Recent Yucatan Seismic Survey Revealing a New Frontier Exploration in the Gulf of Mexico*

Ernest Gomez[1], Michael Doe[2], Sebastian Villarroel[3], Kelsey Noel1, Raul Ysaccis[3], Duplo Kornpihl[3], Mohamed El-Toukhy[3], and Gary Forrest[2]

Search and Discovery Article #30582 (2018)**
Posted October 15, 2018

*Adapted from extended abstract based on poster presentation given at AAPG 2018 Annual Convention & Exhibition, Salt Lake City, Utah, United States, May 20-23, 2018
 DOI:10.1306/30582Gomez2018

[1]Schlumberger - SIS, Denver, CO, United States (egomez@slb.com)
[2]Independent Consultant, Denver, CO, United States
[3]Schlumberger - Western Geco, Houston, TX, United States

Abstract

A broadband long-offset 2D seismic data set acquired off the northern margin of the Yucatan Platform provides a fresh look at the hydrocarbon potential of the Yucatan salt basin and adjacent escarpment. Acquired in 2015 on a 10-km grid over an area of 185,000 km^2 (Figure 1), the survey underwent prestack depth migration in 2017. Integrated petroleum system modeling of selected cross sections to identify leads and play concepts show a variety of exploration opportunities with possible extensions of the contiguous productive fields in the eastern U.S. Gulf of Mexico (GoM) and prolific areas in the Campeche salt basin to the southwest.

Introduction

The northern margin of the Yucatan Platform is a frontier area for exploration. The only wells drilled in the Yucatan 2D survey area are a few shallow, Deep Sea Drilling Project boreholes from the 1970s. To understand the reservoir and source-rock presence within the basin, composite regional seismic sections tied to the existing wells were constructed to connect the new survey area with nearby geological provinces of Campeche, Mexican Ridges, Perdido, and eastern U.S. GoM.

Hydrocarbon Play Assessment

A 2D petroleum system model (PSM) covering the seismic survey and nearby areas was constructed based on wells from the nearby basins and the interpreted seismic data. The PSM results show that there are areas within the survey with good prospectivity. Oil seeps mapped from satellite data over the survey area confirm the presence of hydrocarbons. PSM, together with the oil seep distribution, supports long-distance fluid migration charging plays and prospects, including the Yucatan platform.

The seismic survey area geology includes elements from the GoM regional evolution. Deep reflectors of the survey show steep, apparently normal, faults and reflectors that are likely red beds and volcanics associated with the break-up of the supercontinent Pangea in the late Triassic. Regional tectonism continued with extension of the proto-GoM in the middle Jurassic (ca. 174-164 Ma) and southward drift, with counterclockwise rotation, of the Yucatan block. An opening to the Pacific established in the Callovian (ca. 166-164 Ma) fed ocean waters into a highly restricted, proto-GoM, environment where high evaporation rates at a paleo-equatorial latitude resulted in the deposition of 5 to 7.5 km of salt over variable depths of earlier extended crust.

Continued seafloor spreading within the GoM accelerated during late Jurassic. Open marine conditions predominated with the development of oolitic shoals and banks paralleling the western coastline and platform margins in the Oxfordian and Kimmeridgian producing potential future reservoirs. During the Tithonian (ca. 148 Ma) deposition of anoxic organic rich mudstones across wide, shallow, platforms occurred. These mudstones are the most important source rocks in the Bay of Campeche and the southern part of the GoM that include the Yucatan.

Opening of the GoM diminished by the early Cretaceous as the Yucatan block reached its final position. Fine-grained marls were deposited in the deeper basinal settings, while rudist reefs and associated lagoons occurred along platform margins. Carbonate platform sequences deposition continued through the Middle Cretaceous while outer margin collapse and rapid deepening of continental margins occurred with distinctive basinward tilt. This, combined with the presence of Callovian salt, resulted in local, gravity-driven, listric faulting reflecting tens of kilometers of salt detached extension and tectonism. Deposition of platform or deeper water carbonates continued during the middle (Albian-Cenomanian) and late Cretaceous (Turonian-Maastrichtian) with up to 800 meters of thickness.

The Chicxulub impact on the northern (present-day shoreline) Yucatan Peninsula marked the regional Cretaceous - Paleogene (K-Pg) boundary (ca. 65 Ma). The impact led to deposition of regional locally thick and extensive breccia consisting of mostly Upper Cretaceous and some Middle Cretaceous limestone, dolomite, and anhydrite clasts in a micritic matrix and to collapse of the platform margin in places. New seismic facies were identified along the escarpment as potential breccia deposits related to the Chicxulub impact (Figure 2). This breccia is one of the most important reservoirs in the Mexican part of the GoM, e.g., the Cantarell field has high production rates from this breccia.

