# OFFSHORE OPPORTUNITY - 2020 LICENCE ROUND

## ORPHAN BASIN - NEWFOUNDLAND AND LABRADOR

### EXECUTIVE SUMMARY

- On June 11, 2020, the Canada-Newfoundland & Labrador Offshore Petroleum Board (C-NLOPB) announced Call for Bids Sector NL20-CFB01 in the Eastern Newfoundland region that will close November 4, 2020. As part of the scheduled land tenure process, this high activity region follows a 2-year cycle. In July 2018, a Sector was announced, followed by a Call for Nominations for Parcels that closed in November 2019. These nominations guided the parcel definition for the Call for Bids.
- The area is highly prospective for large hydrocarbon accumulations with 2 wells within the Call for Bids and 16 wells drilled in the basin. Despite the likely presence of petroleum systems and good seismic coverage, in terms of quantity and quality, the area remains mostly under explored. The 2018 Call for Bids in the region resulted in two exploration licences being awarded for over $800 million in work commitments, reflecting the area's potential.

### OVERVIEW

- Located on Canada's East Coast, the province of Newfoundland and Labrador has sustained significant levels of industry interest in its highly prospective offshore basins. Since first oil at Hibernia in 1997, the province's five producing fields - Hibernia, Terra Nova, White Rose, North Amethyst, and recently Hebron, have produced in excess of 1.9 billion barrels of light oil (32-35˚ API). The Newfoundland offshore area now produces over 260,000 bopd and output is estimated to increase to 400,000 bopd when Hebron reaches peak production.
- With substantial undiscovered resources indicated by recent geoscience reports, land available in the 2020 Calls for Bids offers explorers excellent opportunity for substantial discoveries (Figure 1).

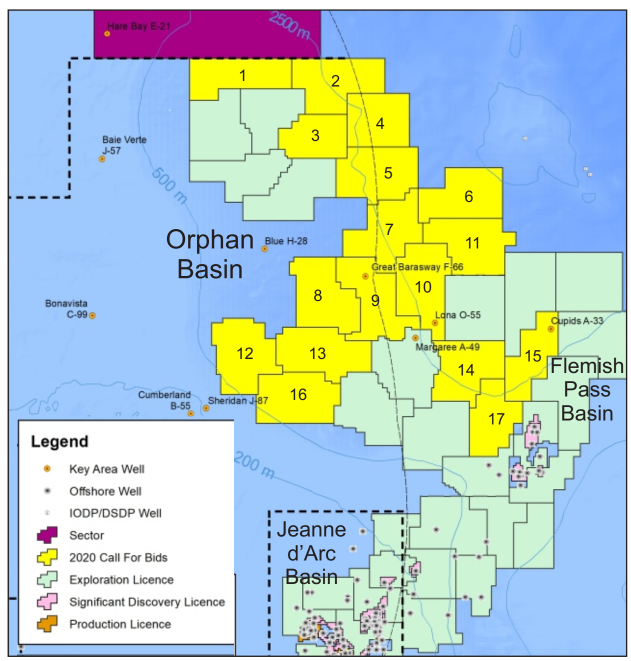



**Figure 1.** 2020 Calls for Bids (yellow) with parcels labelled. Area wells in orange (see Table 1).

### KEY ATTRIBUTES

- The Call for Bids total 4,170,509 ha (10,305,552 acres).
- Closes November 4, 2020 at 12 pm NST.
- Located northeast of the island of Newfoundland.
- Water depth ranges from approximately 480 m to 3,000 m.
- Competitive fiscal regime with very low political risk.
- Modern and historic seismic coverage and tie key wells.
- Virtual Exploration Data Room available
- Proximity to both North American and European markets.
- Open and transparent land management and bid processing system.
- A winning bid is based solely on highest bid amount.
- For more information, visit [www.cnlopb.ca](http://www.cnlopb.ca)

Newfoundland Labrador CANADA

# REGIONAL GEOLOGY OF THE ATLANTIC MARGIN

- The 160,000 $km^2$ Orphan Basin is a Mesozoic extensional basin developed over hyper-stretched Precambrian and Paleozoic basement on the Canadian Atlantic Margin.
- Late Triassic to Early Jurassic rifting of Pangea created a chain of NE-SW oriented intracratonic basins extending from the Gulf of Mexico to the Barents Sea. Offshore Newfoundland basins are part of this Mesozoic rift system. Oblique and perpendicular rift branches (e.g. Bay of Fundy, Orpheus Graben, Aquitaine Basin, Viking Graben, Labrador Sea) also formed during the same series of extensional events.
- In eastern Canada, the Mesozoic rift basin chain starts with George's Bank Basin offshore Nova Scotia, stretches through the Scotian shelf and slope basins and subbasins and continues with the Laurentian Basin, located between Cape Breton Island and Newfoundland. To the north, the system continues with the shallow water Grand Banks basins that includes the Jeanne d'Arc Basin, before extending to the deep water Flemish Pass and Orphan basins (Figure 2).

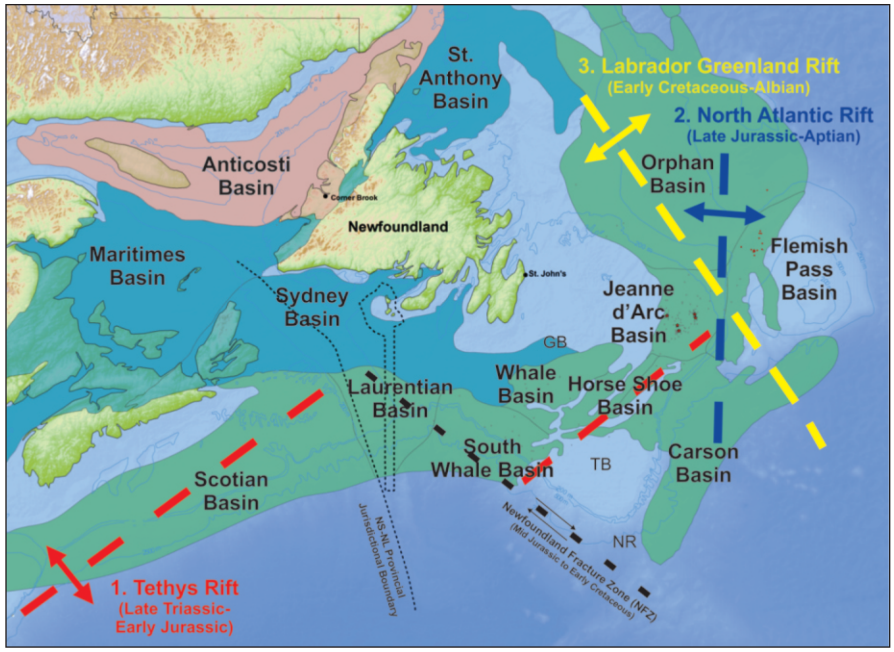



**Figure 2.** Regional geology of the Canadian Atlantic Margin showing main basins and phases of extension. Red stars are producing fields. GB: Grand Banks, NR: Newfoundland Ridge, TB: Tail of the Bank. Modified by Enachescu (2020).

