



Petroleum System Elements of Trinidad – Field School Techniques Comprising Sedimentology and Ichnology

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Summary

While in Trinidad, students from Dalhousie University participating in the Petroleum Geoscience Field Methods course examined each element of the petroleum system by visiting numerous outcrops in the field, completing core and outcrop descriptions, seismic interpretations, and log correlations. Cedros Bay, located on the southern tip of the island, exposes part of the Morne L'Enfer Formation silts and sands. These outcrops were observed, described, and interpreted with sequence stratigraphy and ichnology in mind to produce a final stratigraphic column, including inference of depositional environments and location of the ancient Pliocene delta. Comparison of these outcrops with others viewed around the island serve to equip students with a comprehensive insight into petroleum systems and their elements.

Field Methods

Before departing for the weeklong field excursion to Trinidad, students spend the first month of class preparing by completing presentations and reports on topics regarding field safety as well as geoscience aspects to be encountered while in the field. These reports are compiled into two separate field guides for study and use by all students in the field. Several methods were taught and implemented in the field in Trinidad, including outcrop and core description, gamma ray logging with a scintillometer, measuring permeability with a permeameter, and general recognition of petroleum systems. The initial focus in any field exercise is to do a detailed observation of the outcrop in question, and record the dip and strike, sedimentary geology of the formation, including grain size and shape, colour, deformation, and any structures present. Once observations have been made, interpretations can be formed based on physical and biogenic sedimentary structures; these typically include processes of formation, deformation mechanics, and the evolution of depositional environments. These observations and ensuing interpretations from each student are integral to creating a stratigraphic log, able to be produced from the extensive field notes from the class. The outcrops at Cedros Bay provide a lengthy section of sedimentary strata ideal for constructing a comprehensive stratigraphic log including sedimentary structures, sequence stratigraphic interpretations, levels of bioturbation, trace fossil analysis, and relevant depositional environments.

Results & Discussion

After each full day in the field, students review the field stops and collaborate on exercises based on field locations of the day. For the Cedros Bay review, students shared their field note observations of the outcrops, focusing on descriptions of the sediment and presence of bioturbation. With this compiled observational information, the group can move forward with initial interpretations regarding depositional environments and potential ichnofacies. Compilation of student field notes and class discussions from both 2019 and 2020 contributed to the creation of

the final stratigraphic log of the Cedros Bay section (Figure 2). Four distinct lithofacies were identified: lithofacies one, laminated grey to beige silts and clays, coarsening upwards; lithofacies two, lenticular-wavy-flaser laminated beds grading into massive, poorly consolidated sand beds; lithofacies three, contorted grey silt base topped with interlaminated silts and very fine-grained sands; and lithofacies four, thick bedded sandstones with intervals of swaley and trough cross stratification. Bioturbation is more common in sandier intervals, present in lithofacies two, three, and four. A variety of ichnofacies can be identified, including Skolithos and Cruziana, as well as distinct trace fossils such as *Ophiomorpha nodosa*, which are extremely prevalent in the massive sands of lithofacies four. Four parasequences were defined based on interpreted flooding surfaces, with the entire outcrop defined as a progradational system based on the stacking pattern of each parasequence. Using the defined sequence stratigraphy and ichnology, environments of deposition were interpreted. The first parasequence is comprised of lithofacies one and two; based on interpreted high turbidity, lithofacies one is indicative of a distal prodelta or slope environment, while lithofacies two was interpreted to be in a subtidal environment, likely on the distal delta front or proximal prodelta. Parasequence two, three, and four are all comprised of stacked lithofacies three and four, each one interpreted to represent a delta lobe movement from an abandonment to active phase, indicated by change from bioturbated laminated silts of the offshore to swaley-cross-stratified sands of the delta front.

