QUATERNARY GEOLOGY OF THE HIBERNIA AREA OF NORTHEAST GRAND BANK

Map 14968QG

Geology by

G.B.J. Fader,[1] C.F.M. Lewis,[1] J.V. Barrie,[2] D.R. Parrott,[1] W. Collins,[2] R.O. Miller,[1] and S. d'Apollonia[1]

([1]Bedford Institute of Oceanography)
Atlantic Geoscience Centre
Geological Survey of Canada
Department of Energy, Mines and Resources
Dartmouth, Nova Scotia

in cooperation with
C-CORE (Centre for Cold Ocean Resources Engineering)[2]
Memorial University, Newfoundland

Bathymetry in Metres
Scale 1:250,000 (Latitude 48° N)
Lambert Conformal

Compiled by

O. Nadeau, E.L. King, and G. Hodgson
Geonautics Ltd., St. John's, Newfoundland
(1985)

GENERAL DESCRIPTION

This Quaternary geology map is the first in a series of Canadian offshore geology maps intended to illustrate many varied geological characteristics of the seabed and shallow subsurface. The map-area is centred around the Hibernia oil field which extends across the northeast area of Grand Bank, Grand Banks of Newfoundland, approximately 325 km east of St. John's, Newfoundland. In 1979, Chevron Standard and partners drilled the Hibernia P-15 exploration wildcat which indicated that commercial quantities of oil were present in this area of the Grand Banks of Newfoundland. As a result of the discovery, the Hibernia area of Grand Bank has become one of the better studied areas of the continental shelf off eastern Canada and this map consolidates the (non-proprietary) available data base and geological interpretations.

The geological information of the area is shown on one main map at a scale of 1:250,000 and five additional feature maps at 1:500,000. Representative bottom photographs of the surficial sediments, a regional cross-section, vibrocore log, and sidescan sonar mosaic, complete the graphic data presentation.

Interpretation of the surficial geology is based on Huntec Deep-Towed seismic reflection profiles; airgun seismic reflection profiles; 70, 100, and 500 kHz sidescan sonograms; gravity, vibrocore and piston cores; surficial grab and dredge samples; borehole logs; and submersible and bottom photographs.

BEDROCK GEOLOGY

Samples of basement rocks from the Avalon Peninsula of Newfoundland, and from the Virgin Rocks - Eastern Shoals area, west of the study area on the Grand Banks, consist of Hadrynian metasediments and volcanics. The Hibernia structure (cross-section A-B) is located on the northwestern flank of the Jeanne D'Arc sub-basin, a southwestern extension of the East Newfoundland Basin. The Jeanne D'Arc sub-basin is cut by many northwest trending faults and is infilled with Jurassic, Cretaceous and Tertiary sediments.

Of particular importance to the Quaternary development of the Grand Banks is the seaward thickening wedge of semi-consolidated Tertiary sandstones, shales, and mudstones which extends from the central shelf to the shelf edge, and overlies the Jeanne D'Arc sub-basin. Borehole results from the upper 100 m of the study area show a sequence of interbedded silts and fine sand with hard clays, deposited under relatively quiescent conditions ranging to more massive, stiff sands interpreted to have developed in higher energy environments.

Within the upper Tertiary section, wedge-shaped bodies of prograded sediments are common. The bedrock surface to a large degree controls the major landforms of the Grand Banks of Newfoundland, with the glacial and post-glacial sediments forming a thin veneer deposit ranging from 10 m thick on the bank areas to 50 m thick within the basins and depressions of the shelf. Prior to the post-glacial marine transgression of Grand Bank, the Tertiary surface was subaerially exposed, resulting in leaching of the bedrock surface and the formation of a cemented cap in some locations.

QUATERNARY GEOLOGY

The Quaternary history of the area is rather complex and is presently under study. The extent of glaciation across the Grand Banks of Newfoundland is at present not completely known; however, provenance studies of lithic clasts within the study area and clay mineralogy of the Tertiary bedrock and surficial sediments suggest an Hadrynian-Devonian bedrock source from the west. Ice-rafted material deposited by Greenland icebergs forms a minor component. In addition, seismostratigraphic analyses reveal the presence of buried channels infilled with up to 40 m of glaciomarine sediments, an indicator of former ice cover. We favour the concept of glaciation by a massive ice sheet, during the last glaciation, which later degraded to an ice shelf over the Grand Banks of Newfoundland.

