# HISTORY OF CANADIAN GEOLOGICAL AND GEOPHYSICAL SURVEYS IN THE AREA OF SAINT PIERRE BANK
# 42° to 48°N; 52° to 61°W

by

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# HISTORY OF CANADIAN GEOLOGICAL AND GEOPHYSICAL SURVEYS IN THE AREA OF SAINT PIERRE BANK 42° to 48°N; 52° to 61°W

ABSTRACT

This report presents a history of the geological and geophysical mapping of St. Pierre Bank and its environs. The early 19th to 20th century laying of up to twenty-five telegraph cables in the area was done blindly with little attention to any data but bathymetry. The first maps of surficial geology were prepared by the German Navy in 1942 for the use of U-boat commanders in World War II. The first systematic mapping occurred through the observations of Societ scientists working in conjunction with the large Soviet fishing effort on the Grand Banks of Newfoundland in the 1950's and 1960's. Canadian mapping in the area did not occur until the early 1960's via the Fisheries Research Board and then the Bedford Institute of Oceanography. The 1984 and 1985 BAFFIN programs allowed two new bathymetry maps and a new surficial geology map for St. Pierre Bank and the Laurentian Channel to be produced from high resolution reflection seismic data.

Geophysical mapping of Canada's continental shelf did not begin until the late 1950's with early refraction seismic work being done by American and Canadian university cruises. The geophysical work by Canadian oil companies did not begin in the St. Pierre Bank area until the mid-1960's and very little was accomplished before the 1967 moratorium was agreed to. Until France broke the moratorium in August of 1983, there were almost no deep seismic reflection data on St. Pierre Bank. Canada gathered its own deep seismic on St. Pierre Bank in 1984, 1985 and 1986 but coverage is still very sparse in the study area. A good coverage of gravity data and of airborne magnetic data was completed during the 1984 and 1985 BAFFIN cruises and via the 1985 Bilateral Boundary Studies Program. Few geophysical data are available within the twenty-four n mi limit of the islands of St. Pierre et Miquelon in that all Canadian programs have respected the territorial sea of the islands.

The Atlantic Geoscience Centre and Dalhousie University have done considerable new geological and bathymetric work in the deeper parts of the study area on the continental slope. While the November 18, 1929 "Grand Banks" earthquake was known to have caused breaks in twelve marine telegraph cables, it was not until 1952 that it was realized by Columbia University scientists that a turbidity current that been triggered by the event. Little work occurred on the Laurentian Slope in the area of the epicentre until modern Seabeam and submersible tools became available to Canadian researchers.

## INTRODUCTION

The study area encompasses all of St. Pierre Bank and the flanking channels on the continental shelf; Hermitage Channel and Laurentian Channel to the northwest and southwest respectively and Halibut Channel to the east. To complete the study area, the western position of the central Grand Banks, the eastern Scotian Shelf, the northern portion of the Sohm Abyssal Plain and the Laurentian Slope are included (Figure 1).

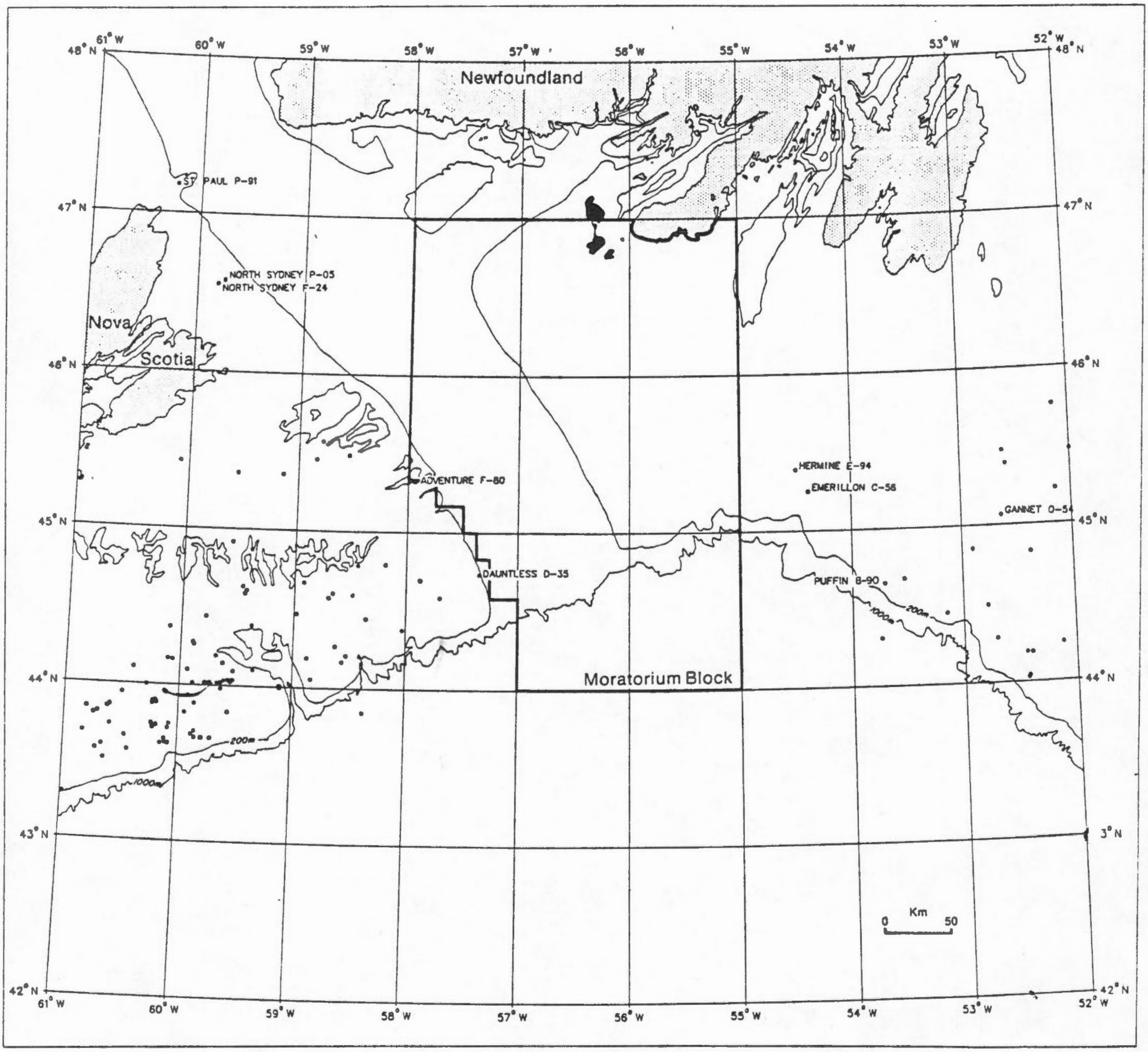
Hydrographers who record water depth to make charts for safe navigation have always tried to record the bottom type or soil type with a view to having their charts serve as a guide to anchoring conditions. Thus, the first mapping of the surficial geology of the ocean floor on the continental shelves off eastern Canada was done by the early hydrographers of Britain and France with lesser work by other Europeans.