# ORPHAN BASIN GEOLOGY

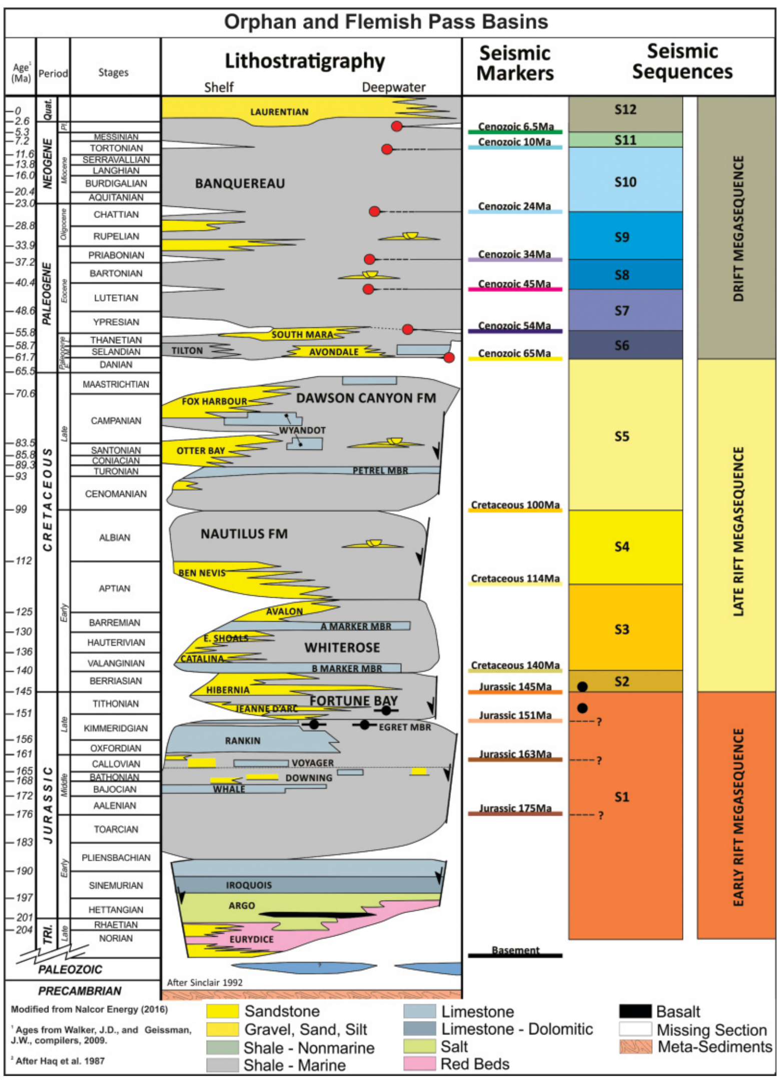
- Orphan Basin is the largest sedimentary basin offshore Newfoundland. It is a wide (> 400 km) non-volcanic, highly extended area, situated on the Canadian Atlantic margin and extending from the shelf into more than 4,000 m water depth (Figures 1 & 2).
- The Mesozoic rifted Orphan Basin is located to the north-northeast of the Jeanne d'Arc Basin and Central Ridge and west-northwest of the Flemish Pass Basin and shares a similar geodynamic evolution. Specifically, these basinal areas share: a) common structural-tectonic evolution, b) comparable depositional regime throughout the Late Triassic to late Early Cretaceous, and c) similar petroleum system.
- A true frontier basin, the Orphan Basin is located North of Grand Banks shelfal area and is separated from the southern rifted basins by a chain of basement highs and transfer faults with gravity and magnetic signatures, known as the Cumberland Belt. The Orphan Basin is separated from the Bonavista Platform by the complex Bonavista Fault Zone, bounded to the northwest by the offshore continuation of the Dover Fault and limited to the northeast by the Orphan Knoll-Flemish Cap lineament.
- An artificial boundary - the Grand Banks' bathymetric drop to approximative 1,500 m water depth - marks the basin extent to the southeast where it joins the Flemish Pass Basin. While the basin resides entirely on continental crust, its northeastern part became a divergent margin in the Aptian when the basin separated from the conjugate Irish margin.
- Formation of the Orphan Basin, is related to Mesozoic continental rifting followed by opening of the North Atlantic Ocean. Intra-continental crustal extension and formation of several sedimentary basins offshore Newfoundland started in Late Triassic and ended in the late Early Cretaceous.
- Three main extensional phases influenced the final structural make-up of the basin:
    1. Tethys Phase, during Late Triassic-Early Jurassic;
    2. North Atlantic Phase, during Late Jurassic-Early Cretaceous; and
    3. Labrador Phase, during late Early Cretaceous (Figure 2).
- The initial phase of rifting has probably affected only some of the eastern Orphan Basin's half grabens, in continuation of rift trends prolonged from the Jeanne d'Arc and Central Ridge areas. In places, episodes of extension may have continued into Mid and early Late Cretaceous. Inter-phase thermal subsidence and a final, intensive Late Cretaceous to Present time subsidence have increased and deepened the basinal area. Finally, the separation of Greenland from Europe and the Iceland hot spot may have also influenced the final structural setting of the basin.

## ORPHAN BASIN GEOLOGY (continued)

- The Orphan Basin's complex evolution is characterized by repeated intra-continental Mesozoic rift phases, transtensional episodes, intermediary and final post-rift thermal subsidence stages and a pronounced crustal inversion event at the end of Cretaceous, marked by a regional K/T unconformity.
- Unlike most other areas offshore Nova Scotia and Newfoundland, no salt diapirism is present in the Orphan Basin. Deposition of coarse clastics including reservoir sandstones was widespread, especially within large paleodrainage systems and deltaic episodes during the Late Jurassic to Early Cretaceous.
- Due to sparse drilling and lack of regional stratigraphic studies, a modified Jeanne d'Arc lithostratigraphic column can be used for the majority of sedimentary sequences within the Orphan Basin (Figure 3).

## ORPHAN BASIN: LITHOSTRATIGRAPHY

- The Orphan Basin basement is part of the Appalachian Avalon terrane, consisting of Precambrian metamorphic, volcanogenic and granitoid units, and of Early Paleozoic (Cambrian to Carboniferous) sedimentary rocks including platform carbonates and clastics. Five of the wells drilled in the central-western part of the basin have terminated in prerift basement after intersecting a thick Tertiary column and several Mesozoic units. In the eastern part of the basin, early rifting had probably begun in Late Triassic, but red beds (Eurydice Formation) or salt (Argo Formation) have not yet been drilled. No diapiric salt is observed on seismic data, but a stratified evaporite/mudstone unit may be present (while imaged by seismic sections in the central-eastern basin), the Early Jurassic Iroquois Formation and Whale Member of the Downing Formation have not been reached by drilling. Nearshore marine deposits dated Bajocian encountered by the DSDP Leg 12 drilling (1970) on Orphan Knoll (Figure 1) are the oldest sedimentary layers penetrated in the basin.
- During the second phase of rifting (Late Jurassic-Early Cretaceous), a predominantly clastic succession accumulated in the basin. Marine organic shales were deposited in a shallow, restricted sea during Kimmeridgian and Tithonian, not unlike the depositional conditions of the Egret source rock in Jeanne d'Arc Basin (Figure 3). Due to tectonism and eustasy, marine shale deposition was interrupted by episodes of continental deposition of alluvial clastics and nearshore marine deltaic and pro-deltaic fine to coarse sandstone (equivalents of Jeanne d'Arc, Hibernia, Avalon formations) (Figure 3). These reservoir quality sandstones were penetrated by the deepwater wells of eastern Orphan Basin and northern Flemish Pass Basin when targeting large faulted anticlines.



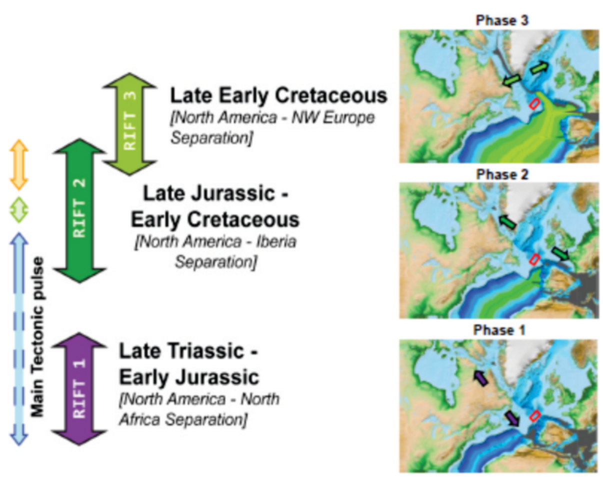




**Figure 3**. Orphan and Flemish Pass Basin stratigraphic chart and North Atlantic tectonic history. Image courtesy of Nalcor Energy (2014). Maps from Muller et al. (2008).

