Monday, May 15, 2017

Westchase Hilton • 9999 Westheimer
Social Hour 5:30–6:30 p.m.
Dinner 6:30–7:30 p.m.

Cost: $45 Preregistered members; $50 non-members/walk-ups

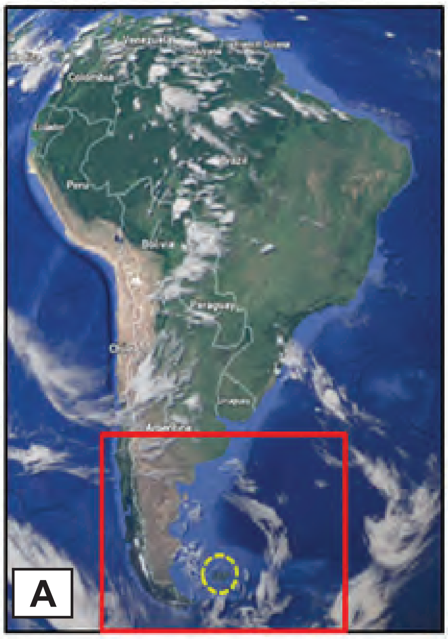
To guarantee a seat, pre-register on the HGS website & pre-pay by credit card.
Pre-registration without payment will not be accepted.
Walk-ups may pay at the door if extra seats are available.

If you are an Active or Associate Member who is unemployed and would like to attend this meeting, please call the HGS office for a discounted registration cost. We are also seeking members to volunteer at the registration desk for this and other events.

HGS International
Dinner Meeting

Carmen M Fraticelli, Yusri Yusri, Don J Yezerski, Jessica A Mercer, Scotty Salamoff, Scott L Miller, and Robert Bunge

Exploring the Geologic Evolution of the Falkland Islands – Where Tectonics and Stratigraphy Merge



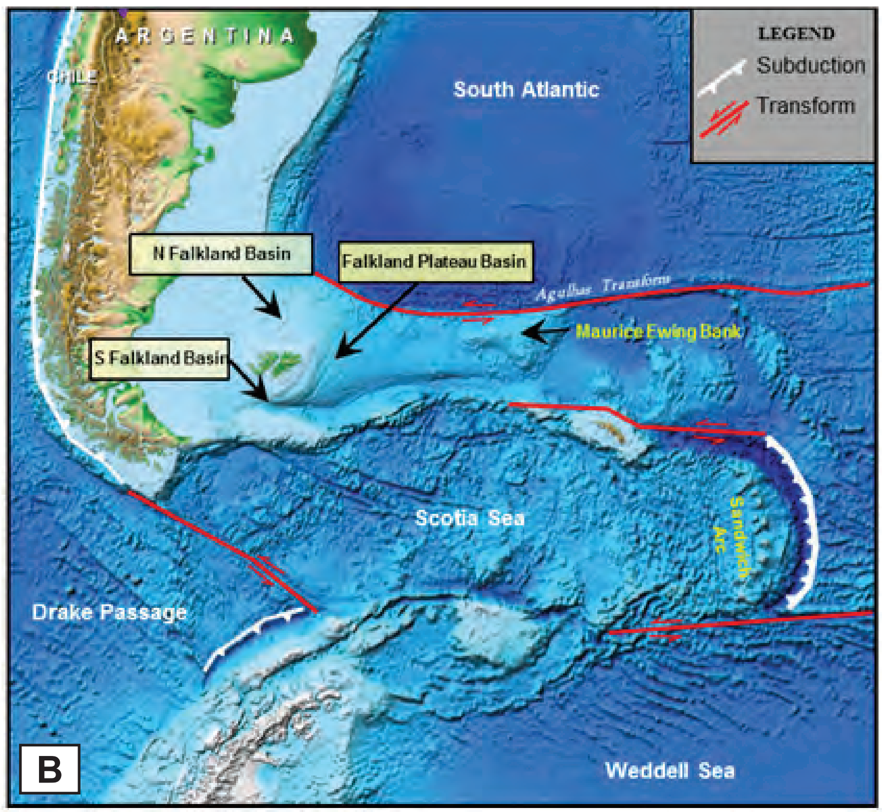
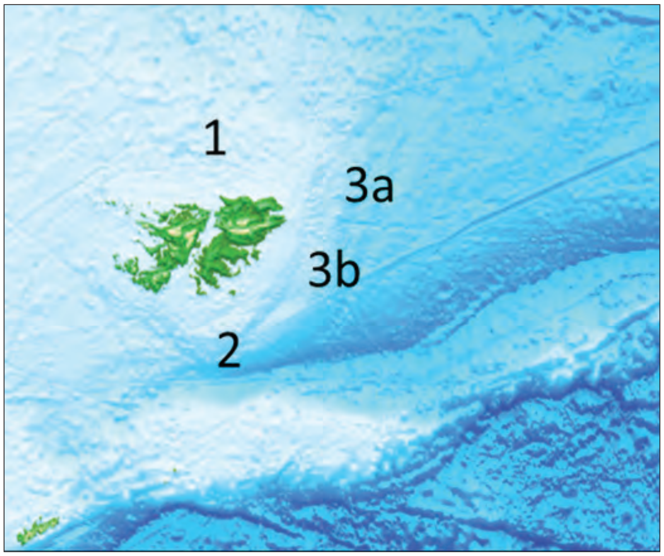