Hydrographers or other vessels wishing to know the bottom type would attach a bit of sticky tallow on the bottom of the lead weight of their sounding line. When it hit the oceanfloor, grains of sediment would adhere to the tallow and give the leadsman an indication of the seafloor type. All charts through to the modern day show the bottom type in a general sense, though now the hydrographer would use a proper grab sampler to document the sediment.

When the first transatlantic cables were laid through the study area (Western Union, 1869, Sydney to St. Pierre to Newfoundland), the bottom topography and to a lesser extent the bottom types, became of greater concern. These concerns became paramount on November 18, 1929 (Kindle,

Figure 1

Index map to study area showing 200 m and 1000 m isobaths to outline the edge of the continental shelf and the Laurentian Channel along the southwestern side of St. Pierre Bank. The 1967 Moratorium Block is outlined by a heavy line. The small solid circles are the commercial hydrocarbon exploration wells put down since drilling began in 1967 on the Scotian and Newfoundland shelves.


Newfoundland
Nova Scotia
ST. PAUL P-91
NORTH SYDNEY P-05
NORTH SYDNEY F-24
ADVENTURE F-80
DAUNTLESS D-35
HERMINE E-94
EMERILLON C-56
GANNET O-54
PUFFIN B-90
200m
1000m
Moratorium Block
Km
0
50
48° N
47° N
46° N
45° N
44° N
43° N
42° N
61° W
60° W
59° W
58° W
57° W
56° W
55° W
54° W
53° W
52° W

INTRODUCTION (continued)

1931) when a major earthquake occurred at the edge of the continental shelf and triggered an underwater slump. The resultant landslide or turbidity current swept down the continental slope and severed 12 transatlantic cables often in several places (Doxsee, 1948; Piper et al., 1988). The cable breaks took up to seven cable vessels about three months to repair all the interrupted segments.

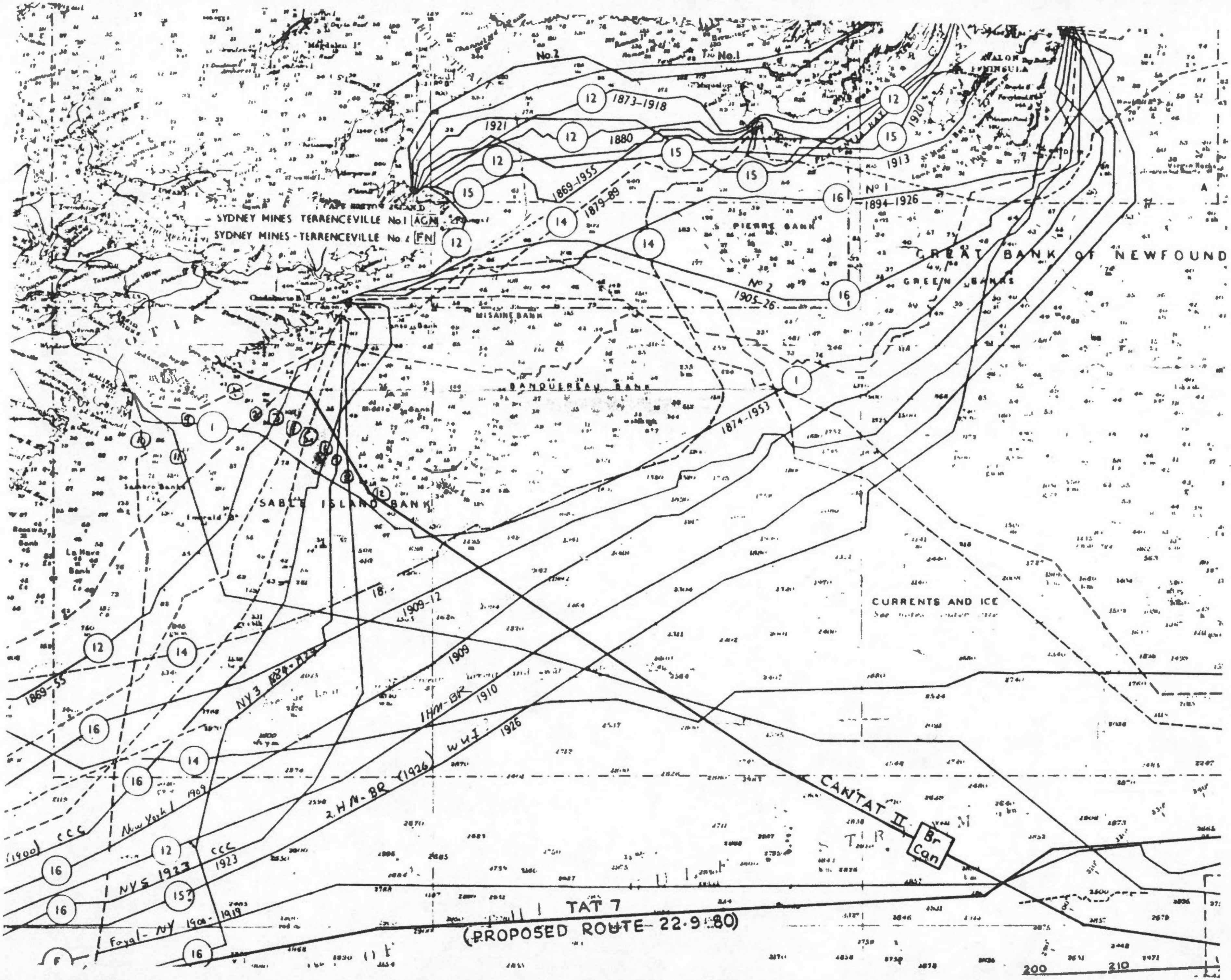
By about 1926, over 25 various telegraph cables traversed the study area (Figure 2). The CANTAT 2 telephone cable shown in Figure 2 was laid by Teleglobe Canada in 1973 (Canada Overseas Telecommunication Corporation, 1971; 1973). Halifax, Nova Scotia was the permanent home of the marine operations of at least three cable companies and several of their vessels for many years. Even now, St. John's, Newfoundland serves as the home of one cable vessel operated by a consortium of companies.