## ORPHAN BASIN: LITHOSTRATIGRAPHY (continued)

- Clastic sedimentation consisting of continental, shelf and shallow water depositional environments continued throughout the Cretaceous. Within the deeper parts of the basin, turbiditic systems were formed at the toe of slope. Toward the end of Cretaceous, clastic deposition was in places interrupted only by thin limestone deposition (e.g. Wyandot Member).
- Except for the deposition of basin margin prograding wedges, slope fans and turbidites that create an impressive shelf/slope edifice in the eastern part of the basin, the Tertiary is dominated by shale deposition in an increasingly deepwater environment created by rapid subsidence (Figure 3).

## ORPHAN BASIN: SEVERAL GEOLOGICAL PROVINCES

The basin can be subdivided into three structural areas (Figures 4 & 5):

1. The East Orphan Basin that predominantly extended during the first two rifting stages,
2. The Central High area containing a series of large, inverted extensional blocks and ridges, and
3. The West Orphan Basin that extended mostly during the last two rifting stages (Enachescu et al., 2005).

**East Orphan Basin (EOB):** This area contains the deepwater part of the basin and the deepest synrift infill. The Tertiary sedimentary sequence is relatively thin. The Late Triassic to mid-Cretaceous sedimentary fill is segmented by numerous normal faults. Major detachment faults have created large complex anticlines and rotated basement block.

**Central Orphan High (COH):** This area consists of numerous elongate anticlines, chain-disposed, in a general arcuate, NNE-NS-SSE direction. The anticlines are formed along a complex, en-echelon fault system, known as the White Sail Fault zone. The Orphan Knoll, a relatively high, sedimented basement block, forms the northernmost part of this Call for Bids.

**West Orphan Basin (WOB):** This area extended mostly during the latest two rift stages and contains numerous high basement blocks overlain by very thick (>4 km) Tertiary and Cretaceous cover. The Late Cretaceous and Tertiary seismic sequences contain submarine fan-like features spanning tens of kilometers.

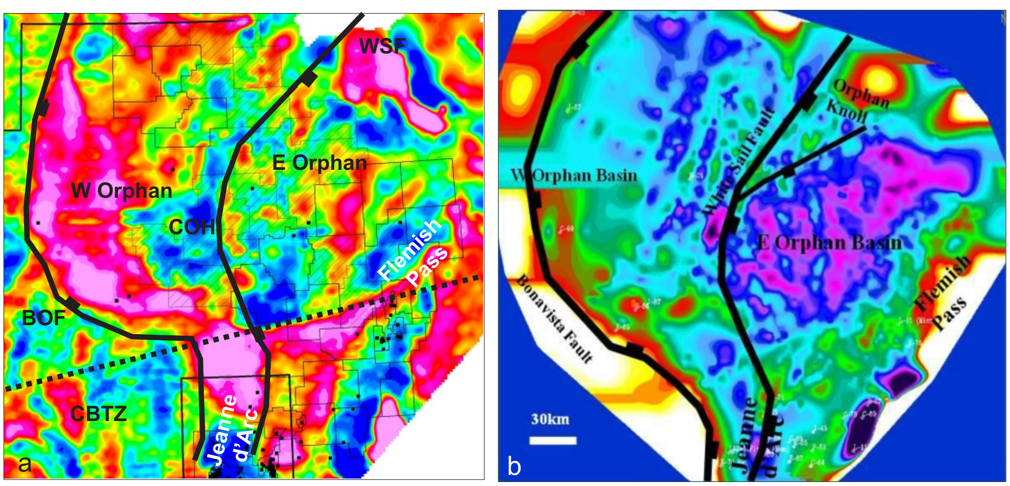



**Figure 4.** (a) Free-air gravity anomaly and (b) Basement time structure identifying Orphan Basin geological provinces. 2020 Call for Bids (cross-hatched), exploration licences (black outline), BOF: Bonavista Fault, CBTZ: Cumberland Belt Transfer Zone, COH: Central Orphan High, WSF: White Sail Fault Zone. Left image data from Natural Resources Canada (2017). Right image modified from Enachescu et al. (2004, 2005).

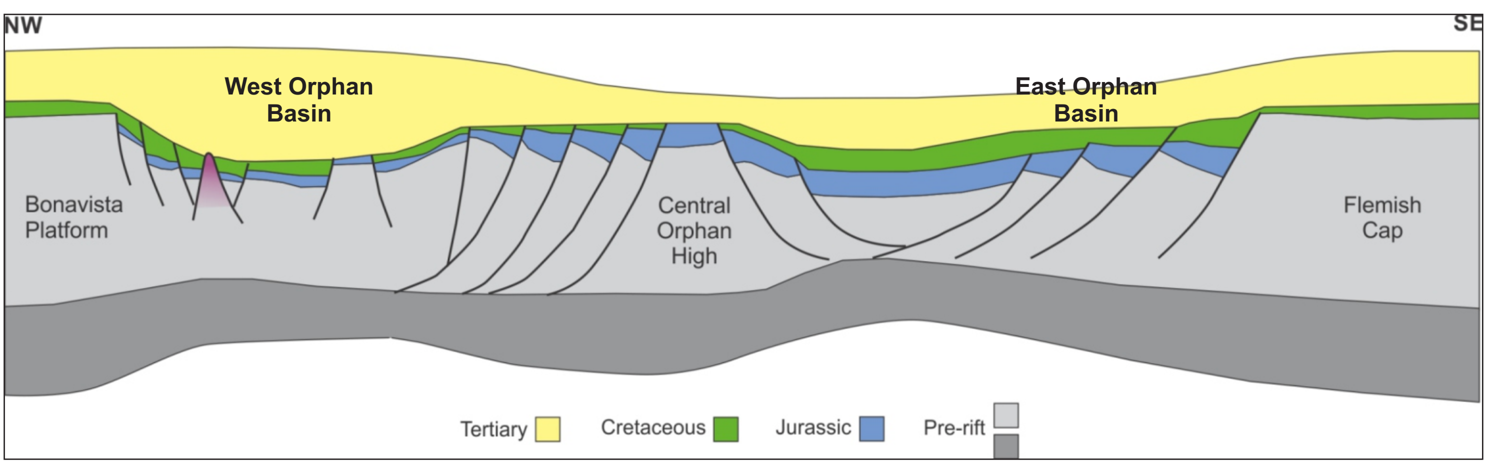



**Figure 5.** Regional cross-section showing basement horst, graben, and rotated block lineaments. Modified from Nalcor Energy (2016).

## PETROLEUM GEOLOGY: OVERVIEW

- As described earlier, the Orphan Basin can be considered as a northern extension of the Jeanne d'Arc and Flemish Pass basins, which both contain proven petroleum systems for light oil and gas. The basin is one of the last Canadian exploration frontiers, with only six wells (1974-1985) drilled in the western side of the basin, one intermediate water depth well (Blue, drilled in 1979), three more recent wells in the basin's deeper eastern side (Great Barasway, Lona, and Margaree, drilled between 2007-2013), and one well drilled on the slope between the Orphan and Flemish Pass basins (Cupids, 2015) (Figure 1).
- The shallow water wells were drilled on large basement highs, located mostly in the downthrown side of the Bonavista Fault. They intersected a thick Tertiary column including seal rocks and all encountered good to excellent Late Cretaceous and Early Tertiary reservoirs. Porosity within these sandstone averages 19-20%. Several high Total Organic Carbon (TOC) intervals were intersected in the wellbores.
- While unsuccessful, the recent deepwater wells have proven the presence of good Late Jurassic source rocks as well as reservoir rocks of Late Jurassic to Early Cretaceous age. The **Lona O-55** well intersected 470 m (180 m net) of sandstones with 20% average porosity, interpreted as part of a prograding delta. The **Cupids A-33** well drilled through two porous and permeable Tithonian-aged sand intervals (average 25% porosity), that are interpreted to belong to the same paleodrainage system proven by the Mizzen and Bay du Nord oil fields.
- The basin contains a thick sedimentary fill above the hyperextended basement which on seismic profiles and structural maps appears as a repeated series of horst, graben, and rotated block lineaments (Figure 5). Numerous basement involved blocks and fault detachment structural closures, some with areas larger than 100 $km^2$, are mapped using available 2D and 3D data. On the basin's southern and western margins, Late Cretaceous and Tertiary sedimentary prograding wedges that might contain large slope fans and turbidite systems are well-imaged. At the bottom of this thick sedimentary sequence both Cretaceous and early Tertiary potential source rocks are currently within the oil window.

