GEOLOGICAL FRAMEWORK

Mesozoic Basins of the North Atlantic

More than 26 billion barrels of oil and 63 tcf of natural gas have been produced from the Mesozoic and Cenozoic basins of the North Atlantic. The primary producing reservoirs thus far have been the Lower Cretaceous, Jurassic and Tertiary sandstones of the British and Norwegian North Sea, but since November, 1997 major production has been achieved from the Lower Cretaceous reservoirs on the west side of the Atlantic - at the Hibernia field. Although the distinction of first oil production in the northwest Atlantic goes to the Cohasset/Panuke field offshore Nova Scotia, which produced about 43 million barrels, Hibernia is the first giant field to be developed and is currently producing at 140,000 bopd from only 14 production wells.

Figure 1.1 illustrates the parallel ancestry of the North Sea and offshore Newfoundland and Labrador basins, both of which were formed by the separation of Europe and northwest Africa from North America by the continental drift that commenced in the Triassic/Early Jurassic.

To date more than 2600 exploration wells have been drilled in the North Sea and have proven resources of more than 55 billion barrels of oil and 200 tcf of gas. Only 127 exploration wells have been drilled offshore Newfoundland and Labrador, by which some 2.1 billion barrels of oil and 9.9 tcf of natural gas have been discovered. Studies of undiscovered oil resources in the Newfoundland and Labrador offshore area have focused primarily on the Northern Grand Banks and have resulted in estimates ranging from 6 to 12 billion barrels recoverable. The undiscovered gas resource for the offshore area is estimated to be about 60 trillion cubic feet.
Exploration is occurring in the Mesozoic Basins of the Grand Banks and Scotian Shelf as well as in the Paleozoic Basins of Western Newfoundland and throughout Eastern Canada. Lands are being offered in the Mesozoic and Paleozoic Basins in Call for Bids NF 01-1.
Figures 1.3 and 1.4 illustrate the primary reservoirs and field locations within the Jeanne d’Arc basin and Ridge Complex. To date the key reservoirs are the Lower Cretaceous Ben Nevis/Avalon and Hibernia sandstones and the Late Jurassic Jeanne d’Arc sandstones. As in the North Sea the source rock is a regional Kimmeridgian shale with total organic carbon in the neighborhood of 4.5% and a hydrogen index in the range of five hundred to seven hundred - indicating a highly oil prone source rock.

The Jeanne d’Arc basin is home to all of the large oil fields discovered to date, including Hibernia, Terra Nova, Hebron and White Rose. Based on current developments (Hibernia and Terra Nova), this basin will be producing about 265,000 barrels per day by late fall of 2001, and if development proceeds as expected at White Rose and Hebron, could be producing 350,000 to 450,000 bopd by 2007. Four parcels in this Call for Bids are located in the northern Jeanne d’Arc Basin (Figure 1.5).

The Hibernia B-16-1 well set a Canadian daily flow rate record in 1998 when it tested at 56,000 barrels of oil per day from the Hibernia Sandstone Reservoir.

The primary reservoirs of the Jeanne d’Arc basin are the Lower Cretaceous Avalon/Ben Nevis and Hibernia Sands, and the Late Jurassic Jeanne d’Arc Sands. The key source rock is the Kimmeridgian aged Egret Member.
Figure 1.4

NOTE: For illustrative purposes only
After: C-NOPB
GEOLOGICAL FRAMEWORK

CUMBERLAND BELT

ORPHAN BASIN

PHOENIX SUB BASIN

DOMINION TR.

CENTRAL RIDGE

JEANNE D’ARC BASIN

FLEMISH PASS BASIN

FLEMISH CAP

MERCURY

BONAÏSTA PLATFORM

BONAVISTA PLATFORM

GABRIEL C-60

Lancaster G-70

Conquest K-09

Bonanza M-71

DOMINION TR.

WHITE ROSE

BACCAIURO I-78

LAND PARCELS OFFERED IN CALL FOR BIDS CLOSING NOV 20, 2001

After: Enachescu, 1988

LEGEND

BASEMENT TERRAINS
SEDIMENTARY TERRAINS
SALT DIAPIR
LAND PARCELS OFFERED IN CALL FOR BIDS CLOSING NOV 20, 2001

BASEIN BOUNDING FAULT
BASEMENT INVOLVED FAULTS
CRETACEOUS BASIN BOUNDING FAULT
MAJOR SEDIMENTARY FAULT
SECONDARY SEDIMENTARY FAULT
TRANSFER FAULT

Figure 1.5

40km
GEOLOGICAL FRAMEWORK

Northern Jeanne d’Arc Basin

The northern part of the Jeanne d’Arc Basin (also known as the “Phoenix Subbasin”) lies to the north of the Dominion Transfer Fault and south of the Cumberland magnetic belt (Figure 1.5). The subbasin likely opened early in the evolution of the Mesozoic basins as a northwestern arm of the main Jeanne d’Arc Basin. Thus, a full Jurassic section can be inferred to exist in the basin including the Kimmeridgian shales that are the source rock to the south. Seismic data also shows a thick Lower Cretaceous section within the basin. To the east, the northern extension of the Central Ridge (“North Central Ridge”) contains a Lower Cretaceous section overlain by thin to absent Upper Cretaceous strata. The Jurassic section on the ridge thins over Paleozoic highs evident on seismic, one of which was drilled by the Bonanza M-71 well. With the Paleozoic highs to the east and the Bonavista Platform to the west, the northern Jeanne d’Arc Basin could be viewed as a restricted embayment during Jurassic time with a high probability of developing oil prone source rock. During the Early Cretaceous the old highs to the north, west and east could have provided a source of coarse sandstones along the basin edges.

