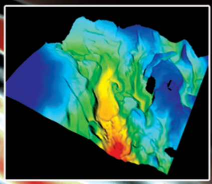
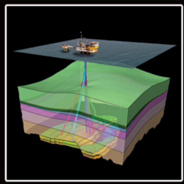

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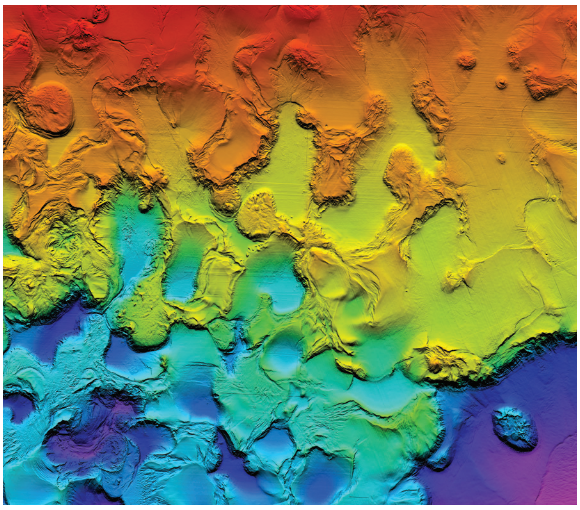
Call for Abstracts – Deadline: 31 May 2019

Salt Tectonics:

Understanding Rocks that Flow

29-31 October 2019

The Geological Society, Burlington House, Piccadilly, London



The complex behavioural and rheological characteristics of salt can strongly influence the structural and stratigraphic evolution of a basin. With many of the largest hydrocarbon provinces existing within salt-related basins understanding of the processes involved in salt tectonics has important scientific and economic implications for geological research and hydrocarbon exploration.

Modern high-resolution 3D seismic data with improved imaging of salt structures in combination with more advanced physical and numerical modelling techniques revolutionises the way we see salt tectonics and the role of salt structures.

This three-day international conference aims to bring together leading academic and industry geoscientists to discuss new techniques and case studies, and to capture an up to date assessment of our understanding of salt tectonic processes including:

- Geographical case studies; e.g. North Sea, Gulf of Mexico, Persian Gulf, Campos Basin
- Salt tectonics in extensional and contractional settings
- Halokinetic sequence stratigraphy
- Analytical methods of interpreting salt in seismic data
- Physical and numerical modelling of salt tectonics
- Implications of salt tectonics for hydrocarbon exploration.

Call for Abstracts:

Please submit talk or poster abstract to sarah.woodcock@geolsoc.org.uk by 31 May 2019.

For further information please contact:

Sarah Woodcock, The Geological Society, Burlington House, Piccadilly, London W1J 0BG.
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