Platform carbonates and fine-grained marine sediments were deposited during the Paleocene, Oligocene, and Eocene. Major salt remobilization was restricted to mini-basins and associated diapirs established during earlier Jurassic-Cretaceous gravity-driven sediment systems (Figure 2). Middle Miocene subduction of the Cocos Plate beneath the North American Plate in southwestern Mexico initiated clastic influx, both primary (turbidite channels and fans complexes) as well as growth strata in the Campeche basin and possibly in the northwest part of the seismic survey.

Gravity-driven halokinesis continues today as evidenced by topographic highs and lows on the sea floor often associated with hydrocarbons seeps.

Summary

This high-quality 2D seismic survey reveals a diversity of play types, including structural and stratigraphic traps. Within the Late Jurassic to Cretaceous section, up-dip salt rollers related to basinward-dipping growth faults and down-dip compressional structures occur (Figure 2). An

important analogue for this play is the Appomattox discovery in the eastern U.S. GoM where the main reservoir is the Oxfordian Norphlet. In the Cenozoic, the play types include salt diapirs with adjacent mini-basins and pinch-outs as well as unconformity onlaps, and turbidite channel and fan complexes (Figure 3). The Ram/Powell field, located offshore northern GoM, is an analogue for the turbidite channel and fan complex.

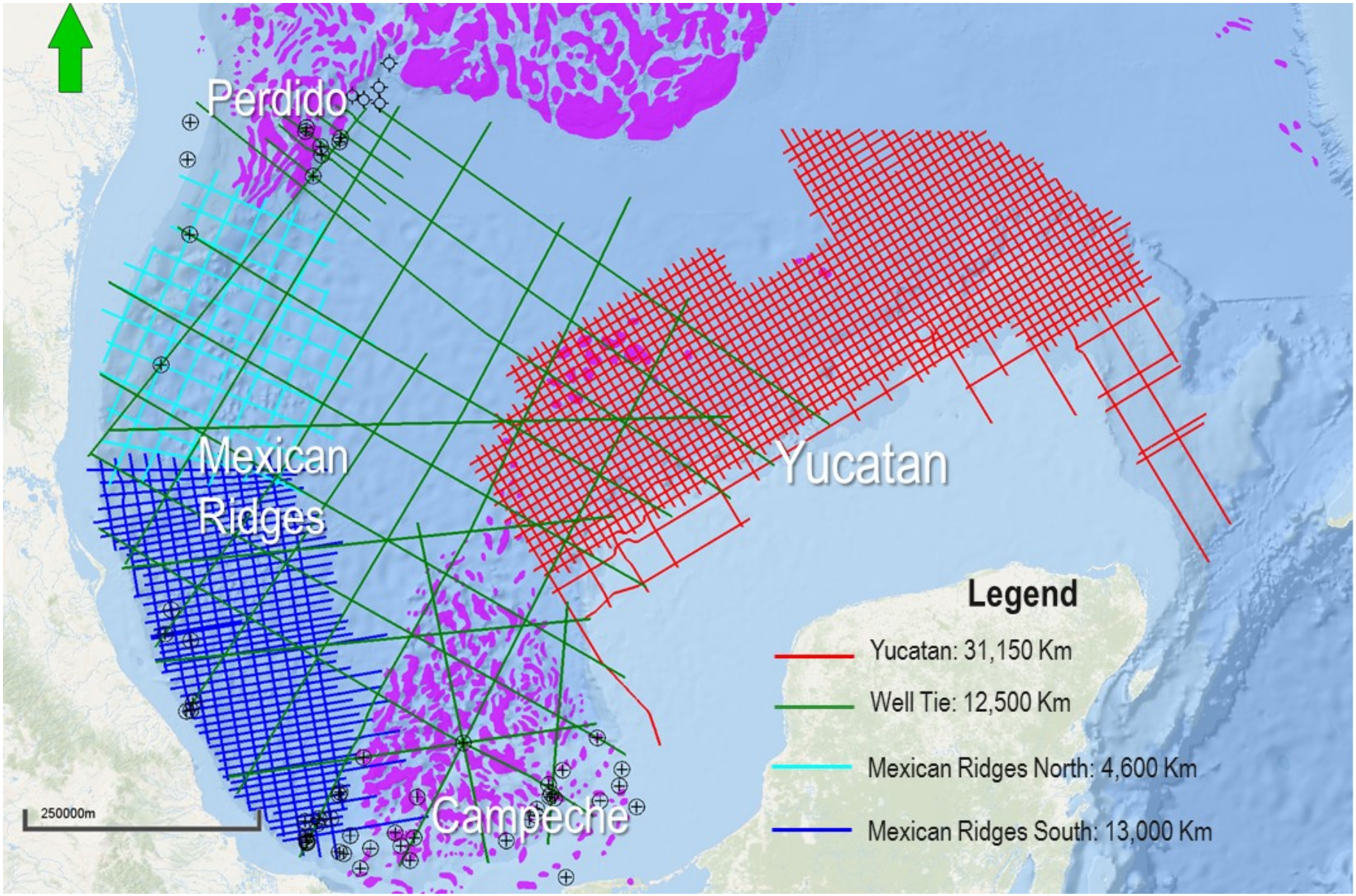

Figure 1. Map showing the multiple seismic surveys used in this study for stratigraphic correlation. The Yucatan survey with a 10-km by 10-km seismic grid is in red.

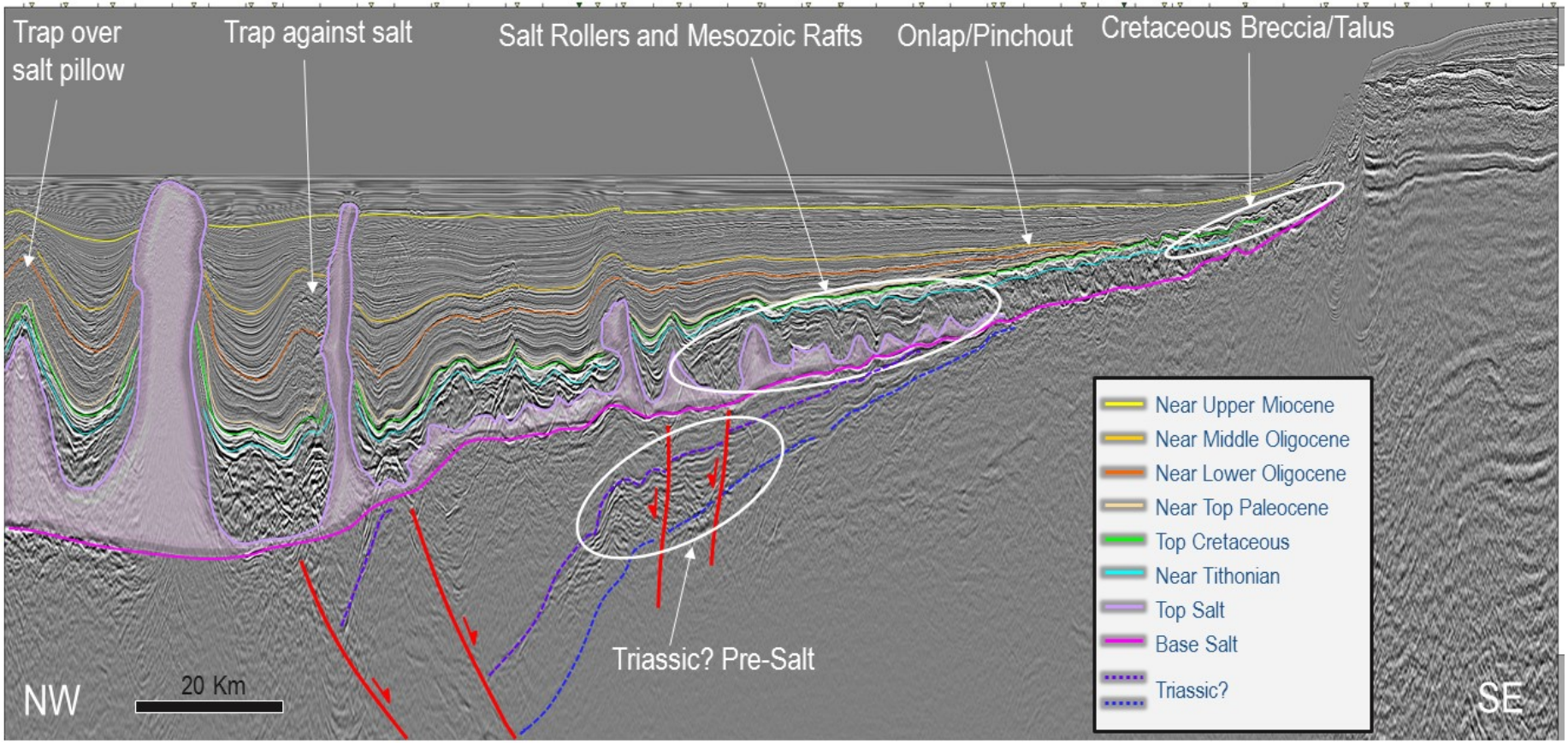

Figure 2. Regional section showing the main hydrocarbon plays in the Yucatan.