All the early telegraph cables are "O.O.U." (out of use), but the cable companies will seldom admit that they have abandoned them though they want no responsibility if bottom trawling equipment becomes ensnarled in such cables. Some interest has been shown in recent years in salvaging the larger old, copper-cored cables for their metal value. Interest varies with metal prices; some preliminary discussions have been held with Canadian government authorities in the past seven to eight years.

The mapping of the geology and geophysics of the continental shelves of Canada for resource exploration only began in earnest in the late 1950's and early 1960's. Prior to that, the main interest in the geology of the shelves came from fish biologists who were beginning to realize the relationships between bottom sediment types and certain fish habitats.

Figure 2

Portion of a map of marine cables traversing the continental shelf of Canada, produced by the Hydrographic Department of the [British] Admiralty (1958) and updated by Teleglobe Canada to show the 1973 CANTAT 2 cable to the southwest of Sable Island. The numbers in circles represent the original ownership of the cables; 1 was Cable and Wireless Ltd. (British); 12 was the Anglo-American Telegraph Company (British); 14 was la Compagnie francaise des cables telegraphiques (French); 15 was the Western Union Telegraph Company (American), and 16 was the Commercial Cable Company (American). The smaller circles west and southwest of Sable Island were an identification code used by Ruffman in a report for Mobil Oil Canada as part of the Venture gas development project (Ruffman, 1983).


SYDNEY MINES TERRENCEVILLE No1 AGN
SYDNEY MINES-TERRENCEVILLE No 2 FN
GREAT BANK OF NEWFOUND
GREEN BANKS
S PIERRE BANK
MISAINE BANK
BANQUEREAU BANK
SABLE ISLAND BANK
AVALON PENINSULA
CURRENTS AND ICE
No.2
No.1
1873-1918
1921
1880
1920
1913
1869-1955
1879-89
No 1
1894-1926
No 2
1905-26
1874-1953
1909-12
1909
1910
1926
1869-55
NY 3
1HN-BR
WU I
2 HN-BR (1926)
CANTAT II
Br Can
New York 1909
CCC
(1900) CCC
CCC 1923
NYS 1923
Fayal-NY 1900-1919
TAT 7
(PROPOSED ROUTE 22.9.80)
200
210

However, nearly twenty years earlier, more sinister interest peaked in the 'grundbeschaffenheitskarte' - the maps of the geology of the seabed. The 'Oberkommando der Kriegsmarine' (Supreme Command of the [German] Navy) published a whole series of 'Ubootshandbuchs' including one for 'Ostküste Kanadas' (East Coast of Canada; Appendix 1). This atlas contained a geology of the seabed map for the 'Bänke Südlich von Neufundland' (southern banks of Newfoundland) [including St. Pierre Bank] and for the 'Südküste von Neufundland' (south coast of Newfoundland)[including St. Pierre et Miquelon and St. Pierre Bank](Oberkommando der Kriegsmarine, 1942a;b).

This atlas contained a series of interpreted seafloor geology maps out to water depths of about 150-200 fm. The above map of interpreted surficial geology (Appendix 1) shows under 'Harte des Bodens' (strength of the soil), 'Felsig' (rocky), Sand und Kies (sand and gravel), 'Sclickiger Sand' (silty sand) and 'Sandiger Schlick' (sandy silt) plus depth contours (translation via personal communication, Hans Neu, Halifax, February 2, 1990). It is not known how the interpreted surficial geology was developed, but it may have been in part dependent on the British Admiralty bottom types (which are duplicated on the maps) and from fishing vessel data.

The purpose of the coloured atlas seabed geology maps was to give U-boat commanders some idea where they could safely sit their vessels on the seafloor and in what areas they could probably find 'accoustically hard' bottom which would provide a more difficult search terrane for surface vessels conducting an asdic search.

Portions of the above atlas, including the St. Pierre Bank seabed geology map (Oberkommando der Kriegsmarine, 1942a) are found in Appendix 1.

