Petroleum Field Methods Course: Trinidad

Summary Report

Submitted to:

Offshore Energy Research Association of Nova Scotia (OERA) to fulfill the requirements of the Undergraduate Student Research Travel Program

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Introduction:

The Petroleum Field Methods Course offered at Dalhousie University provides a unique opportunity for selected students to further their understanding of petroleum systems. The intensive, senior level course is located in Trinidad and integrates various teaching methods, which include: individual literature review, fieldwork, core and well log analyses.

The course is divided into three sections. (1) pre-travel, each student is expected to write a report and present on a particular topic that relates to Caribbean geology, tectonics or petroleum systems, as well as a specific safety topic. (2) in Trinidad, the majority of the time is spent visiting various outcrops and laboratories. In addition, strong ties between the University of Dalhousie and the University of West Indies (UWI), the geological society of Trinidad and Tobago (GSTT) and Petotrin has facilitated the opportunity for students to collaborate with industry professionals. (3) post-travel, students come together and share their experience with the Dalhousie faculty.

Figure 1: (left) students record scintillometer and permeameter readings from cretaceous aged source rocks located at Naparima Hill. (right) students and industry professionals collaborate at the Petrotrin core laboratory.

Topics covered in both class and fieldtrip include:

- Basin Tectonics and Structural Setting
    - Caribbean Tectonics and Seismicity, EL Pilar Fault System, Tectonic and Geology
    - Caribbean Volcanoes
- Source Rock, Maturation, and Overpressure
    - Overpressure, Mud Volcanoes, and Shale tectonics
    - Biodegradation: Pitch Lake
    - Cretaceous Source Rocks, Trinidad
    - Oil and Gas Generation in the Southern Basin
- Depositional Systems and Modern Day Analogues
    - Sequence Stratigraphy: Accommodation Space
    - Micropaleontology and Paleobiology
    - Modern Fluvial and Deltaic Settings, Mangrove Ecosystems
    - Fluvial-Estuarine and Deltaic Reservoirs, Shelf Margin Delta and Slope Reservoir Characterization
- Economics
    - Future of Oil and Gas and Economy in Trinidad
- Health and Safety

Trip Itinerary:

Day 1: Sunday February 15

- Travel from Halifax – Toronto – Trinidad

Day 2: Monday February 16

- Stop 1: (8:30-11:00am): Asa Wright – Rain Forest Ecosystem & Overview of Caribbean and Trinidad Tectonics

- Stop 2: (1:30-2:30pm): La Fillette Bay – Petroleum Systems
  - Field Exercise: Structural and Metamorphic Interpretation, Failed Petroleum System, Passive Margin

- Stop 3: (3:00-5:00pm): Maracas Bay – Swim and late lunch

- Stop 4: (5:30pm): Port of Spain Lookout – Overview of Trinidad Geology & Gulf of Paria

- Arrive at Pax Guesthouse, check in (6:30pm), and dinner (7:30pm)

Day 3: Tuesday February 17

- Depart Pax Guesthouse (7:00am)

- Stop 1: (10:30am-3:00pm): Cedros Bay – Deltaic Systems, Sequence Stratigraphy and Trace Fossils
  - Field Exercise: Log and Measure Sections (Permeameter and Scintillometer)

- Stop 2: Los Bajos Fault

- Return to Pax Guesthouse (7:00pm) and dinner (7:30pm)

- Evening Exercise: Bonasse Log and East Field Correlation

Day 4: Wednesday February 18

- Depart Pax Guesthouse (7:00am)

- Stop 1: (8:30am-12:00pm): Vessigny, Guapo Bay – Sequence Stratigraphy
  - Field Exercise: Log and Measure Section (Permeameter and Scintillometer)

- Stop 2: (1:00-3:00pm): Stollmeyer's Quarry – Fluvial Estuarine Channel Complexes & Compartmentalization.
  - Field Exercise: Reservoir Characteristics

- Stop 3: (4:00-5:00pm): Pitch Lake, LaBrea – Biodegradation& Migration
- Return to Pax Guesthouse (7:00pm) and dinner (7:30pm)
- Evening Exercise: Reserve Estimates of Stollmeyer's Quarry

Day 5: Thursday February 19

- Depart Pax Gueshouse (7:00am)
- Stop 1: (10:00am-12:00pm): Naparima Hill, San Fernando – Central Range, Source Rocks, and Migration, Trap & Seal
- Stop 2: (2:00-3:00pm): Piparo, Digity, or Devil's Woodyyard – Mud Volcanoes, Migration, and overpressure
- Evening Exercise: Well log and seismic correlation, and update/review field notes.