Figure A. *Satellite map of South America showing location of* **B**
Figure B. *Location map of Falklands Plateau Basin*

The Falkland Islands, an archipelago situated 620 km east of Argentina, are much more geologically complex than one would expect given their size (**Figures A, B, & C**). The region is an amalgamation of superimposed extension-compression cycles spanning hundreds of millions of years. The islands themselves are made up of Southern Gondwana remnants – lateral equivalents of the Cape Fold Belt and Karoo Basin – because, at the time of deposition and uplift, the Falkland microplate was positioned between South Africa and Antarctica. Deposition on the islands essentially ends in the Permian. However, Mesozoic and Tertiary rocks can be found throughout the offshore areas surrounding the islands. This talk will address the influence of this structurally complex history on the stratigraphy of the basins surrounding the Falkland Islands.

The offshore area is separated into 3 mega basins: the North Falkland Basin, made up of 2 sub-basins: the Falkland Plateau Basin (also made up of 2 sub-basins) and the South Falkland Basin (**Figure B**). These 5 basins are distinct and unique in both tectonic history and sedimentary fill. Because of this, knowledge from one basin is rarely applicable to another.

The North Falkland Basin (NFB) is an intracratonic failed rift associated with the opening of the South Atlantic in the Early Cretaceous (**Figure 1**). The northern rift displays simple shear extension setting up a series of half graben structures. The basin fill here is similar to that seen in many rift basins, starting with fluvial and alluvial fan deposition evolving to lacustrine and eventually becoming marine. The lake widens and shallows



Gplates Portal http://portal.gplates.org/cesium/
Figure C. *Location map for Figures 1, 2, 3a and 3b*

through time, evolving from a balanced filled to an overfilled lake. It is generally accepted that the primary controls on lacustrine rift systems are tectonics and climate, which provide both the accommodation and the fill (water + sediment). The characteristics of the NFB are strikingly similar to equivalent plays in basins along both the South American and African margins. However, given the latitudinal range from Potiguar to Campos (or Gabon to Benguela), one would expect little similarity between the NFB lacustrine system and those in northern South Atlantic. In fact, we find the opposite to be true.

Current literature on the evolution of the Falkland Plateau Basin emphasizes the break-up of West Gondwana (~130 Ma) as the controlling tectonic event. In addition, most plate models maintain the integrity of the Falkland Plateau as an extension of Patagonia throughout the creation of the South Atlantic. Our regional analysis, based on extensive seismic coverage, illustrates that this interpretation is not compatible with observable structural elements, nor is the South Atlantic opening the primary tectonic event from which the basin characteristics are derived. The Falkland Plateau Basin is actually made up of two Mesozoic basins – the Volunteer and Fitzroy (**Figures 3a & 3b**). Seismic data reveal the remnants of an orogenic belt and associated foreland basin underlie the Mesozoic stratigraphy. It is the distribution of antecedent tectonic domains underlying these that gives rise to the uniqueness of each basin. The geometries of the receiving basins, the shelf to slope transitions, and the distribution of reservoirs all appear to be controlled by these earlier structural styles.

The Volunteer Basin (north) is associated with the portion of the Plateau that is underlain by an extension of the Cape Fold Belt (**Figure 3a**). Extensional faulting is apparent in seismic but is controlled by reactivation of antecedent thrust faults. Topographic highs caused by these pre-existing units strongly influence sediment fairways into the basin and result in shelf depositional systems that are detached from their deep-water counterparts by 10-40 km and resulting in two directional alignments of deep-water turbidites (NW – SE and SW -NE).