INTRODUCTION (continued)

This copy of the 'Ubootshundbuch' for 'Ostküste Kanadas' was copy no. (Prüf=Nr.) 843 and is found in the Bundesarchiv-Militararchiv, Wiesentalstrasse 10, 7800 Freiburg, West Germany as 'Bestand: RMD 4/299 Atlas' (personal communication, Mr./Ms. Montfort and Dr. Giessler, Freiburg, February 2, March 28, 1990 and May 4, 1990 respectively). The library at Bedford Institute of Oceanography has moved to obtain a full xerox copy of this atlas (personal communication, J. Elizabeth (Betty) Sutherland, Library Services, B.I.O., March 21, 1990). A second copy of the U-boat East Coast of Canada Atlas (copy no. 829) was later found at the U.S. National Archives in Washington, D.C. (Collection of Foreign Records Seized, Record Group 242).

Practising fishermen had long come to an intuitive understanding of these relationships and in their daily labours had each built up their own personal series of annotated charts or notebooks logging areas of "foul ground" and wrecks where bottom trawled nets or lines got snagged and gear was regularly lost. Thus, areas such as "The Stone Fence" along the southwest side of the Laurentian Channel came to be named and are enshrined on modern charts. Fishermen also traditionally noted and protected information about areas of consistently good catches; one might presume that "Halibut Channel" on the east side of St. Pierre Bank may reflect such a tradition.

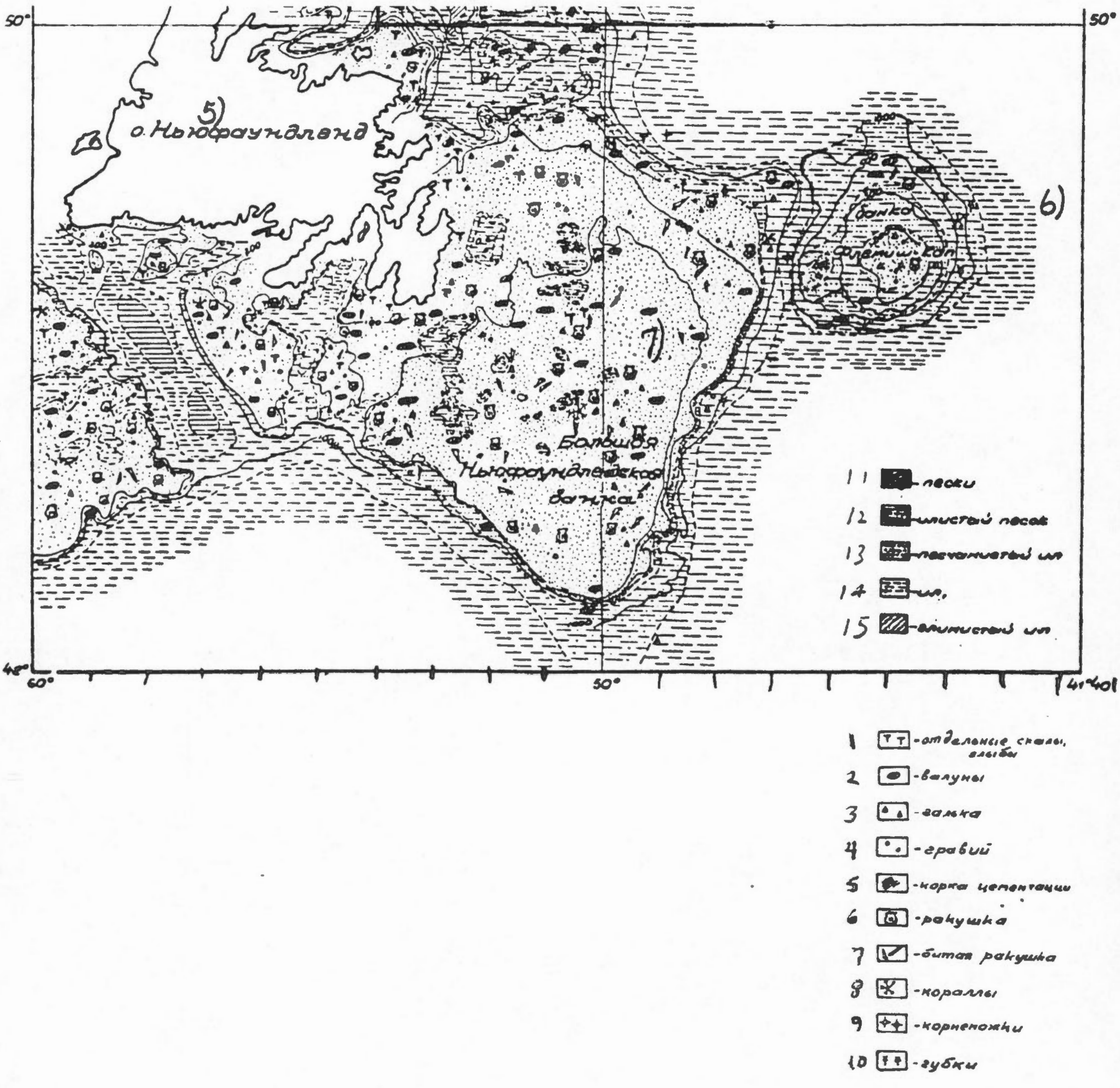
The Soviet scientists were the first to publish on the relationship between the bathymetry with the surficial geology and the prolific fishery in the study area. Litvin and Rvachev (1962; 1963) and Avilov (1965) from

Figure 3

Enlarged portion of Avilov's (1965) bathymetric and surficial geology map of the Grand Banks of Newfoundland. The two parts of the legend have been moved to fit on the enlarged diagram.