Day 6: Friday February 20

- Depart Pax Guesthouse (8:15am)
- Stop 1: (8:45-3:00pm): Petrotrin, Point-a-Pierre – Geological Lab and Biostratigraphy
  - Field Exercise: Distributary Channel Morphology
- Return to Pax Guesthouse (7:00pm) and dinner (7:30pm)

Day 7: Saturday February 21

- Depart Pax Guesthouse (7:00am)
- Stop 1: (9:00-3:30pm): Mayaro – Shelf Margin Deltas, Active and Abandonment Phases
  - Field Exercise: Log and Measure Sections (Permeameter and Scintillometer)
- Return to Pax Guesthouse (7:00pm) and dinner (7:30pm)
- Evening Exercise: Mayaro Log Correlation and Complete any outstanding assignments and field notes.

Day 8: Sunday February 22

- Travel from Trinidad – Toronto –Halifax

Benefits of Travel:

The island of Trinidad is approximately 4,700km^2, or approximately the size of the Halifax municipality (5,400km^2). Consequently various outcrops stretching across the entire islands can be visited each day. These outcrops include various petroleum system components such as source, reservoir, traps and seals that extend offshore Trinidad. The fact that these outcrops can be traced offshore is essential for understanding the complexities within the petroleum systems that are currently being explored within the marine setting, offshore Trinidad.

While in the field, challenges petroleum companies face when extracting for hydrocarbons were discussed, and include heterogeneities within the hydrocarbon reservoir assemblage. A good example of such a feature was observed in the Stollmeyer's Quarry. Here a thin, but laterally continuous shale layer was observed within a charged sandstone body (Fig 2). This shale layers acts as a baffle to hydrocarbon migration within the reservoir, and has the potential to lead to a large volume of by-passed hydrocarbons upon extraction.

Figure 2: Thin yet laterally continuous shale layer within the reservoir sandstone assemblage belonging to the Morne L'Enfer Formation exposed at Stollmeyer's Quarry.

Sequence stratigraphy was another major topic that was observed and discussed in the field, as large volumes of hydrocarbons accumulate in these settings. The process of systems tract and the associated terminology was first introduced before the major components of this system, including individual parasequences were identified along the cliffs faces at Mayaro Beach, (Fig 3).

Figure 3: Foreshore sandstone unconformably overlain by a flooding surface at Mayaro Beach. Red line indicates the beginning of a new parasequence.

Outcomes of Travel:

The main focus of this trip is to illustrate the importance of using land outcrops as window into the subsurface. The Mayaro Beach provides an excellent example of where this technique is currently being applied throughout Trinidad. Here offshore drilling platforms are currently producing from reservoir assemblages that greatly resemble reservoir assemblages that outcrop along the Mayaro Beach cliff face.

The Pliocene aged Gros Morne and Mayaro formations are the dominant reservoir rocks exposed along this cliff face. These formations were deposited along

a shelf-margin and represent both active and inactive phases of deposition. Slumping features represent the active phase of deposition and include a ball-and-pillow structure (Fig 4). The inactive phase of deposition is characterized by an increase in trace fossils and hummocky cross-beds, which indicates sediment re-working. Fluid-escape structures where also prevalent throughout the cliff face, which indicates that the stratum was deposited rapidly.

Figure 4: Slumping features observed along the cliff face at Mayaro Beach.

In addition to the complex depositional history of the stratum, both compressional and extensional forces have subsequently complicated the entirety of the stratum. Small-scale faults associated with these tectonic forces act as barriers to hydrocarbon migration. Similarly to shale barriers, these structures can lead to a large volume of by-passed hydrocarbons.

Figure 5: Normal fault along the cliff face at Mayaro Beach, which acts as a barrier to hydrocarbon migration.

Significance to Nova Scotia:

Extrapolating information from onshore reserves across Trinidad and transferring this suite of information to offshore prospects, has served a vital role in the discovery and successful exploitation of offshore Trinidad. Applying this same technique to reserves offshore Nova Scotia has been a challenge due to the lack of exposed outcrops, onshore Nova Scotia. However, the similarity in depositional environments and tectonic history between offshore Nova Scotia and onshore Trinidad has facilitated a greater understanding of the heterogeneous hydrocarbon model for the Scotian Basin. The sable gas project of offshore Nova Scotia is an example of where this is already taking place. Here the reserves are partly composed of fluvial wave and tide dominated deltaic settings, which are analogous to the Morne L'Enfer Formation found onshore Trinidad.

Acknowledgments:

I would like to thank OERA for their generous support and allowing myself to travel to Trinidad and partake on an amazing undergraduate learning experience. The information I have learned throughout my travels can be directly applied to my study of offshore Nova Scotia, which is where I plan on focusing my graduate research.