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A Late Jurassic, Tithonian to Early Eocene, Ypresian, stratigraphic framework for the Mizzen F-09, L-11, and O-16 exploration wells, Flemish Pass Basin, Offshore Newfoundland

Nigel R. Ainsworth[1], Leslie A. Riley[2], Simon Haynes[3], Michael McDonough[4], & Edward Stacey[5]

[1] *39 De Tany Court, St. Albans, U.K.*

[2] *Riley Geoscience Limited, Walsall, U.K.*

[3] *Statoil Canada Limited, Calgary, Canada*

[4] *Suncor Energy Inc., Calgary, Canada*

[5] *Husky Energy Inc., Calgary, Canada*

Introduction

The Late Jurassic, Tithonian to Early Eocene, Ypresian, stratigraphy for the three Mizzen discovery and appraisal wells (Mizzen F-09, L-11 and O-16), located within the Flemish Pass Basin, is described using a combination of petro-physical logs, in association with lithological (ditch cuttings, sidewall and conventional cores) and palaeontological (micropalaeontology, palynology) analyses.

All three Mizzen wells occur within the northern half of the Flemish Pass Basin, and are situated over 450 km east of St. John's Newfoundland (Figure 1). They are located within a north-south striking, extensionally faulted, oblique-slip, doubly-plunging horst block, 15 km in length and 6 km wide (Gruschwitz *et al*., 2013). The original discovery well (Mizzen L-11) drilled by Petro-Canada in 2003, encountered non-commercial hydrocarbons in the Tithonian sandstones of the informally designated "Bodhrán formation". The subsequent Statoil Mizzen O-16 and F-09 wells, drilled in 2009 and 2011 respectively, also encountered hydrocarbons from the "Bodhrán formation" sandstones.

Stratigraphy

Seventeen lithostratigraphic units (7 formations and 9 members) are recognized. The oldest recognized sedimentary sequence (occurring in the Mizzen O-16 well) comprises "metasediments" of questionable Palaeozoic age, comprising dark grey to greyish black non-calcareous, fissile claystones. These sediments unconformably underlie the Jurassic sediments in this well.

A 43 m thick white to light grey, lime mudstone, which is locally oolitic, (Tithonian), underlies the "Bodhrán formation" in the Mizzen O-16 well. In both the Mizzen F-09 and L-11 wells, their well T.D.'s are within the upper "Bodhrán formation" ("Late" Tithonian). The lower part of this formation has not been penetrated by any of these three wells. The upper "Bodhrán formation" comprises an interbedded sequence of claystones and sandstones / conglomerates. The claystones comprise medium to dark grey, greyish orange/dark grey mottled, often organic-rich, generally non-calcareous sediments. The organic claystones are micro-laminated often with pale orange lime mudstones, the former containing abundant flimsy amorphous organic matter.

Five clastic reservoir units have been recognized (base Ti-0 to top Ti-4) in the Mizzen discovery (Haynes et al., 2013), with the Ti-3 sandstone unit the primary reservoir. The base Ti-0 represents a major

regional sequence boundary and down-cutting unconformity (equivalent in age to the base Terra Nova Member, Jeanne d'Arc Formation).

Six lithofacies types have been described from conventional core samples (Haynes *et al*., 2013). These comprise lime mudstone, matrix supported gravels and cobble conglomerates, planar cross-stratified sandstones, horizontally stratified sandstones, ripple cross-laminated sandstones, and interbedded shale / siltstone / fine grained sandstone. The claystones are envisaged to have been deposited in marginal to shallow marine environments, often dysaerobic / anoxic; while the arenaceous deposits comprise braided channel / fluvial and restricted nearshore deposits (Haynes *et al*., 2012 and 2013).

The Cretaceous and Tertiary sediments occurring in the Flemish Pass Basin have their lateral sedimentary equivalents in the Jeanne D'Arc Basin. The Flemish Pass Basin sediments do require a newly defined lithostratigraphic framework, and with increased drilling in the region it will be possible to propose new formal names for these units in the future.

The Berriasian sediments, which are laterally coeval with the Hibernia Formation as defined in the Jeanne d'Arc Basin, are informally subdivided into two units; a "Lower Hibernia Shale Member" (Early – intra-Late Berriasian) and an "Upper Hibernia Shale Member" (Late Berriasian). Both the "Lower and Upper Hibernia Shale Members" are argillaceous dominated, comprising grey and light brownish grey, calcareous claystones, with poorly developed light brown lime mudstones. Rare thin beds of white, fine grained sandstone, are noted within the "Lower Hibernia Shale Member". Deposition is envisaged to be in well oxygenated, low energy, inner to possibly middle shelf environments.