English translation of key to the items in the order in which they are presented on the map:

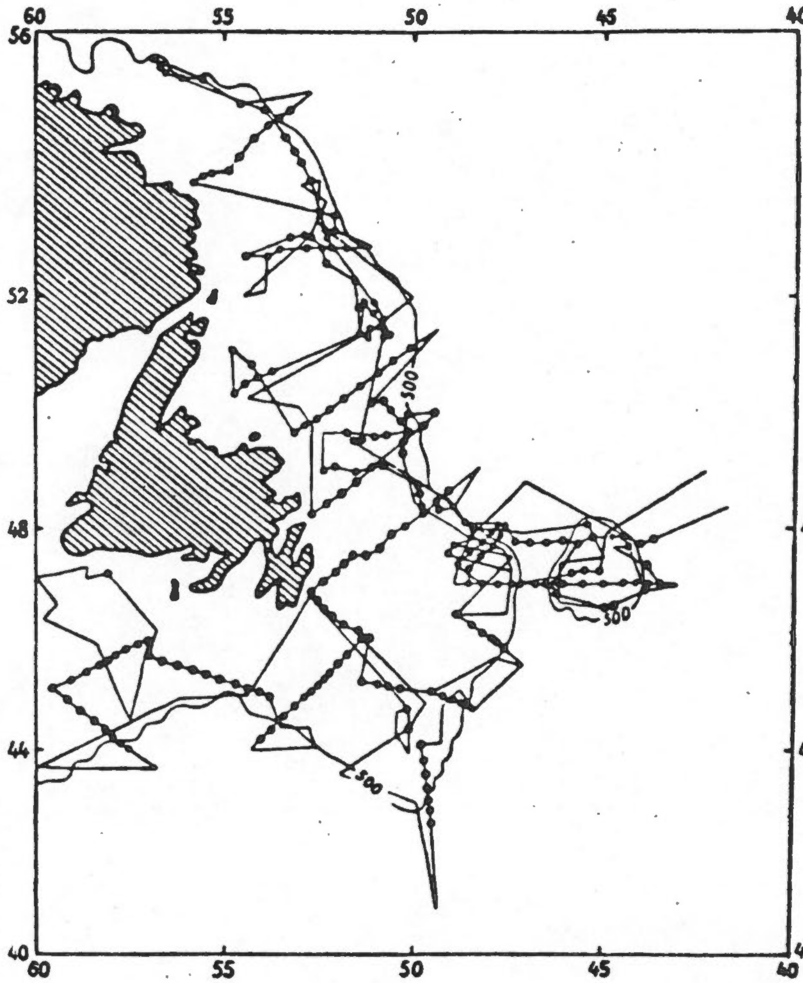
1) individual rocks, blocks
2) boulders
3) pebble
4) gravel
5) cement crust
6) shell
7) crushed shell
8) corals
9) rhizopods
10) sponges
11) sand
12) clay sand
13) sandy silt
14) silt
15) clay silt



50°
50°
5)
о. Ньюфаундленд
6)
банка
Флемиш Кап
7)
Большая
Ньюфаундлендская
банка
11 - пески
12 - илистый песок
13 - песчанистый ил
14 - ил
15 - глинистый ил
48°
60°
50°
41°40'
1 - отдельные скалы, глыбы
2 - валуны
3 - галька
4 - гравий
5 - корка цементации
6 - ракушка
7 - битая ракушка
8 - кораллы
9 - корненожки
10 - губки

Figure 4

Avilov's (1965) index map to the R/V SEVASTOPOL cruises Numbers 14 and 17 in 1954-58. A line of bottom samples was run across St. Pierre Bank and the Laurentian Channel onto Banquereau.



60
55
50
45
40
56
52
48
44
40
500
500
500

INTRODUCTION (continued).

the PINRO Laboratory of Marine Geology (Polar Institute) published the first surficial geology maps of the study area (Figure 3) as a result of the Newfoundland and Labrador Expedition of 1954-58 wherein the R/V SEVASTOPOL worked and sampled in the study area (Figure 4).

The first Canadian marine geological work in the area occurred as a result of the renewable fisheries interest. This interest then evolved and merged with an interest in mapping the subsea non-renewable resources mainly hydrocarbons. Mapping in recent years has developed in part because of an interest in hydrocarbons and mineral resource potential but also to evaluate environmental assessment concerns such as the earthquake potential of the Laurentian Slope Seismic Zone and the routing of cables and pipelines or engineering problems involved in drilling offshore wells, etc.