No wells have penetrated the deeper sediments in this area. The ridge wells to the southeast confirm the presence of Kimmeridgian source rocks but are limited in the development of reservoir quality sands. Only one well (Bonanza M-71) penetrated the Kimmeridgian in the immediate area. The geochemistry report submitted by Mobil indicated that the sediments “represent a moderately mature, very good oil and associated gas facies” (McIntyre & Sinclair, 1999). Later analysis by Fowler and Snowden questioned this conclusion because of contamination of samples by drilling mud additives. Nevertheless, anti-correlative sonic and resistivity log responses over the interval typify the log responses of known source intervals on the Grand Banks (Sinclair, 1998; Passey et al, 1990). Four parcels (Parcels 4-7) offered in this Request for Bids lie within the northern Jeanne d’Arc Basin.

Flemish Pass Basin

The Flemish Pass Basin has had only three wells drilled to date - Kyle L-11, Baccalieu I-78 and Gabriel C-60. These wells have proven the existence of both reservoir and source rock within the basin. Gabriel C-60 is listed as having an oil show (a sandstone core of equivalent age to the Hibernia Formation bled oil), and gas shows while drilling. Most of the basin is in water depths of about 1000 meters. Recent land sale parcels in this basin have attracted record bids and extensive 3D seismic has been acquired over the past couple of years. Petro-Canada has indicated that it has identified five targets on its acreage in this basin, each having reserve potential in the 500 million barrel range. Seismic data in the area indicates that the Tertiary contains widespread submarine fan sequences which also exhibit numerous amplitude anomalies. Petro-Canada and its partner Norsk Hydro are expected to drill two wells in the basin next year.

Three parcels (Parcels 1-3) offered in this Call for Bids lie within the Flemish Pass basin.
Figure 1.6

Modified after: Canada-Newfoundland Offshore Petroleum Board and Geological Survey of Canada
GEOLOGICAL FRAMEWORK

South Whale Subbasin

The South Whale Subbasin was the first to be drilled offshore Newfoundland and Labrador. Fourteen wells were drilled between 1966 and 1974 and one well (Narwhal F-99) was drilled in 1987. In the first phase of Grand Banks exploration the companies primarily targeted the salt piercement features involving the Lower Jurassic Argo Salt. It appears, however, that the Argo salt movement may have postdated the migration of hydrocarbons, and no discoveries were made. There were several oil and gas shows in the South Whale Subbasin but a source rock has yet to be identified. However, given that the South Whale Subbasin lies on trend with the Scotian Basin which has a rich gas-prone source rock in the Upper Jurassic Verill Canyon Shales, there is a very good chance of similar age source rocks in the deeper parts of the South Whale. It is also possible that the Egret Member, that has sourced the oil and gas discoveries of the Jeanne d’Arc Basin may be present in this area. Although similarities to the Scotian Basin suggests that the area may be gas prone, large basement ridges (observed on seismic data) that run parallel to the shelf may have provided the restricted marine conditions that favor the development of oil-prone source rocks.

The South Whale Subbasin contains the equivalent of the Micmac and Mississauga sandstones that are key reservoirs in the Scotian Basin. Seismic data indicates the presence of an Upper Jurassic reef front, that is known to contain thick porous intervals on the Scotian Shelf, but which has never been drilled offshore Newfoundland. Pan-Canadian Petroleum recently announced a major gas discovery within such a reef front offshore Nova Scotia. Individual wells in this “Deep Panuke” discovery have flow-tested in excess of 50 million cubic feet per-day, with the flow rates limited by equipment.

Three parcels (Figure 1.6) offered in Call for Bids NF01-1 are located within the South Whale Subbasin.

Comparative stratigraphy of Scotian Shelf, Southern Grand Banks and Northern Grand Banks.
**GEOLOGICAL FRAMEWORK**  
**Western Newfoundland**

The presence of petroleum in Western Newfoundland has been recognized in surface seeps and shallow drilling since the late 1800's. The first modern exploration effort - using seismic to select a well location - was carried out by Hunt Oil and Pan Canadian in 1994-95 and resulted in the Hunt/Pan Canadian Port au Port #1 discovery. This well encountered four zones of good reservoir quality in the Cambro-Ordovician platform. The two lower zones were wet, but the upper two zones flowed oil at rates of 1528 and 1742 b/d respectively. Although follow up drilling at four other locations failed to make additional discoveries, the Port au Port #1 well proved the presence of a viable petroleum system in the area. Released seismic data show that large undrilled prospects remain to be tested throughout the offshore and onshore areas of western Newfoundland. Four parcels (Figure 1.11) are offered in the Western Newfoundland offshore area under this Call for Bids NF01-1.

In Western Newfoundland and offshore in the Gulf of St. Lawrence, a Cambro-Ordovician carbonate platform overlies Paleozoic clastic sediments of the Labrador Group and crystalline basement. The Ordovician carbonates and clastics are locally overlain by Carboniferous clastic, evaporite and carbonate sediments. Reservoir quality rocks have been identified in both the Cambro-Ordovician and the Carboniferous. The tectonic history of the area is complex. In the late Ordovician subsidence reactivated faulting that had initiated during a period of extension in the Cambrian and produced normal faults within the carbonate platform. Later, compression brought the onset of thrusting and reverse faulting of the carbonate platform and older formations. Strike slip faulting along the Cabot Fault Zone during the Carboniferous led to the creation of pull apart basins.
Cross section AA’ shows the transition from the Triangle Zone to the foreland basin within the Anticosti Basin. Fault blocks within the foreland basin present the possibility of very large traps.