## PETROLEUM GEOLOGY: RESERVOIRS AND SEALS

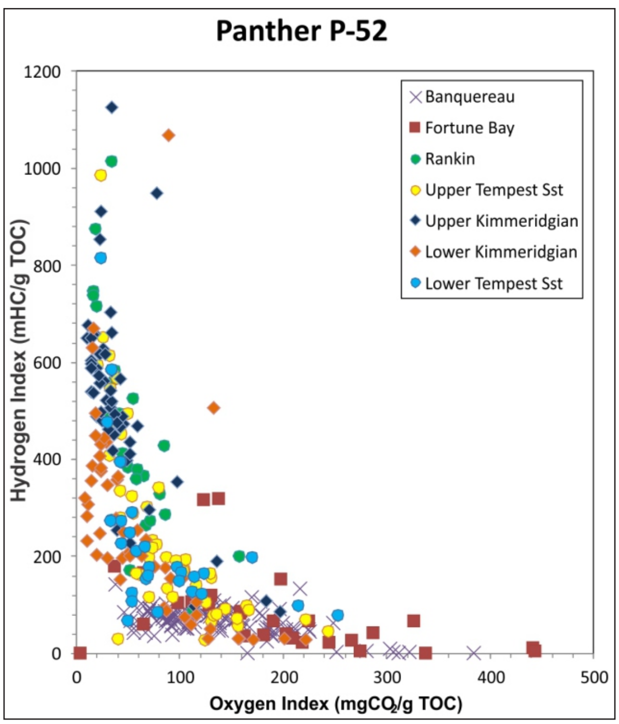
- Reservoir rocks in the Orphan Basin and environs consist of high porosity, high permeability quartz rich sandstones, mainly deposited during synrift phases. Additionally, postrift turbidite sands should also be present in the Late Cretaceous and Tertiary successions, especially on the western and southern sides of the basin.
- The most prolific reservoirs in the neighboring basins that are producing at Hibernia, Terra Nova, White Rose and Hebron are the Jeanne d'Arc (Tithonian), Hibernia (Berriasian-Valanginian), Avalon (Barremian) and Ben Nevis (Aptian) sandstones (Figure 3). The equivalent Late Jurassic-Early Cretaceous aged sandstones with good quality reservoir properties (porosity 18-24%; permeability 100-3000 md) should be present in the Calls for Bids area. Alluvial sandstones of Tithonian age form the reservoirs in the Mizzen (average porosity 21%; average permeability 1.2 D) and Bay du Nord (porosity 22-26%) fields. Similar reservoirs have also been encountered in the Cupids A-33 well.
- Within the Orphan Basin, the **Lona O-55** well intersected a thick column of Late Jurassic to Early Cretaceous sandstone (180 m net; 20% average porosity) with shale intercalations, characterized as a large prograding delta. The **Blue H-28** well, in the middle of the basin, encountered Early Cretaceous coarse, sub-angular sandstone with 19% porosity. Several of the wells drilled in the western part of the basin have intersected good Late Cretaceous reservoirs (Otter Bay and Fox Harbour sandstones) (Figure 3).
- Finding adequate seal rocks should not be a problem in the basin as thick intra-formational shale intervals and thick overlying shale formations were drilled in the synrift sequence, while the thermal subsidence sequence spanning from Late Cretaceous to Present contains predominantly shale and mudstone (Dawson Canyon and Banquereau formations).

## PETROLEUM GEOLOGY: SOURCE ROCKS

- Similar to the other northeast Newfoundland basins, the Orphan Basin contains all the prerequisites to become a world class petroleum province. Numerous regional seismic sections show that the Orphan Basin was connected during the Late Jurassic with the Jeanne d'Arc and Flemish Pass basins and that the seismic signature of marine organic shales can be recognized in the half grabens and rotated blocks containing synrift sedimentary sequences (Enachescu et al., 2005).
- Most significant source rocks offshore Newfoundland are the Late Jurassic Tithonian and Kimmeridgian shales. In the Jeanne d'Arc Basin, the Kimmeridgian Egret Member of the Rankin Formation is the predominant source rock for all producing light oil accumulations. This unit is equivalent to the prolific Kimmeridgian source rocks of numerous Atlantic Margin basins, including the Viking Graben and Norwegian Sea. In the Jeanne d'Arc Basin, the Kimmeridgian Egret Member is a Type II, oil prone source rock with up to 9% TOC. The average TOC content varies from 3.4 wt.% in the west to 2.8 wt.% in the east of the Jeanne d'Arc-Central Ridge area (Figure 1). Similarly, the average hydrogen index (HI) decreases from 560 mg HC/g TOC in the west to 410 mg HC/g TOC in the east while source rock thickness ranges from 50 m to over 500 m at Panther P-52 (Figures 6 & 7).

## PETROLEUM GEOLOGY: SOURCE ROCKS (continued)

- According to Magoon et al. (2005), the burial history chart for the Kimmeridgian Egret Member in Jeanne d'Arc Basin indicates that petroleum expulsion began in the Egret source rock at about 120 Ma at 3,800 m burial depth (below mud line, BML), peak generation occurred at about 100 Ma at 5,000 m depth (BML), and was depleted after burial to 5,600 m (BML) during the Late Cretaceous (90 Ma).
- The Tithonian source rocks, first identified in the Flemish Pass, are mostly shale with 2-4% average TOC. The presence of a rich Tithonian-aged source rock (around 3% TOC) were proven in Great Barasway F-66 well (Figures 8 & 9) in the Orphan Basin, and the Baccalieu, Lancaster, Mizzen, and Bay du Nord wells in the neighbouring Flemish Pass Basin.
- Predominant kerogen in the Tithonian unit is Type II and therefore oil-prone. In Flemish Pass Basin, both Kimmeridgian and Tithonian aged source rocks were intersected (e.g. at Baccalieu I-78). Egret Member beds in the Flemish Pass Basin average 130 m thick, have a TOC range between 1.9 and 13% (2.3% average), and a HI range of 197-586 (328 average) (McCracken et al., 2000). The marine shales that separate the Tithonian reservoirs in the Mizzen oil field have 8-12% TOC (Haynes et al., 2012).
- Other rich TOC intervals in Late Jurassic rocks (Type II kerogen) were encountered elsewhere in the Grand Banks basins in the Callovian to Oxfordian successions (Rankin and Voyager formations).
- Younger source rocks were intersected in Turonian-Cenomanian aged layers in the Great Barasway (Figures 8 & 9) and Sheridan wells. Type II and III Tertiary-aged source rock were logged regionally in most wells drilled in the Orphan and northern Flemish Pass basins. The lower Paleocene has average TOC of 2-5% depending on the basinal settings and is buried to more than 4 km in the western part of the basin. None of these source rock intervals have yet been proven to generate petroleum accumulations, but they could be in the maturation window in the Call for Bids.
- Recent resource assessment studies produced by Beicip-Franlab on behalf of Nalcor that included Orphan Basin wells, showed that the average burial depth at which the 0.6% Ro threshold (top of the early oil window) is reached around 3200 m BML for a 29 to 33°C/km average geothermal gradient. The initiation of the gas condensate generation zone (> 1.3% Ro) seems to occur around 4500 m BML. The same studies showed that the above-mentioned Late Jurassic and Cretaceous source rocks could generate significant quantities of oil in the area (http://exploration.nalcorenergy.com/exploration-reports/resource-assessments/). A thorough evaluation of the geology and petroleum potential of the Call for Bids will be issued by Beicip-Franlab and Nalcor Energy prior to the upcoming licencing round.