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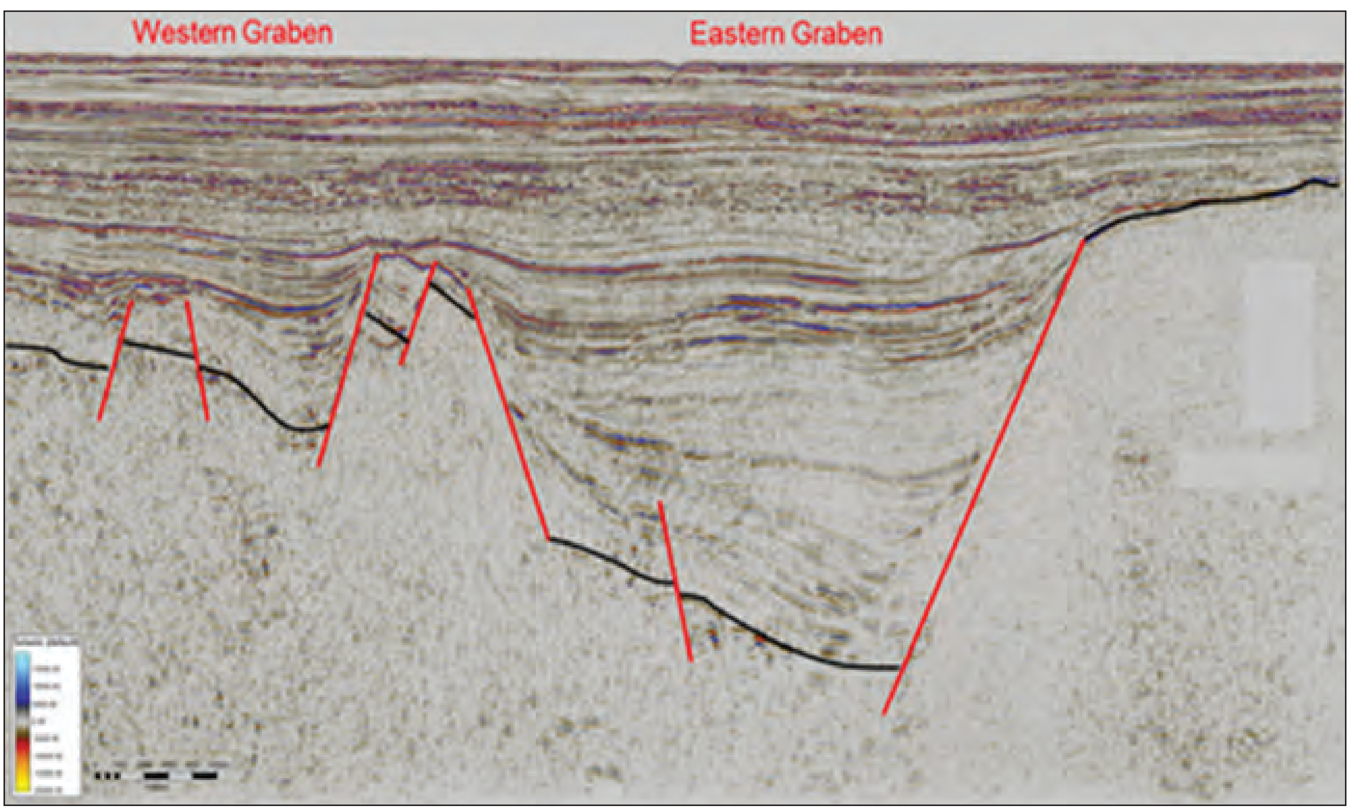