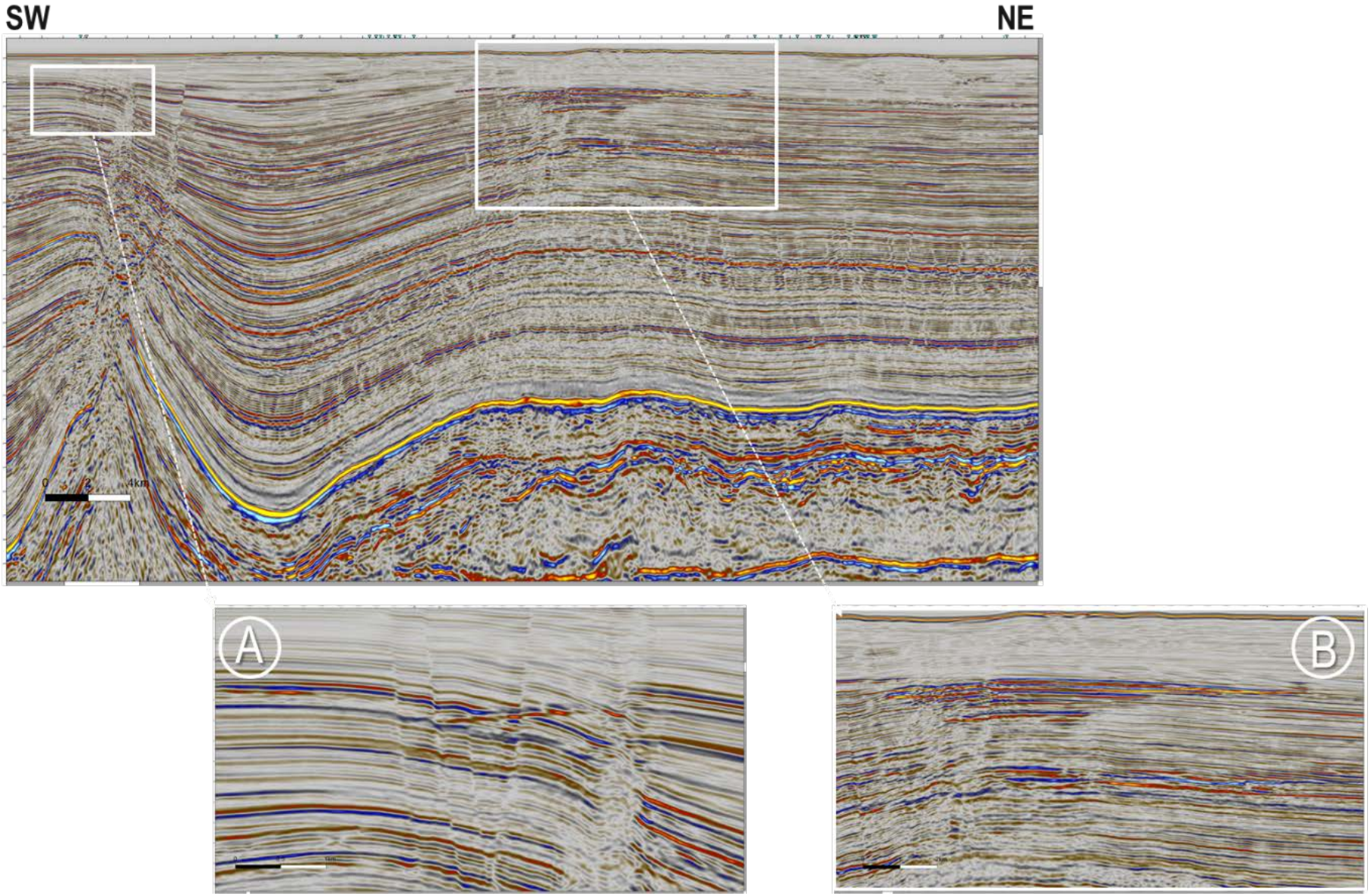

Figure 3. Selected section in the northeastern area of the Yucatan survey showing: A) Fault-block trap over salt pillow with flat spot, and B) Tertiary turbidite stacked channels.