In most areas of the Grand Banks of Newfoundland, evidence exists from only the most recent glaciation (Wisconsinan). Previous glacial deposits were probably reworked during the advance of Wisconsinan ice (approximately 60,000 yBP) and incorporated into its till and glaciomarine deposits.

Very little glacial or glaciomarine sediment presently occurs within the study area. The major control on the present distribution and character of sediments in the study area is the late Pleistocene low sea-level stand and subsequent transgression. This was a very effective process for erosion of pre-existing glacial materials on Grand Bank. Low gradients across the shelf edge make it difficult to locate precisely the low sea-level position. It is interpreted to occur between 90 and 110 m water depth. During the transgression, pre-existing glacial tills and glaciomarine sediments were eroded and reworked. Lag gravels, boulders and clean well-sorted sands, together with subsurface isolated remnants of glacial sediments in buried channels, are all that remain of these sediments. The main characteristics of the seabed sediments such as texture, sorting and distribution were developed during the transgression.

Within the study area we recognize two surficial formations at the seabed:

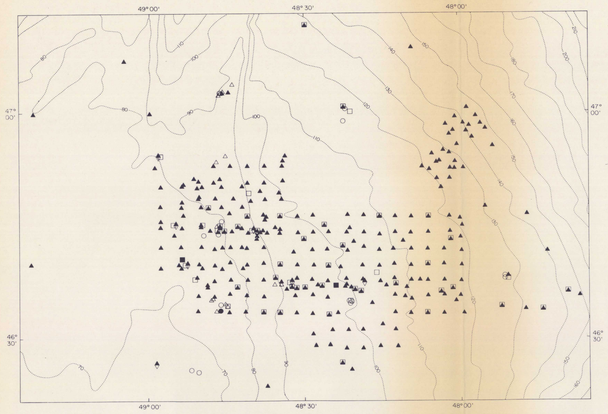
(1) Adolphus Sand and Gravel:

This formation is named after the Adolphus well (the first indicator of hydrocarbons from this area of the Grand Banks). To the east it is a clean sand with little or no mud content and occurs as a continuous blanket infilling small local depressions on the Tertiary surface. To the west it consists of thin sand ribbons overlying a gravel lag. It is interpreted to have formed in the sublittoral to littoral zone of the late Pleistocene low sea-level stand (15,000 yBP) and represents reworked Tertiary and glacial sediments. To the northeast of the map-area a large zone of degraded relict iceberg furrows occurs within the Adolphus Sand. These iceberg furrows are interpreted to represent the population formed adjacent to the low sea-level stand and are considered older than 10,000 yBP.

(2) Grand Banks Sand and Gravel:

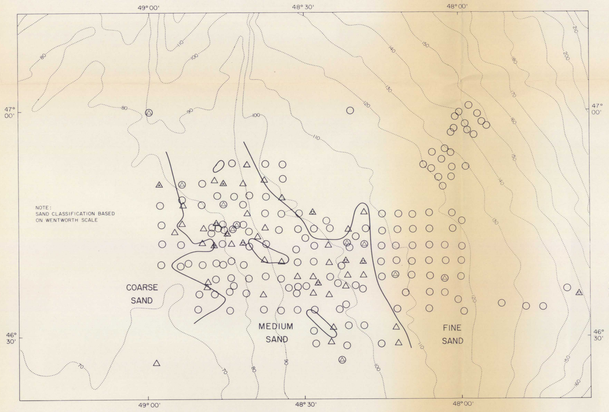
The Grand Banks Sand and Gravel Formation is a basal transgressive deposit which occurs above the late Pleistocene low sea-level stand. It is an erosional product of the underlying Tertiary bedrock and glacial sediments and was formed during the marine transgression of the bank. It has been divided on the basis of its sidescan sonar character and textural analyses into three facies: Gravel 4A, Sand 5, and Boundary Sand 3. The Boundary Sand, the lowermost facies of the formation, occurs as a medium sand in an area of increased slope adjacent to the Adolphus Sand and Gravel Formation. The Grand Banks Sand, map-unit 5, essentially occurs as a field of sand ridges which range up to 5 m in thickness and over 3 km wide. They are developed on a lag gravel suface, Grand Banks Gravel, map-unit 4A. Bedforms in the troughs and on the sand ridges consist of arcuate sand waves, with their convex side facing north, two- and three- dimensional megaripples and wave-induced ripples. The crests of bedforms trend east-west and indicate sediment transport to the south in water depths less than 110 m.