Figure 1. *North Falkland Basin Failed Rift System*

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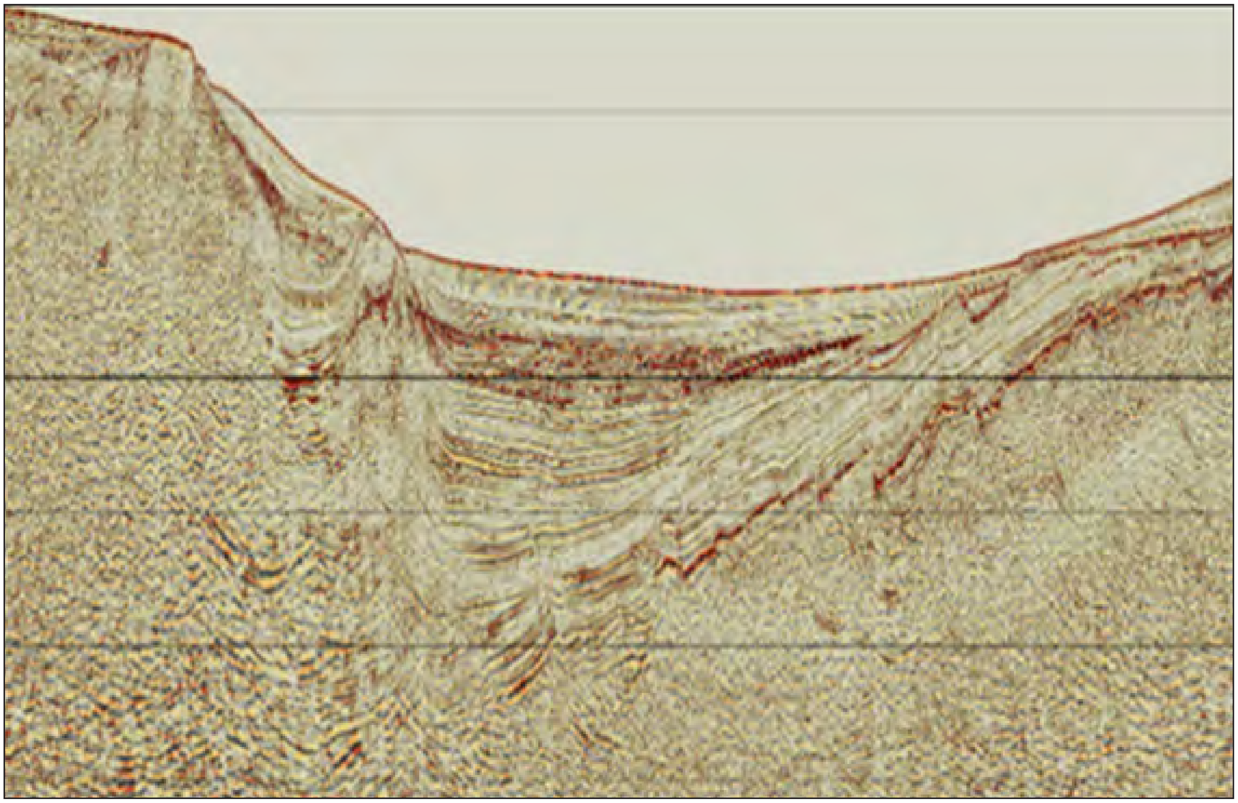

Figure 2. *South Falkland Basin Continent-Continent Collision*

The Fitzroy Basin (central) was created in the portion of the Plateau that is underlain by Karoo equivalent foreland basin deposits (**Figure 3b**). It displays many characteristics of a typical passive margin with a series of Cretaceous (Berriasian – Cenomanian) prograding successions on the shelf linked to deep-water systems in the basin. Shelf successions are all strongly progradational and capped by major flooding surfaces resulting in shoreline regression on the order of 10's of km. Shelf margin units vary between successions from relatively thin, low angle clinoform packages displaying a strongly regressive pattern to thick, moderate angle clinoform packages displaying a dominantly aggradational pattern. The deepwater systems between successions vary from thin flat-lying units to ones with strong compensational stacking and evidence of levees to erosionally confined channel belt packages with no visible levees.

Subsequent tectonic events again modified the Falkland Plateau in the Late Cretaceous. A previously unidentified compressional event transforms the two Mesozoic basins (Volunteer and Fitzroy) into a single Tertiary basin (**Figures 3a & 3b**). Sedimentation from the Falkland Islands is dramatically reduced and sediments are sourced from a seemingly unrelated, and unidentified, provenance. Characteristics of these Late Cretaceous to Eocene units are distinct from those of the underlying Mesozoic system. This compressional event plays an important role in reservoir quality and petroleum systems risk along the Falkland Plateau.

In frontier basins, heat flow predictions often rely on crustal thickness estimates derived from gravity inversion. Such analyses on the Falkland Plateau concluded that the continental crust must thin to zero, based on >12 kms of post rift fill. A basin with no continental crust is inherently cooler than one in which continental crust still exists, thus it was concluded that Fitzroy Basin was cooler than the Volunteer Basin. However, recent exploration wells have shown that both these basins are significantly warmer than predicted. The underlying assumption in gravity inversion is that the current bathymetry and thickness of post-rift fill in a basin can be used to calculate the degree of crustal thinning via isostatic relationships. However, on the Falkland Plateau, only part of the accommodation filled by sediments is attributable to crustal thinning. Starting in the Late Cretaceous accommodation was created by tectonic loading of the Falkland plate. Including this late stage sediment fill in the gravity inversion, calculations resulted in models of basins with much cooler temperatures, whereas in reality, the crust is significantly thicker, making the basins warmer, raising the level of the oil window, and elevating quartz cementation risk. Although a useful tool, gravity inversion is less reliable when the sediment thickness is the result of tectonics beyond just crustal thinning. In frontier exploration, using crustal thickness results from gravity inversion before one fully understands the structural evolution of a basin can lead to errors in basin modeling and diagenesis prediction.