The Whiterose Shale Equivalent (Early Valanginian – Middle / Late Barremian) comprises a monotonous sequence of grey to locally brownish grey, calcareous claystones and marls, interbedded with thin, pale orange lime mudstones. Deposition is envisaged to have been open marine, inner to outer shelf. The occurrence of large numbers of radiolaria within the Late Valanginian and Early Hauterivian intervals would indicate an outer shelf environment, with marine up-wellings, providing high nutrients levels during this time.

The Nautilus Shale Equivalent is informally subdivided into two; a "Lower Nautilus Shale" (Middle Albian) and an "Upper Nautilus Shale" (Late Albian). The former comprises both reddish brown and grey calcareous claystones, deposited in a middle to outer shelf, while the latter is dominated by grey calcareous claystones, deposited in an open marine, outer shelf.

A thin Dawson Canyon Formation Equivalent, "Lower Dawson Canyon Member" (Early – Middle Cenomanian) is recognized in two of the wells (Mizzen L-11 and O-16), comprising light grey calcareous claystones, deposited in an outer shelf, well oxygenated, marine environment.

In situ Wyandot Formation (Late Campanian / Maastrichtian) sediments are only recognized, in the Mizzen L-11 well. This unit comprises a highly attenuated white bioclastic limestone, deposited under bathyal, open marine conditions.

The lower part of the Banquereau Formation comprises a lower "Late Paleocene Claystone Member" (Late Paleocene, Early-Late Thanetian) and an upper "Early Eocene Limestone Member" of Early Eocene, Ypresian, age. The former sediments comprises dark grey, non-calcareous claystones, deposited in a locally restricted, bathyal environment, while the latter comprises light grey to pale orange, highly bioclastic (foraminiferal rich), argillaceous limestones and marls, deposited in an open marine, bathyal environment. Marked Campanian / Maastrichtian, Wyandot Formation limestones (c.4 m thick) occur at the boundary between the "Late Paleocene Claystone Member"/"Early Eocene Limestone

Member". Succeeding the limestones are the non-calcareous, brownish grey claystones of the Early to Middle Eocene, Ypresian – Bartonian.

Unconformities

Three major and three possible minor unconformities have been recognized in these three wells:

1. A intra-Tithonian sequence boundary / local unconformity at base Ti-0 level within the "Bodhrán formation" and it's correlative in the Jeanne d'Arc Basin.

2. A base Cretaceous Unconformity between the Hibernia Formation Equivalent, "Lower Hibernia Member" (Early Berriasian) and the underlying "Bodhrán formation" (Tithonian).

3. An unconformity between the Nautilus Shale Equivalent, "Lower Nautilus Shale" (Middle Albian) and the underlying Whiterose Shale (Late / Middle Barremian).

4. A possible Late / Early Cretaceous unconformity between the Dawson Canyon Formation Equivalent, "Lower Dawson Canyon Member" (Middle / Early Cenomanian) and the underlying Nautilus Shale Equivalent, "Upper Nautilus Shale" (Late Albian).

5. An unconformity between the Wyandot Formation (intra-Maastrichtian / Late Campanian) and the underlying Dawson Canyon Formation Equivalent, "Lower Dawson Canyon Member" (Middle / Early Cenomanian).

6. A regional Base Tertiary unconformity between the Banquereau Formation, "Late Paleocene Claystone Member" (Thanetian) and the underlying Wyandot Formation (intra-Maastrichtian / Late Campanian).

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References

Gruschwitz, K., Haynes, S., McDonough, M., Johnson, T. & Stacey, E. 2013. Mizzen – the first oil discovery in the Flemish Pass Basin, Offshore Newfoundland. . *In* Abstracts of the CSPG/CSEG/CWLS GeoConvention 2013: Integration, Calgary, Canada.

Haynes, S., McDonough, M., Gruschwitz, K. Johnson T. and E. Stacey, 2012. Mizzen - An Overview of the First Oil Discovery in the Flemish Pass Basin, East Coast Offshore Newfoundland. *In* Abstracts of the Third Conjugate Margins Conference, 2012. Dublin, Ireland.