Across the surface of the map area, in water depths less than 110 m, is a population of linear iceberg scours (furrows), the Holocene to Recent population. They range in depth to 3 m and to a maximum width of 50 m and are interpreted as being younger than 10,000 yBP. In contrast to this Holocene population is a relict population of degraded furrows which occurs below water depths of 120 m. These are interpreted as forming in the sublittoral zone of the 15,000 yBP low sea-level stand and may be considerably older. They extend to water depths of 700 m over the shelf edge. In addition, large "pits" up to 10 m in depth occur across the map-area, and may have been formed by icebergs impacting on the seafloor, resulting in sediment failure, local slumping and current erosion.

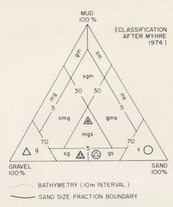


BATHYMETRY / SAMPLE LOCATIONS AND TYPES

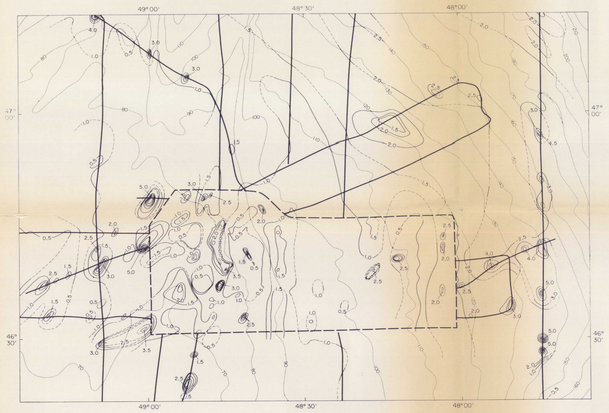
- BATHYMETRY (10m INTERVAL)
- CAMERA
- GRAB
- SEDIMENT CORE
- BOREHOLE
- DREDGE
- GRAB, CAMERA
- BOREHOLE, GRAB
- SEDIMENT CORE, CAMERA
- SEDIMENT CORE, GRAB
- SEDIMENT CORE, CAMERA, GRAB



GRAIN SIZE AND SAND FRACTION DISTRIBUTION

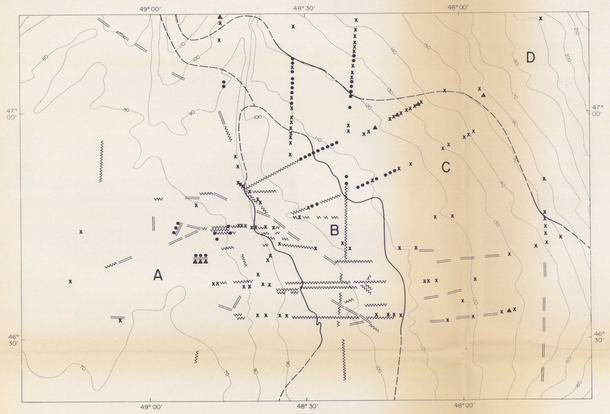


- BATHYMETRY (10m INTERVAL)
- SAND SIZE FRACTION BOUNDARY



ISOPACH OF SURFICIAL SEDIMENTS

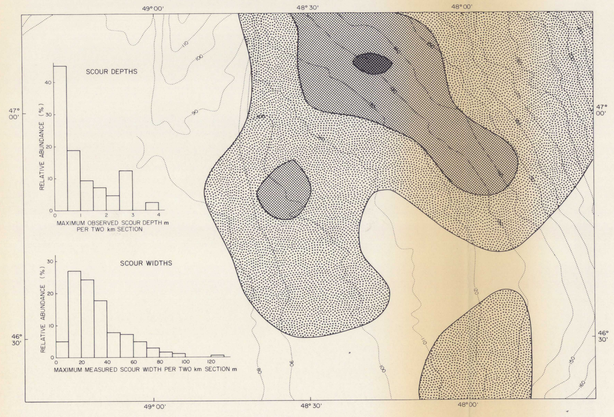
- HUNTEC SEISMIC REFLECTION TRACK
- AREA OF CLOSELY SPACED HUNTEC TRACKS
- DEFINED BOUNDARY (0.5m INTERVAL)
- APPROXIMATE BOUNDARY
- BATHYMETRY (10m INTERVAL)