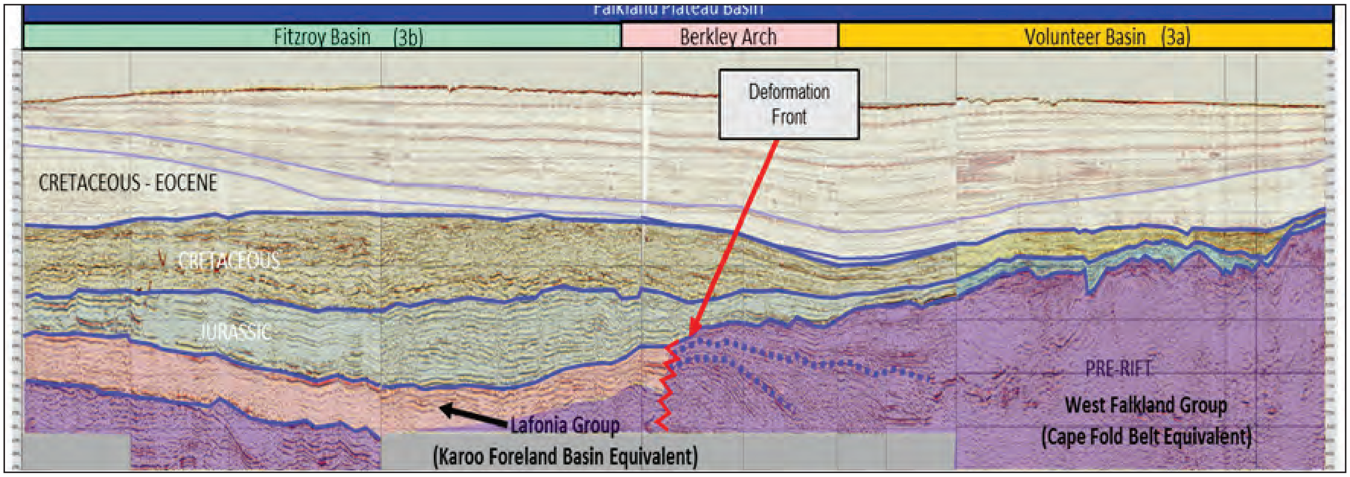

Figure 3b. *Antecedent Foreland, Loaded Plate in Fitzroy Basin (above left)*

Figure 3a. *Falkland Plateau Basin Antecedent Thrust Belt in Volunteer Basin (above right)*

In the South Falkland Basin, the dominant tectonic events post-date deposition of the Mesozoic section (**Figure 2**). In the Cretaceous, it too displays many characteristics of a typical passive margin. However, in the Eocene South America and Antarctica separated and the Scotia Sea was created. The exact mechanism by which it formed are still debated, but many of the islands along both its northern and southern boundary are thought to be sheared remnants of the originally joined continents. The southern basin visible today is the result of the collision between Burdwood Bank and the southern Falkland Island. Seismic traverses clearly show a Tertiary fold and thrust belt which strongly overprints the original Mesozoic passive margin.

Biographical Sketch

Carmen M. Fraticelli has spent over 16 years in the oil and gas industry. Since 2014 she has worked for Noble Energy as a Geologist Advisor, but has also worked for ExxonMobil, Imperial Oil (XOM affiliate), and Unocal spending much of her career in frontier exploration & research functions where integration of disparate datasets is critical. Besides the four basins of the Falkland Islands, she has also worked as a regional and petroleum systems geologist in Suriname, Eastern Canada, the Eastern Mediterranean, Canadian Beaufort & Banks Island, Alaskan Beaufort, Offshore Angola, Brazil (Campos, Santos), Gulf of Mexico, Laptev Sea, Mahakam Delta, Anadarko Basin, and Caspian Sea. She has a Master's degree from Louisiana State University and a Doctorate from Rice University.

She has served on the Technical Program Committee for both 2016 AAPG ACE (Calgary) and 2017 AAPG ACE (Houston) and as co-convener of the 2014 Hedberg Conference Latitudinal Controls on Stratigraphic Models and Sedimentary Concepts. She also currently serves on two AAPG committees (Research and Education), in addition to past service on AAPG's Technical Advisory, Student Expo, and Publication's Committees.