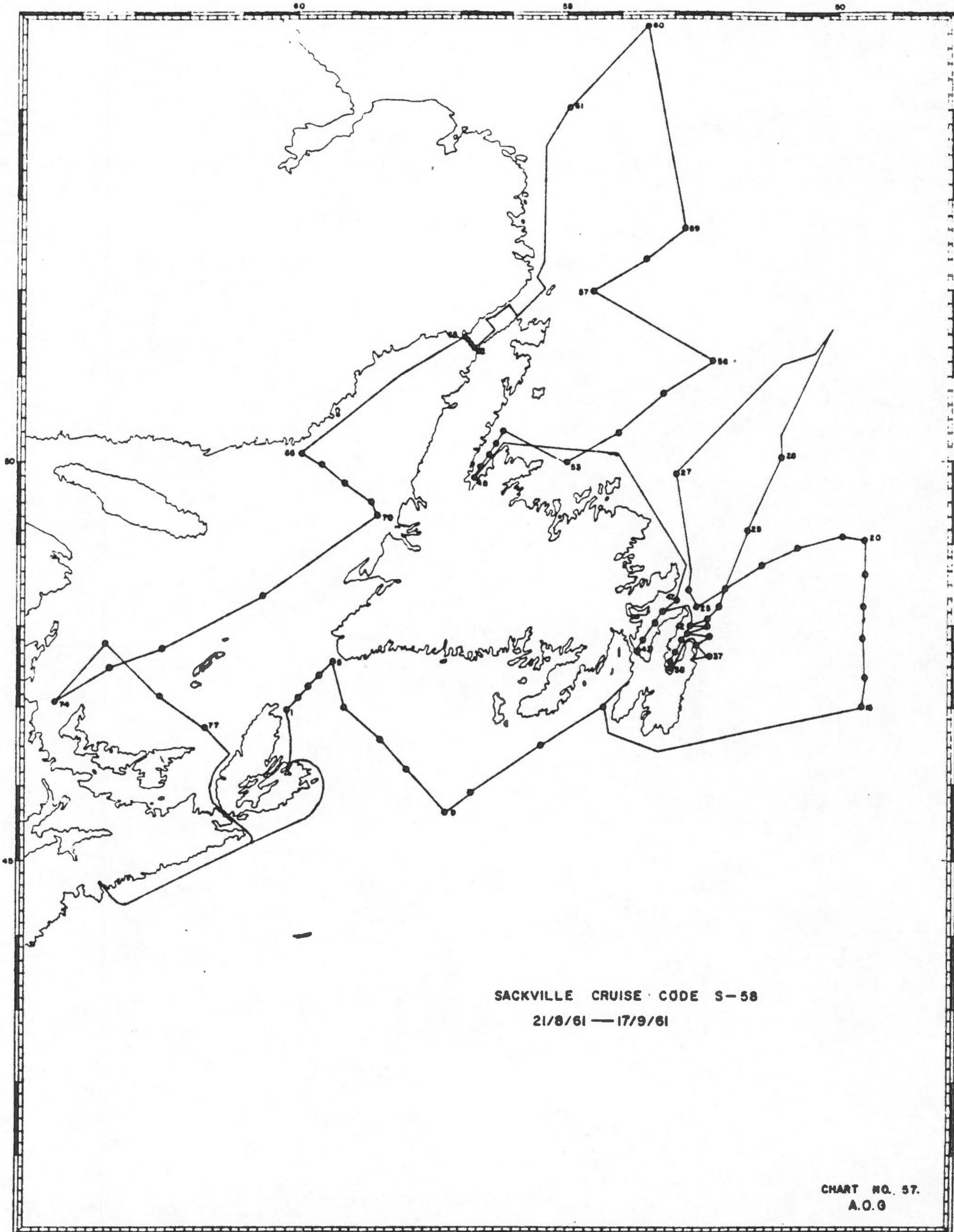
## MAPPING OF SURFICIAL GEOLOGY AND BATHYMETRY

The first Canadian work on surficial geology in the study area was done by the Fisheries Research Board from the original Canadian survey vessel CNAV SACKVILLE cruise S-58 (August 21-September 17, 1961) and included one leg through the area (Figure 5). Doug Loring's interpretation (1962a;b) incorporated the bottom samples of sediment and integrated these with the EDO Precision Depth Recorder echosounder data to develop an early and rudimentary surficial geology map. Bottom types were subdivided between acoustically "hard bottom" and a "soft sedimentary layer" (Figure 6).

Loring's work was then supplanted, expanded upon and updated as the Bedford Institute of Oceanography came into existence in 1962 and Lewis H. King began his work on the acoustic classification of bottom sediments.

Figure 5

D. H. Loring's (1962a;b) index map to the track and samples of the CNAV SACKVILLE S-58 cruise. The SACKVILLE obtained continuous 12 kHz profiles from an EDO Precision Depth Recorder (PDR) and obtained 12 bottom samples in the study area. The samples are shown as black dots along the track and are numbered sequentially.