BEDFORMS AND SEABED FEATURES

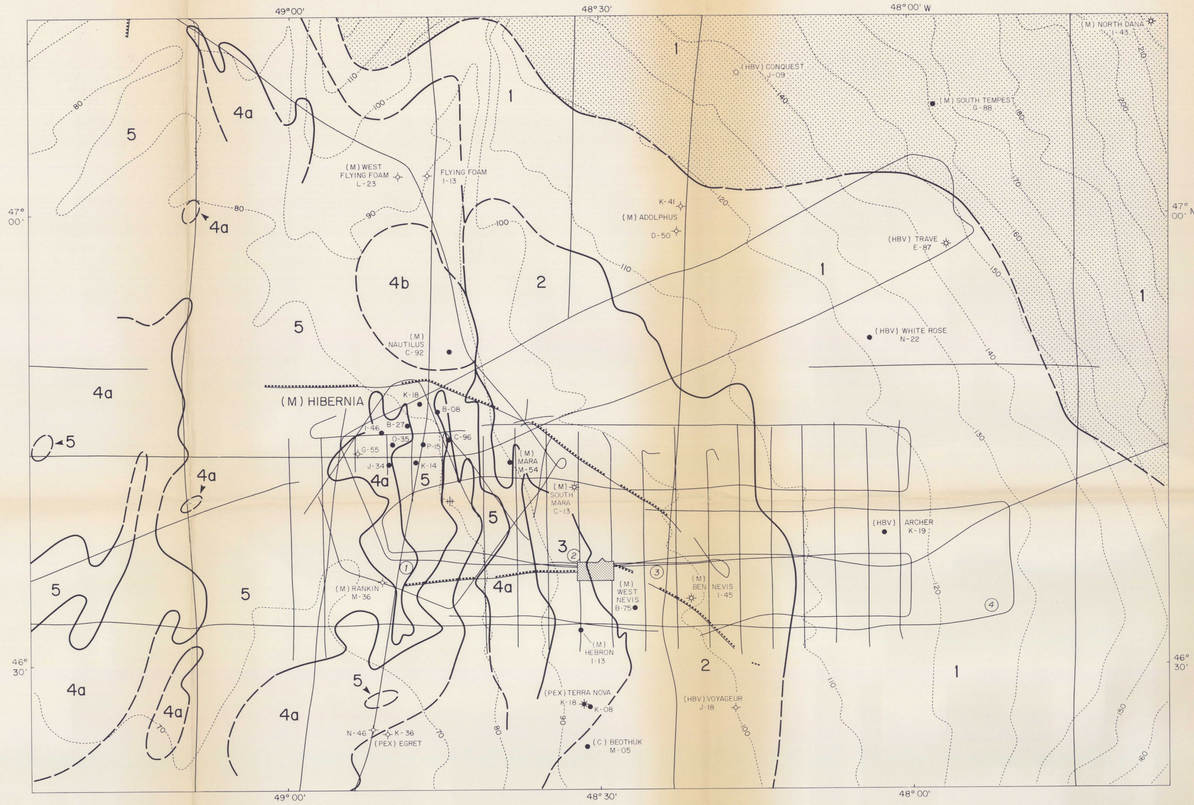
- BATHYMETRY (10m INTERVAL)
- DEFINED BOUNDARY
- APPROXIMATE BOUNDARY
- ICEBERG FURROW, SCOUR
- BOULDER FIELD
- ICEBERG PIT
- TRAWL MARK
- SAND WAVES
- A SAND RIDGE PROVINCE
- B SAND RIBBON PROVINCE
- C CONTINUOUS SAND PROVINCE
- D DEGRADED ICEBERG FURROW PROVINCE