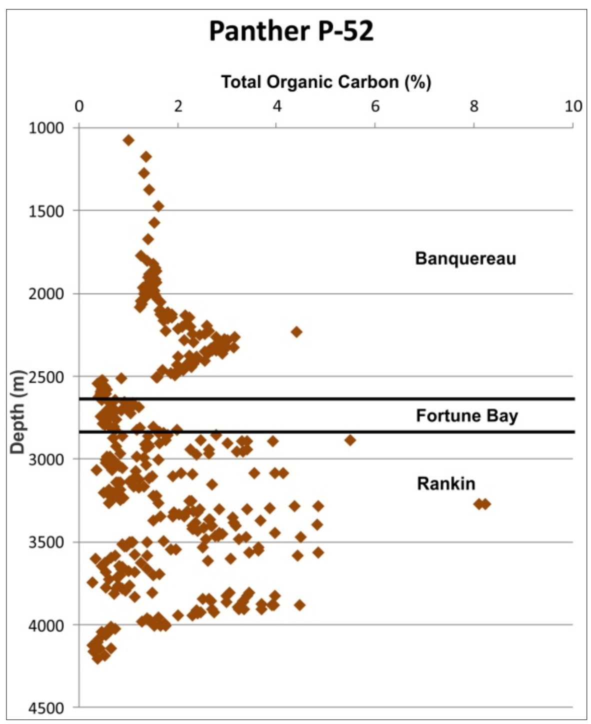




**Figure 6** (left). Panther P-52 modified van Krevelen graph. Data from Geological Survey of Canada (2012).

**Figure 7** (right). Panther P-52 total organic content versus depth. Data from Geological Survey of Canada (2012).

## PETROLEUM GEOLOGY: TRAP STYLES

- Within the Orphan Basin, the tectonically distinct EOB, COH and WOB contain large structural, stratigraphic and combination traps (Figure 4). The early wells were drilled into fault-bounded rotated basement blocks, while the deepwater wells targeted Cretaceous and Late Jurassic reservoirs in detachments or rollover anticlines. Numerous similar large structural closures remain undrilled in the basin, including in the Calls for Bids. Several large submarine fan features were also mapped on 2D and 3D seismic but they are yet to be drilled.
- Structural traps in the Orphan Basin are associated with: 1) multiphase rifting of the Atlantic Margin; 2) transtension and inversion; and 3) subsidence and tilting. Main structural trap types are rotated blocks, extensional anticlines, rollovers, multi-side fault bounded anticlines, compression modified extensional anticlines (due to transtension), faulted/tilted blocks, elongated horsts, onlap or drape over basement highs. Local inversion due to transtension is also a trap-forming mechanism.
- The majority of faults in the basin are down-to-basin or down-to-margin listric normal faults, but some oblique normal faults and transfer faults exist forming horsts, ridges, and trap-door features.
- Stratigraphic traps are widespread, especially in the postrift sequence. Sub-unconformity traps, paleo-valleys, basin margin, slope and basin floor fans are abundant in the basin and on seismic data form large geophysical anomalies.

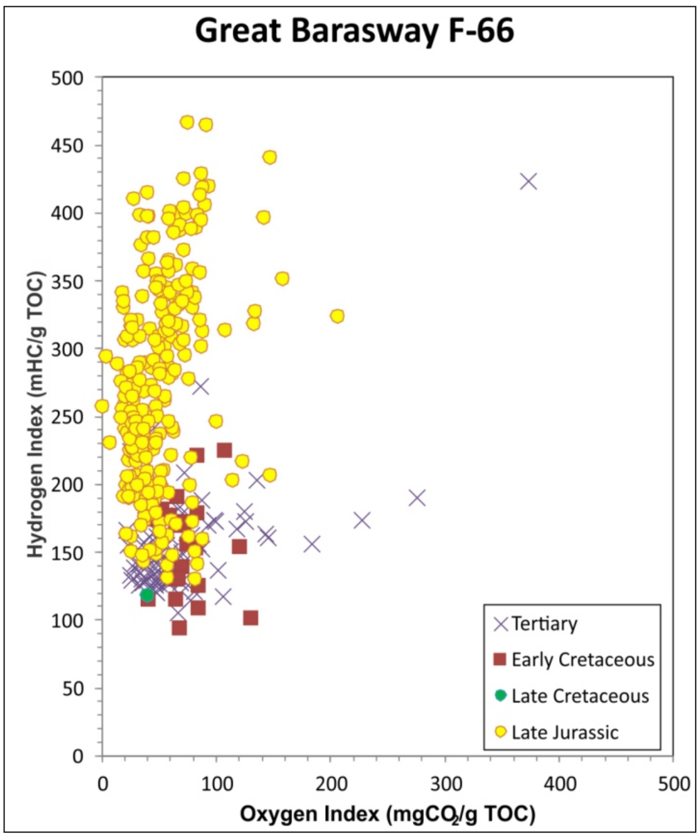



**Figure 8.** Great Barasway F-66 modified van Krevelen graph. Data from Geological Survey of Canada (2012).

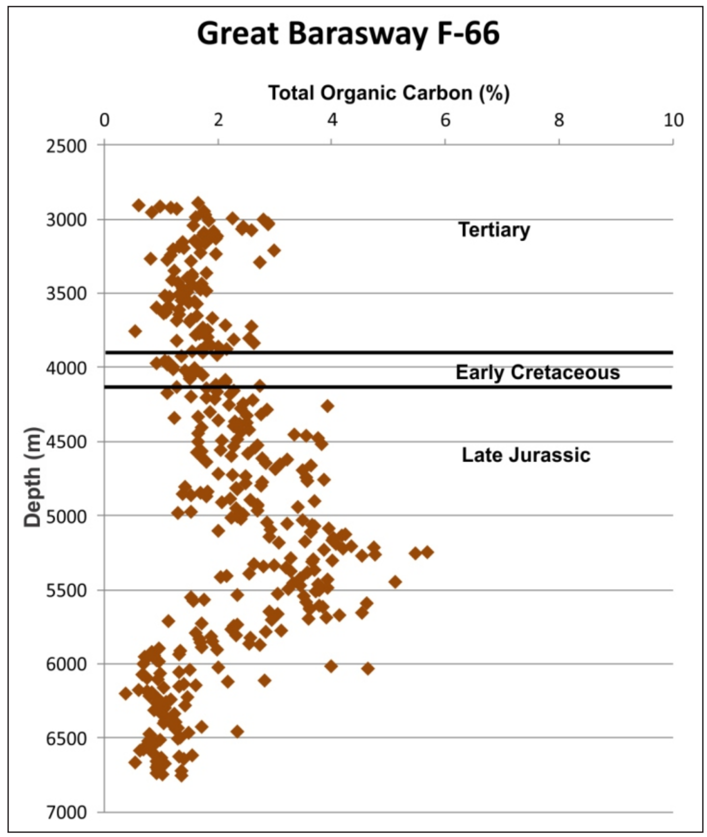



**Figure 9.** Great Barasway F-66 total organic content versus depth. Data from Geological Survey of Canada (2012).

## PETROLEUM GEOLOGY: PLAYS AND RISKS

- Multiple play types are conceptualized in the Orphan Basin, including large structural fault-bounded closures, Cretaceous fans, Tertiary lowstand submarine fans, and channel complexes.
- Conventional plays exist in the Orphan Basin:
    1. Late Jurassic Tithonian Sandstone associated with fault bounded closures
    2. Early Cretaceous Sandstone associated with fault bounded and strat-structural closures
    3. Late Early Cretaceous Sandstone associated with lowstand stratigraphic closures
- These plays are formed by the above reservoirs trapped in roll-over anticlines, listric fault bounded blocks, multi-fault closures, and drapes over basement highs.