Conclusion

The outcrops described at Cedros Bay comprise the Lower Morne L'Enfer Member of the Morne L'Enfer Formation. These Pliocene sands form superb reservoirs in the offshore Palo Seco oil field. The formation also outcrops in active oil sands mining operation at Stollmeyer's Quarry. Comparison of the same formation at different outcrops and from subsurface exercises demonstrate the reservoir heterogeneity within the petroleum system and illustrate how a single formation can produce in one area but not another. At Cedros Bay, effective pathways, traps, and seal have not been created to allow the deltaic sands to become gas or oil-bearing reservoirs.

Additive Information

2021 is the first year since its inception in 2003 that this field course has not gone forward, due to the ongoing pandemic. We are hopeful the course will go ahead as planned in 2022, to continue to provide our students with this opportunity to study petroleum elements and processes in an exceptional field environment.

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Figure 1: 2019 students and Hasley Vincent in front of lithofacies four. Extensive burrows of *Ophiomorpha nodosa* can be seen in the massive sands above.

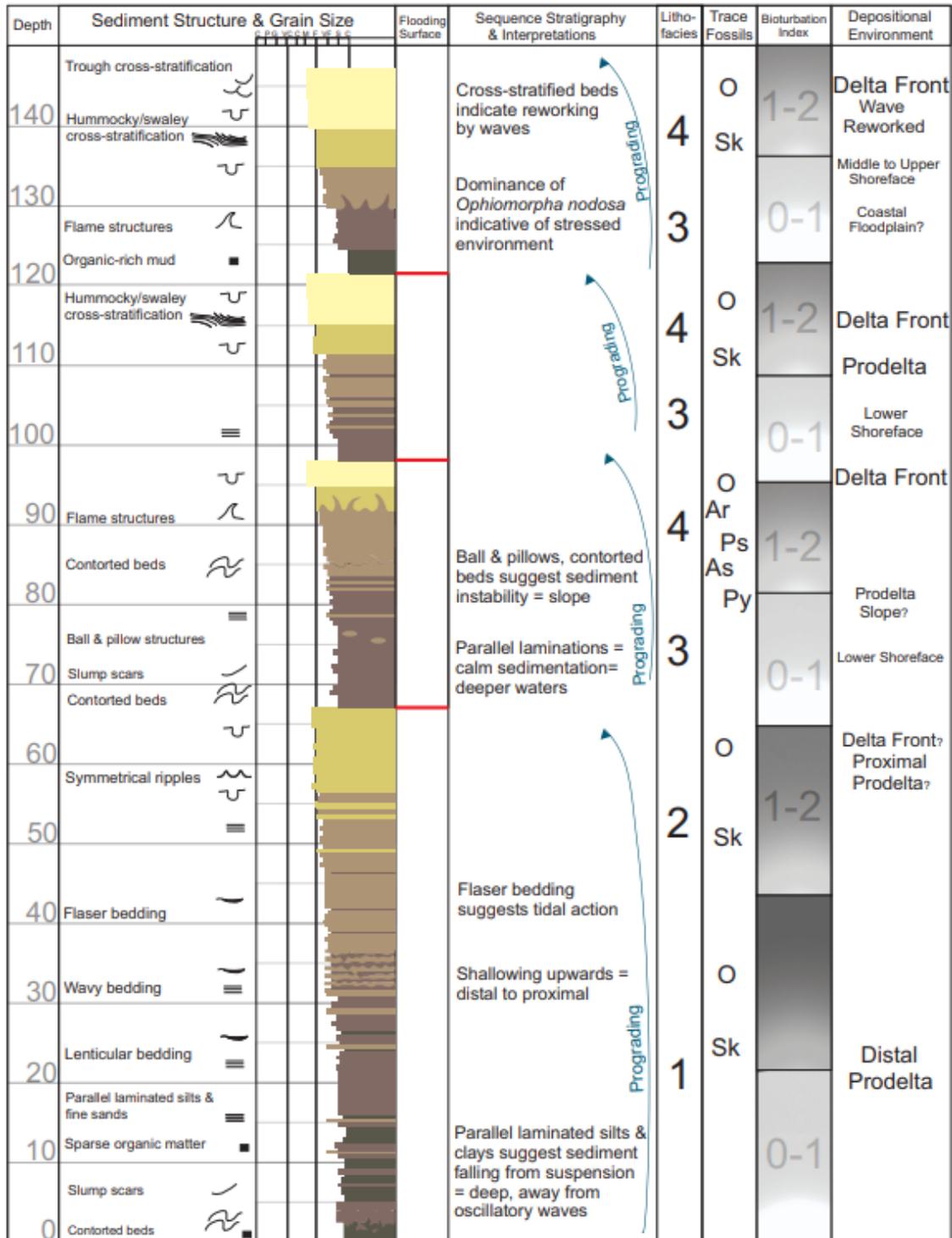


Figure 2: Stratigraphic log of the Cedros Bay section of the Lower Morne L'Enfer Member with physical sedimentary structures, ichnology, and sequence stratigraphic interpretations. Lithofacies described in text are noted. Depositional environments were determined from these observed features.

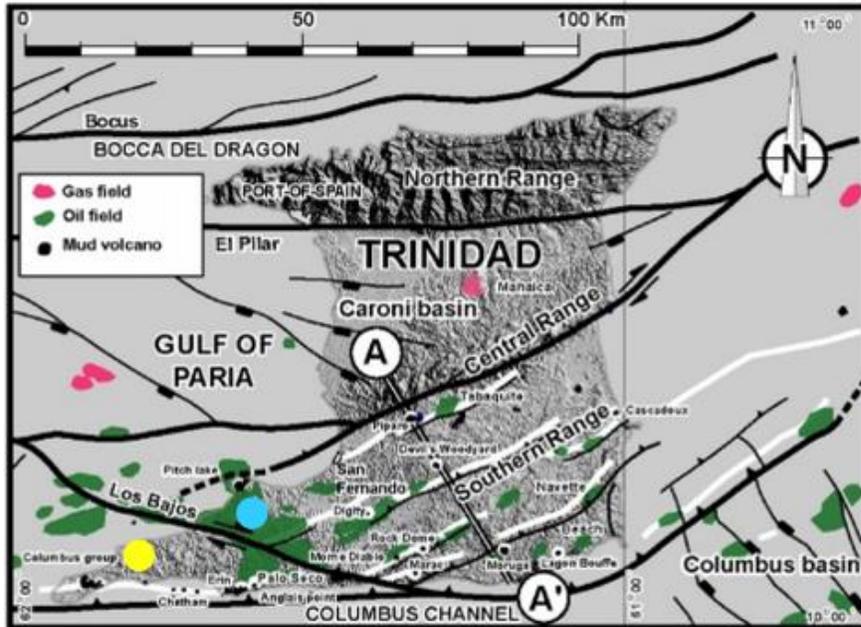


Figure 3: Map of Trinidad indicating gas and oil fields, as well as significant faulting & other structures. Cedros Bay is marked with a yellow dot, Stollmeyer's quarry in blue (Deville et al 2009).



Figure 4: Traverse along Cedros Bay, beginning in the southwest (Google Earth).

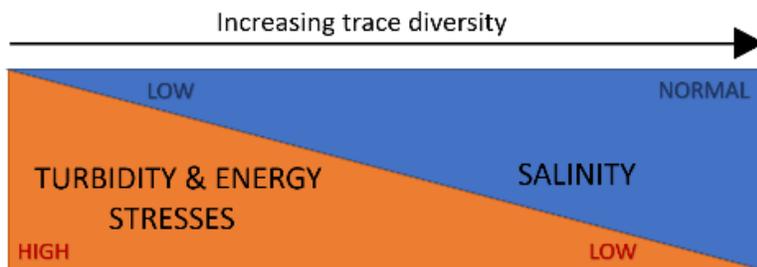


Figure 5: Components comprising relative environmental stresses for marine organisms, and the resulting impact on ichnological diversity.