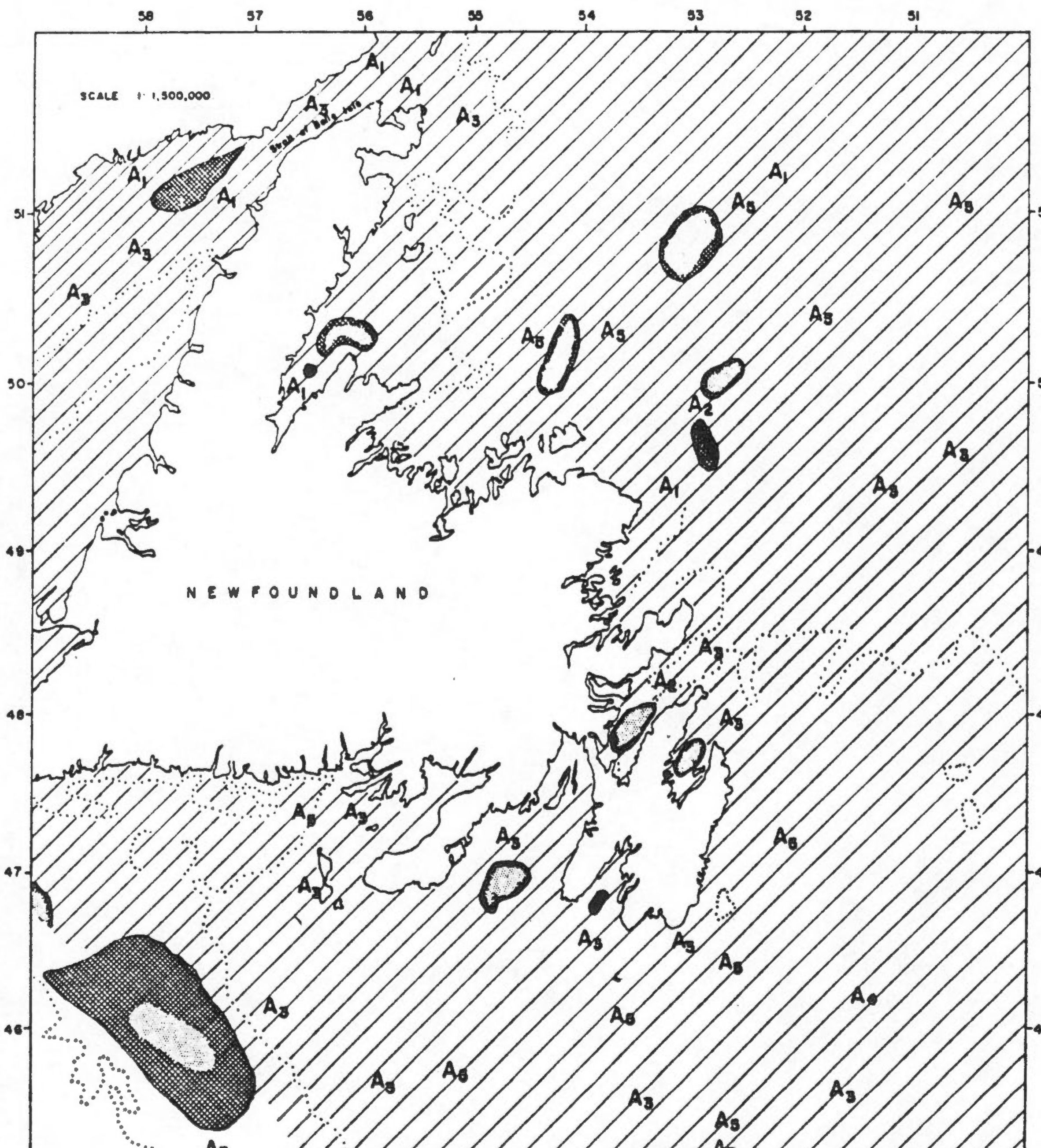


SACKVILLE CRUISE CODE S-58
21/8/61 — 17/9/61

CHART NO. 57.
A.O.G

Figure 6

Loring's (1962a;b) isopach map of the "distribution of the soft sedimentary layer on the Newfoundland shelf" as mapped by an EDO, PDR echosounder. His legend appeared on his Figure 4 in the two papers. The widely-crosshatched, majority of the ocean floor, which he called [acoustically] "hard bottom" has the following bottom types: A1 = rocky and jagged; A2 = isolated peaks; A3 = mainly rocks and gravel; A4 = sandy material; A5 = compacted sediments. The shaded areas represent the "soft sedimentary layer" which were penetrated by the PDR: solid black = greater than 50 ft; light gray = 20 to 50 ft thickness; light black crosshatched area = less than 20 ft in thickness. The 100 fm line is shown as a faint dotted line.


58 57 56 55 54 53 52 51
SCALE 1:1,500,000
51
50
49
48
47
46
NEWFOUNDLAND

MAPPING OF SURFICIAL GEOLOGY AND BATHYMETRY (continued)

The Dalhousie Institute of Oceanography began at about the same time and a supply of graduate students became available in about 1962-63 to begin to work on various areas and problems. Norman Silverberg (1965) and Anthony Cok (1970;Cok et al., 1965) are examples of students that worked on the eastern Scotian Shelf on the western side of the study area. These students and others such as Noel James (1966) who did a major piece of work around and on Sable Island (James and Stanley, 1967;1968) were directed by Dalhousie University's Department of Geology's first full-time marine geologists, Daniel J. Stanley and Donald J.P. Swift (Stanley, 1969; Stanley and Cok, 1968; Stanley and Silverberg, 1969; Stanley et al., 1968; 1972; 1973; Swift, 1976). There were a few other marine geology students in the mid 1960's who came from other Canadian universities to work on the east coast. Chris Yorath of Queen's University worked on the very western edge of the study area on sediment dispersal patterns as part of a PhD thesis (1967a;b).

With the advent of the Bedford Institute of Oceanography and its later-named Atlantic Geoscience Centre (AGC) marine geological and geophysical studies developed an ongoing focus in Eastern Canada and a repository for data began to form. In marine geology, Lewis H. King, as a very early staff member of the AGC who worked on the Canadian shelves for over 25 years (and still is privately), had a profound influence. He perfected the systematic mapping of shelf sediments, using initially the acoustic reflectivity from the early 12 kHz echosounders and ground truthing with bottom sampling (King, 1965;1967a;b), then he and his co-workers at AGC integrated various subbottom profilers and sidescan sonars into the mapping

MAPPING OF SURFICIAL GEOLOGY AND BATHYMETRY (continued)

programs. The Atlantic Geoscience Centre has played an important role in sponsoring and developing new mapping tools such as the Huntec Deep Towed Boomer developed especially to map the accoustically "hard" ocean bottoms found in glaciated terrains.

Canada did not have its own hydrographic service until 1910 and did not produce its own navigation charts until this point. Prior to 1910, navigators in the study area generally used charts of the British Admiralty or, on occasion, those of other nations such as the United States or France (Tompkins, 1986). For the first 55 years or so, the Canadian Hydrographic Service (CHS) only had one main survey vessel CSS ACADIA. Prior to the late 1950's, the hydrographic work of CHS generally had been confined to ports, harbours and nearshore areas where the pressures of the shipping industry were most felt. Canada did not own a vessel suitable for long term, open-ocean work until CSS BAFFIN was added to the fleet in 1956. Mapping of the continental shelves, where there were few to no navigation hazards, could not be a CHS priority in the first half of the 20th century.

The systematic mapping of the surficial geology of the continental shelves of eastern Canada that L. H. King embarked upon was initially entirely dependent upon the earlier-begun program of mapping the bathymetry of the continental shelves which commenced in about 1957 by the Canadian Hydrographic Service. The CHS program was initiated with the general availability of a reliable electronic positioning system over the Newfoundland and Scotian shelves and the recent expansion of the fleet. Canada had set up several DECCA chains and by the late fifties good coverage was available for the Scotian Shelf, Gulf of St. Lawrence and the Grand Banks -

Southern Newfoundland. A program began using CSS KAPUSKASING and later CSS BAFFIN to systematically map the Scotian Shelf and Grand Banks over several years. The echosounder that was in general use by CHS at the time was the 12 kHz EDO Precision Depth Recorder. L.H. King and his colleagues used these records to classify the bottom (King, 1965, 1967a) and added a calibration grid of bottom samples, cores and camera stations to build much more detailed surficial geology maps of the seafloor than had been possible before.