## PETROLEUM GEOLOGY: PLAYS AND RISKS (continued)

- Late Jurassic to Cretaceous and Early Tertiary lowstand clastics are expected to have significant play potential on the slope/upper rise and within the Bonavista prograding wedge.
- The typical hydrocarbon play in the basin is a structural high such as an extensional anticline, roll-over anticline, horst, rotated block, faulted anticline, drape anticline, with any of the Late Jurassic - Early Cretaceous fluvio-deltaic and shoreface sandstones (primary target) and/or Late Cretaceous and Paleocene marine fan sandstone (secondary target) sourced from Late Jurassic (Kimmeridgian, Tithonian-aged) marine source rocks.
- Additionally, individual marginal fans and lowstand fans sourced from Late Jurassic or younger rocks may form a novel play in the basin. Based on the area of closure and typical reservoir thickness in neighboring oil discoveries, the identified traps can contain 100 to 1,000 mmbbls recoverable resource equivalent.
- The main geological risks are considered to be, locally, reservoir quality, source rock presence and quality, and sealing across faults.

## WELL DATA

- 11 wells have been drilled within the confines of the Orphan Basin or on its margins (Figure 1, Table 1).
  - Six in the shallow water, within or on the western margins:
    - Bonavista C-99, Cumberland B-55, Hare Bay E-21, Sheridan J-87, Linnet E-63, Baie Verte J-57
  - Four in the deepwater:
    - One in the central part of the basin, Blue H-28, and
    - Three more recently in the eastern part of the basin: Great Barasway F-66, Lona O-55, and Margaree A-49
  - One on the easternmost edge of the basin at the boundary Flemish Pass-Orphan Basin boundary: Cupids A-33
  - All wells were abandoned, some with good oil and gas shows (Table 1).
- The three wells drilled in the East Orphan Basin and within or close to the Call for Bids area have encountered Late Jurassic reservoir and source rocks. The Cupids A-33 well intersected a sedimentary column similar to the Mizzen and Bay du Nord discovery wells.
- Some shallow wells encountered Cenomanian-Turonian source rock that was immature to moderately mature, e.g. Sheridan J-87.
- These well results point toward exploring in deeper basinal areas such as those offered in the Calls for Bids, where source rocks may be mature.
- These well results are in the public domain and well reports and paper copies of logs are available from C-NLOPB. Digital logs can be obtained for a fee from vendors or viewed in Natural Resources' Exploration Data Room.

## SEISMIC DATA

- Excellent seismic coverage exists for the Calls for Bids:
  - There is over 4,000 km of 2D and 16,000 km$^2$ of 3D seismic that is available publicly from the C-NLOPB (Figure 10) as well as in Natural Resources' virtual Exploration Data Room on a subscription basis, and
  - A dense 5x5 km grid of 2D data and over 20,000 km$^2$ of 3D for purchase from seismic vendors (Figure 11).
- Seismic quality is excellent in the Tertiary-Late Jurassic sequence where reservoirs are present. Data deteriorates in the Late Jurassic to Basement interval. Pre-rift basement is mappable in places (Figures 12 & 13).
- Within syn-rift formations, high quality regional seismic markers exist such as carbonate and sandstone intervals. Prominent regional markers are widespread unconformities such as the Base Tertiary, Avalon, and Base Cretaceous. Main and secondary faults are readily traceable on the data.
- As previously shown in other parts of the basin, targeting geophysical anomalies may indicate sand fairways and/or presence of hydrocarbons.

**Table 1**. Orphan Basin well results. Abnd: Abandoned, COH: Central Orphan High, Cret.: Cretaceous, EOB: East Orphan Basin, O-FP: Orphan-Flemish Pass, WOB: West Orphan Basin.

| Well | Drilled | WD (m) | Status | TD (m) | Loca-tion | Prerift Unc. | TD in | Reservoir | Source Rock |
|---|---|---|---|---|---|---|---|---|---|
| Bonavista C-99 | 1974 | 329 | Abnd | 3685 | Shelf, WOB | 3679 | Granitic basement | Upper Cret. | Not penetrated |
| Cumberland B-55 | 1975 | 195 | Abnd | 4137 | Shelf, WOB | 3706 | Basement | No | Not penetrated |
| Blue H-28 | 1979 | 1486 | Abnd | 6103 | COH | >4892 | Carboniferous basement | Thin Lower Cret. | Not penetrated |
| Hare Bay E-21 | 1979 | 239 | Abnd | 4874 | Shelf, WOB | 3977 | Carboniferous clastics | No | Immature Cret. |
| Sheridan J-87 | 1981 | 216 | Abnd | 5486 | Shelf, WOB | 4857 | Basement | Thin Cret. | Cenomanian-Turonian |
| Linnet E-63 | 1982 | 160 | Abnd | 4520 | Shelf, WOB | 3758 | Oxfordian/ Paleozoic | Upper Cret. | Possible |
| Baie Verte J-57 | 1985 | 303 | Abnd | 4911 | Shelf, WOB | 3939 | Early Cret. | Thin Cret. | Immature Cret. |
| Great Barasway F-66 | 2007 | 2338 | Abnd | 6751 | EOB | 4165 | Jurassic | Thin Tithonian | Tithonian, Kimmeridgian |
| Lona O-55 | 2010 | 2602 | Abnd | 5580 | EOB | 4710 | Tithonian | Aptian, Tithonian | Tithonian |
| Margaree A-49 | 2013 | 2477 | Abnd | 6158 | EOB | 5753 | Tithonian | Early Cret., Tithonian | Tithonian |
| Cupids A-33 | 2015 | 2835 | Abnd | 4925 | O-FP | 4495 | Kimmeridgian | Tithonian | Upper Jurassic |