NOTE: ORIENTATION OF FEATURES NOT IMPLIED



ICEBERG SCOURS PER SQUARE km

- < 0.8
- 0.8 TO 1.6
- 1.6 TO 2.4
- > 2.4



LEGEND

SURFICIAL GEOLOGY

GRAND BANKS SAND AND GRAVEL
- 5 SAND
- 4b INDIFFERENTIATED SAND AND GRAVEL
- 4a GRAVEL
- 3 BOUNDARY SAND

ADOLPHUS SAND
- 2 ZONE OF SAND RIBBONS OVERLYING GRAVEL
- 1 SAND

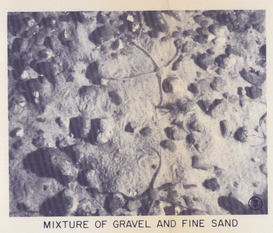
WELLSITES
- (M) MOBIL OIL CANADA LTD
- (PEX) PETRO-CANADA EXPLORATION INC
- (C) CANTERRA ENERGY LTD
- (HBV) HUSKY-BOW VALLEY EAST COAST PROJECT
- GAS
- OIL AND GAS
- DRY (ABANDONED)
- OIL
- DRILLING

- BATHYMETRY (10m INTERVAL)
- WRECK ?
- DEFINED BOUNDARY
- APPROXIMATE BOUNDARY
- HUNTEC SEISMIC REFLECTION AND SIDESCAN SONAR TRACK
- BRUTY (BOTTOM CAMERA SLED) TRACK
- SIDESCAN SONAR MOSAIC
- AREA OF DEGRADED ICEBERG FURROWS
- (2) BOTTOM PHOTOGRAPH

0 5 10 NAUTICAL MILES
0 5 10 15 20 KILOMETRES

GRAVEL LAG WITH BROKEN SHELL DEBRIS

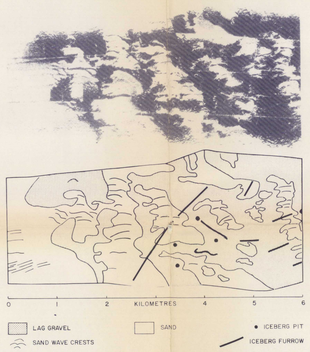
RIPPLED FINE SAND



MIXTURE OF GRAVEL AND FINE SAND

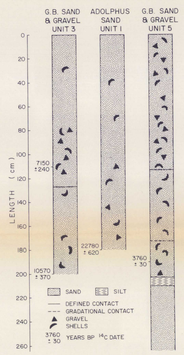
COARSE SAND, GRAVEL, WHOLE AND BROKEN SHELLS

SIDESCAN SONAR MOSAIC

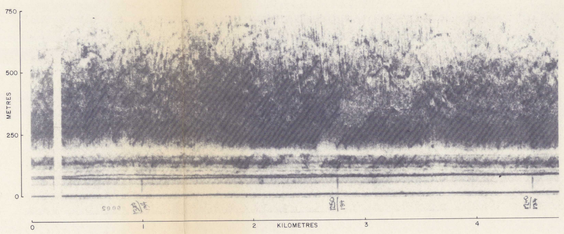


- LAG GRAVEL
- SAND WAVE CRESTS
- SAND
- ICEBERG PIT
- ICEBERG FURROW

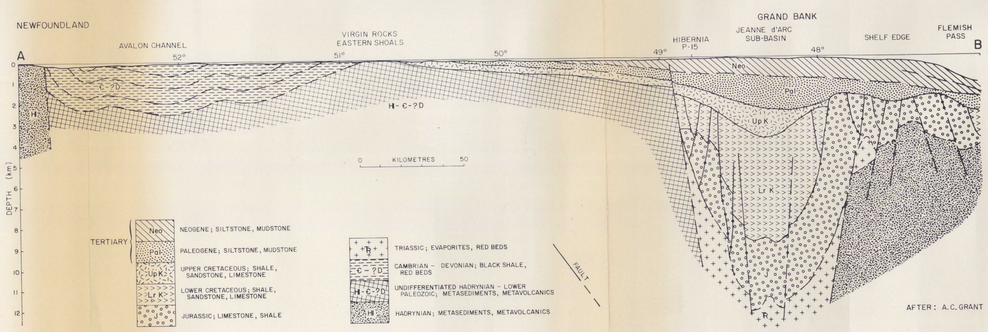
VIBROCORE LOGS



SIDESCAN SONOGRAM
(Degraded Iceberg Furrows, Adolphus Sand)



- 100 BATHYMETRY (m)
- A—B CROSS-SECTION
- INTERPRETED BEDROCK GEOLOGY BOUNDARY
- OCEANOGRAPHIC CURRENT TREND
- P15 LOCATION OF THE HIBERNIA P-15 WELL



AFTER: A.C. GRANT