Haynes, S. R., Marshall, J., Wathne, E. I., Minielly, G. & Mortlock, E. 2013. Depositional interpretation and reservoir characterization of the Tithonian in Mizzen F-09, Flemish Pass Basin, Canada. *In* Abstracts of the CSPG/CSEG/CWLS GeoConvention 2013: Integration, Calgary, Canada.

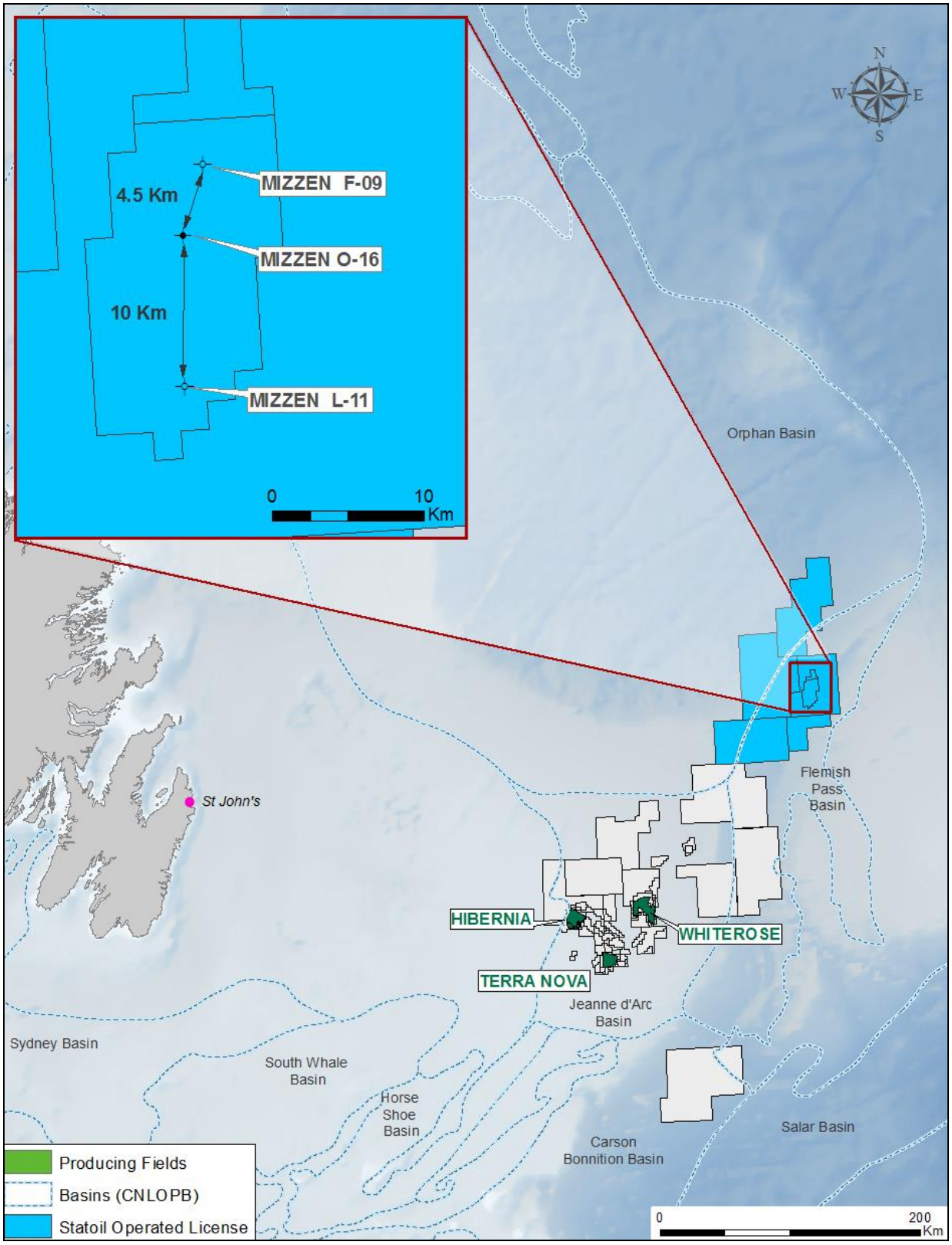

Figure 1. Regional map of offshore Newfoundland with license boundaries and generalized basin outlines from the C-NLOPB (Canada-Newfoundland Offshore Petroleum Board). Inset map displays location of wells discussed in text.