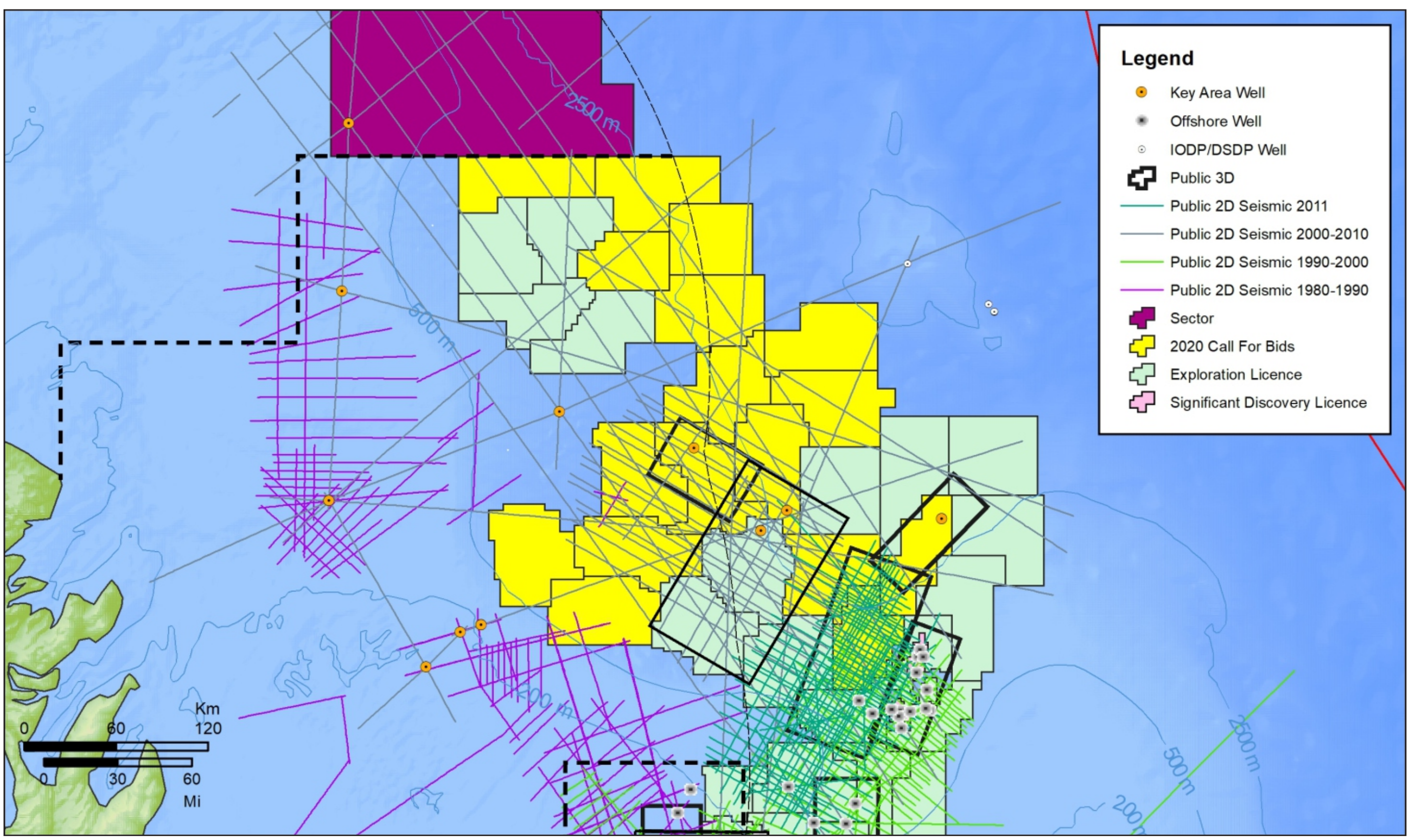



**Figure 10.** Public-domain seismic coverage over Orphan Basin and Flemish Pass. Map can be accessed at Department of Natural Resources (https://www.gov.nl.ca/nr/energy/petroleum/offshore/offmaps/). Key area wells in orange. Data from C-NLOPB and available to view in Natural Resources' Exploration Data Room.

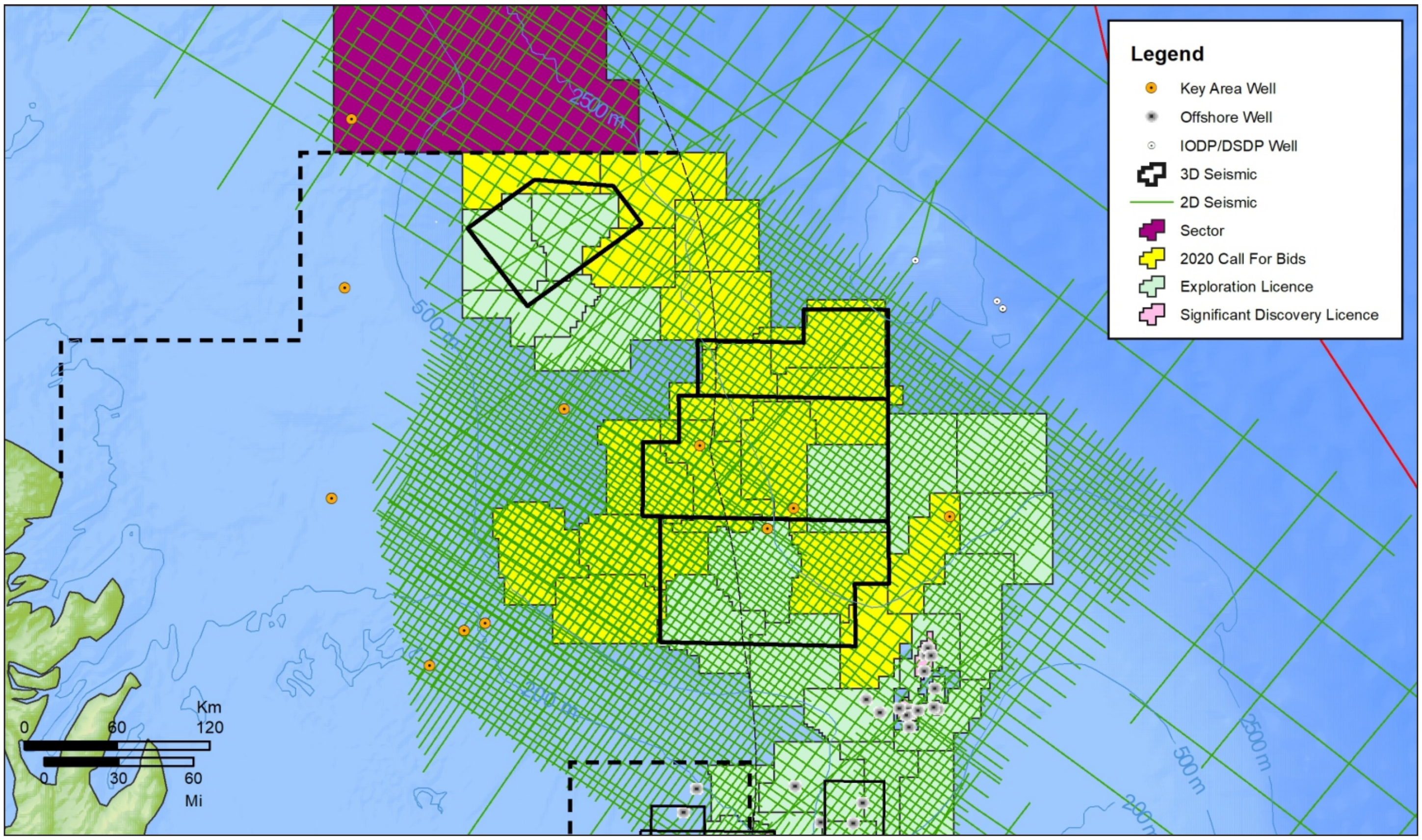



**Figure 11.** TGS/PGS/Nalcor Energy modern seismic data coverage over Orphan Basin and Flemish Pass. Area wells in orange; see Table 1. Data courtesy Nalcor Energy.

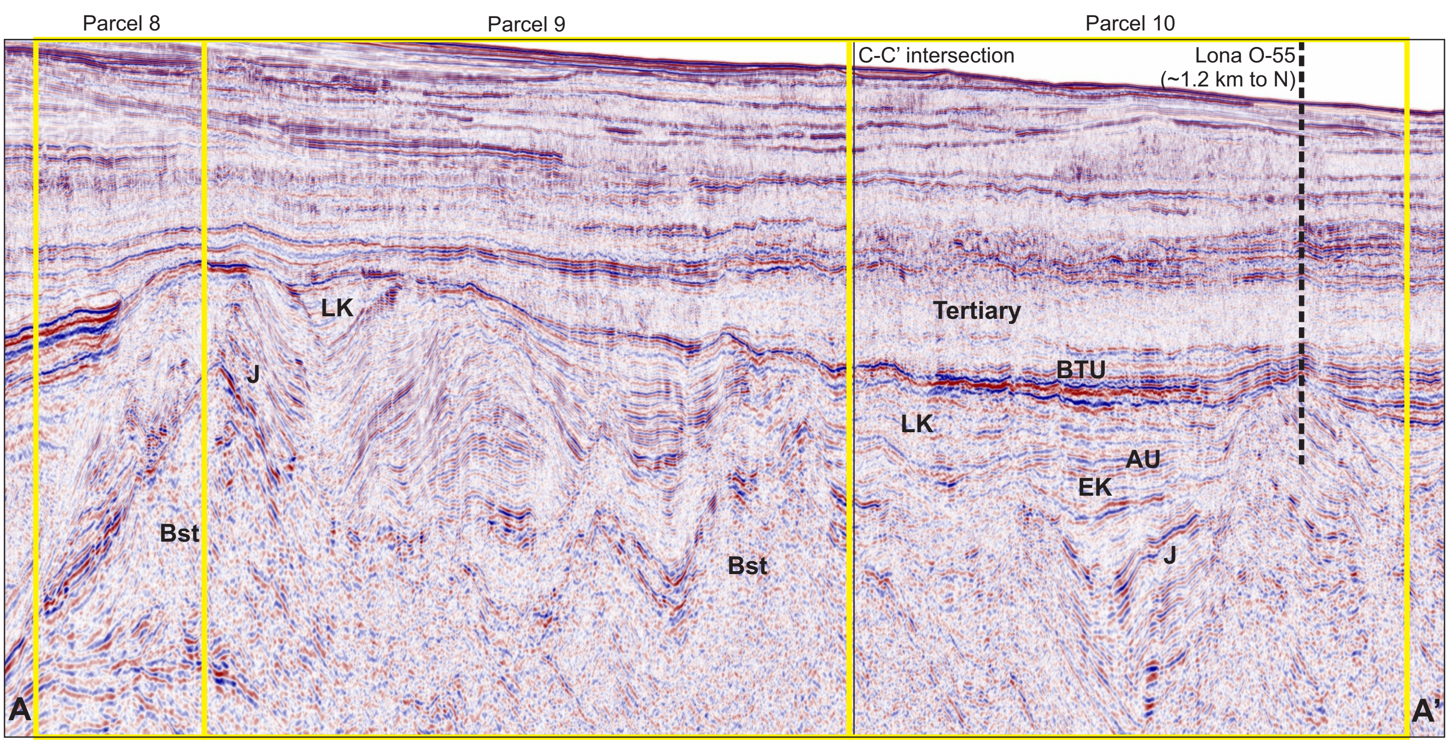



**Figure 12.** Public-domain seismic lines through 2020 Calls for Bids in the Orphan Basin. Lona O-55 well is located 1.2 km north of the line and is projected on line. Data from C-NLOPB. Available upon request to C-NLOPB or subscription to Natural Resources' Exploration Data Room. **AU:** Avalon Unconformity; **Bst:** Basement; **BTU:** Base Tertiary Unconformity; **EK:** Early Cretaceous; **J:** Jurassic; **LK:** Late Cretaceous. Yellow lines mark Call for Bids parcel boundaries and are approximate.

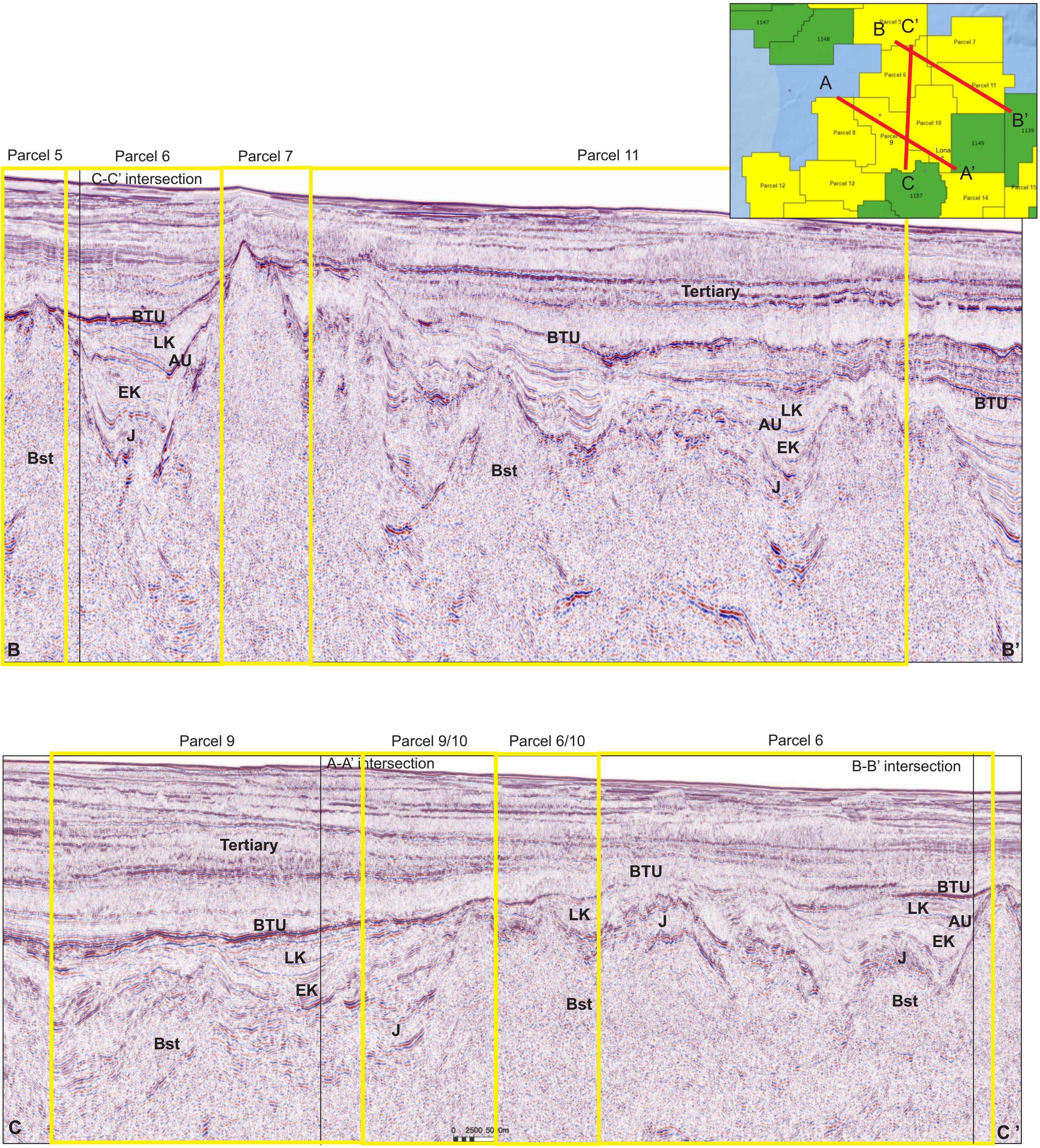



**Figure 13.** Public-domain seismic lines through 2020 Calls for Bids in the Orphan Basin. Data from C-NLOPB. Available upon request to C-NLOPB or subscription to Natural Resources' Exploration Data Room. **AU:** Avalon Unconformity; **Bst:** Basement; **BTU:** Base Tertiary Unconformity; **EK:** Early Cretaceous; **J:** Jurassic; **LK:** Late Cretaceous. Yellow lines mark Call for Bids parcels and boundaries are approximate.

## ADDITIONAL INFORMATION AND CONTACTS

For more information:

Department of Natural Resources
Petroleum Development Division
50 Elizabeth Avenue
PO Box 8700
St. John's, NL, Canada
A1B 4J6
www.nr.gov.nl.ca

Canada-Newfoundland and Labrador Offshore Petroleum Board
240 Waterford Bridge Road
The Tower Corporate Campus – West Campus Hall
Suite 7100
St. John's, NL, Canada
A1E 1E2
www.cnlopb.ca

## MANDATE AND ROLES

The **Canada-Newfoundland & Labrador Offshore Petroleum Board (C-NLOPB**) is mandated to interpret and apply the provisions of the Atlantic Accord and the Atlantic Accord Implementation Acts to all activities of operators in the Canada-Newfoundland and Labrador Offshore Area and to oversee operator compliance with those statutory provisions.

Their role is to facilitate the exploration for and development of petroleum resources, including health and safety of workers, environmental protection, effective management of land tenure, maximum hydrocarbon recovery and value, and Canada/Newfoundland and Labrador benefits.

As Offshore Regulator and Administrator for the Areas of Interest, the C-NLOPB are the primary contact for participation in this resource opportunity. They operate a registry to record exploration, significant discovery and production licences and information related to these interests for public review. They are also the curators of all geoscientific data pertaining to the Newfoundland and Labrador Offshore Area. The C-NLOPB has no active role in promotion of the Province's hydrocarbon resources.

The **Government of Newfoundland and Labrador, Department of Natural Resources** is responsible for providing marketing and promotional services to foster the exploration, development and production of the Province's hydrocarbon resources internationally as well as promoting the maximization of fiscal and industrial benefits through the negotiation, development, administration and monitoring of petroleum project agreements and legislation.

**Compiled by** Department of Natural Resources from previously published studies, papers, and Department of Natural Resources work. Edited and reviewed by M. Enachescu.

**Author:** Department of Natural Resources

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http://www.nr.gov.nl.ca/nr/publications/energy/index.html

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