The Yarmouth - Brown's Bank map sheet to the west of the study area was the first area done. The next two sheets completed and published were Sable Island Bank and Banquereau with Canso Bank and St. Pierre Bank following; all four cover part of the study area. The easternmost part of the study area has been compiled but is not yet published. The surficial geology of the continental slope and rise portion of the study area was the latest mapped area and is discussed separately below.

The Sable Island Bank sheet on the Scotian Shelf used a dense net of echogram tracks and a grid of samples on about a 10 km grid (Figure 7) and in the report an acoustically-defined seismo-stratigraphy was developed (King, 1970a;b) that became the basis for later work over much of the glaciated shelf areas of Eastern Canada (King and Fader, 1986). The same approach was carried to the east on Banquereau (Figure 8) in the work by Brian MacLean and Lew King (1971a;b) then to the north (Figure 9) by MacLean, Fader and King (1977a;b). The systematic work of King et al. in mapping the Scotian Shelf has lead to a number of review papers tying

Figure 7

King's (1970a) index map across the Halifax-Sable Island map area showing the grid of coverage of 12 kHz echo-sounder records available for analysis. The black dots represent the bottom grab samples, cores or camera stations taken to calibrate the acoustic data. The hole in the data on the West Bar of Sable Island was left because of the uncertain positioning and the shallow water in the waters close to the island and over West Bar Extension and Northern Spur.

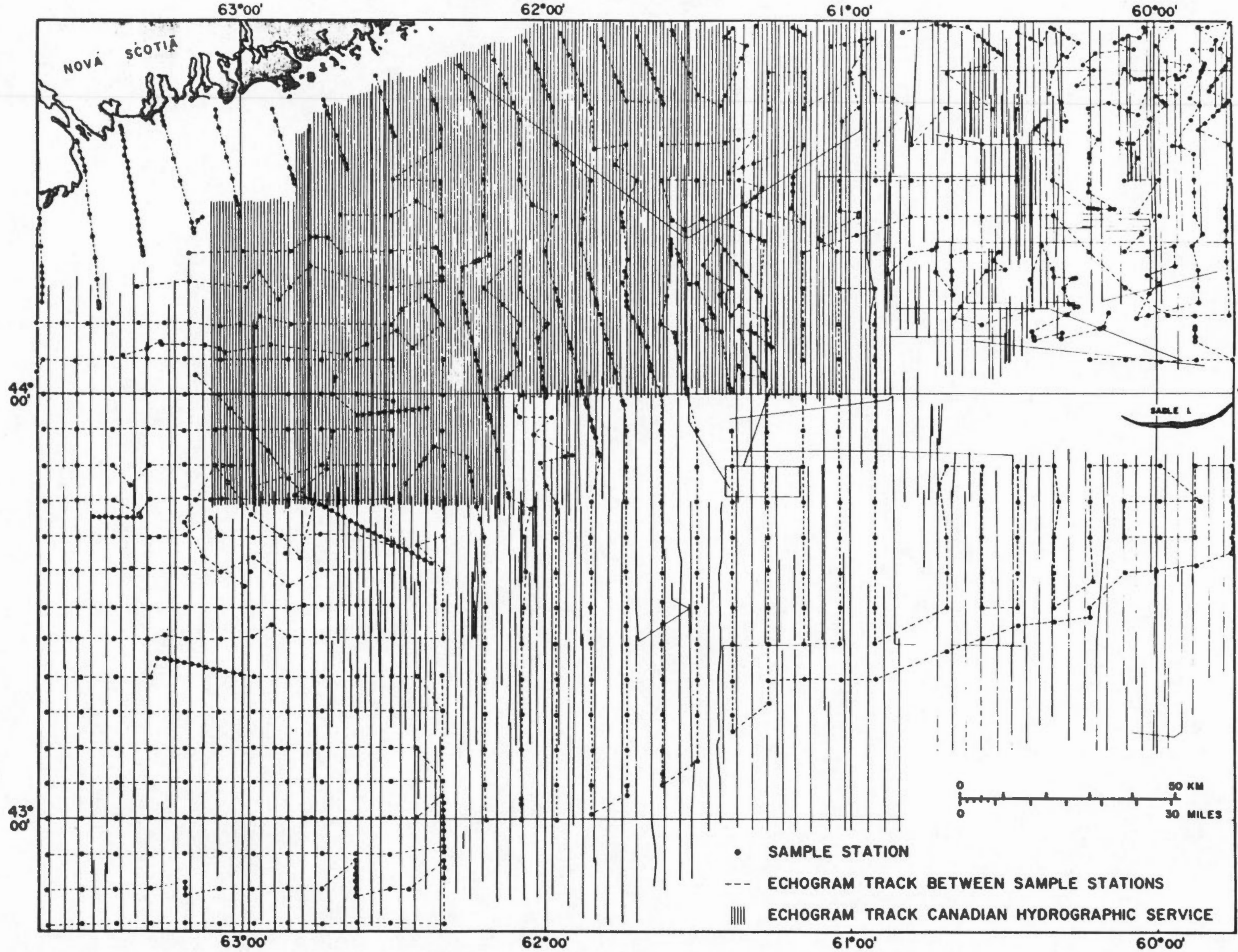

63°00'
62°00'
61°00'
60°00'
NOVA SCOTIA
44° 00'
43° 00'
SABLE I.
0
50 KM
0
30 MILES
SAMPLE STATION
ECHOGRAM TRACK BETWEEN SAMPLE STATIONS
ECHOGRAM TRACK CANADIAN HYDROGRAPHIC SERVICE

Figure 8

MacLean and King's (1971a) index map across the Banquereau and Misaine Bank map area showing the grid of coverage of 12 kHz echosounder records available for analysis. The black dots represent the bottom grab samples, cores or camera stations taken to calibrate the acoustic data. The hole in the data on the East Bar of Sable Island was left because of the uncertain positioning and the shallow water in the waters close to the island and over East Bar Extension.

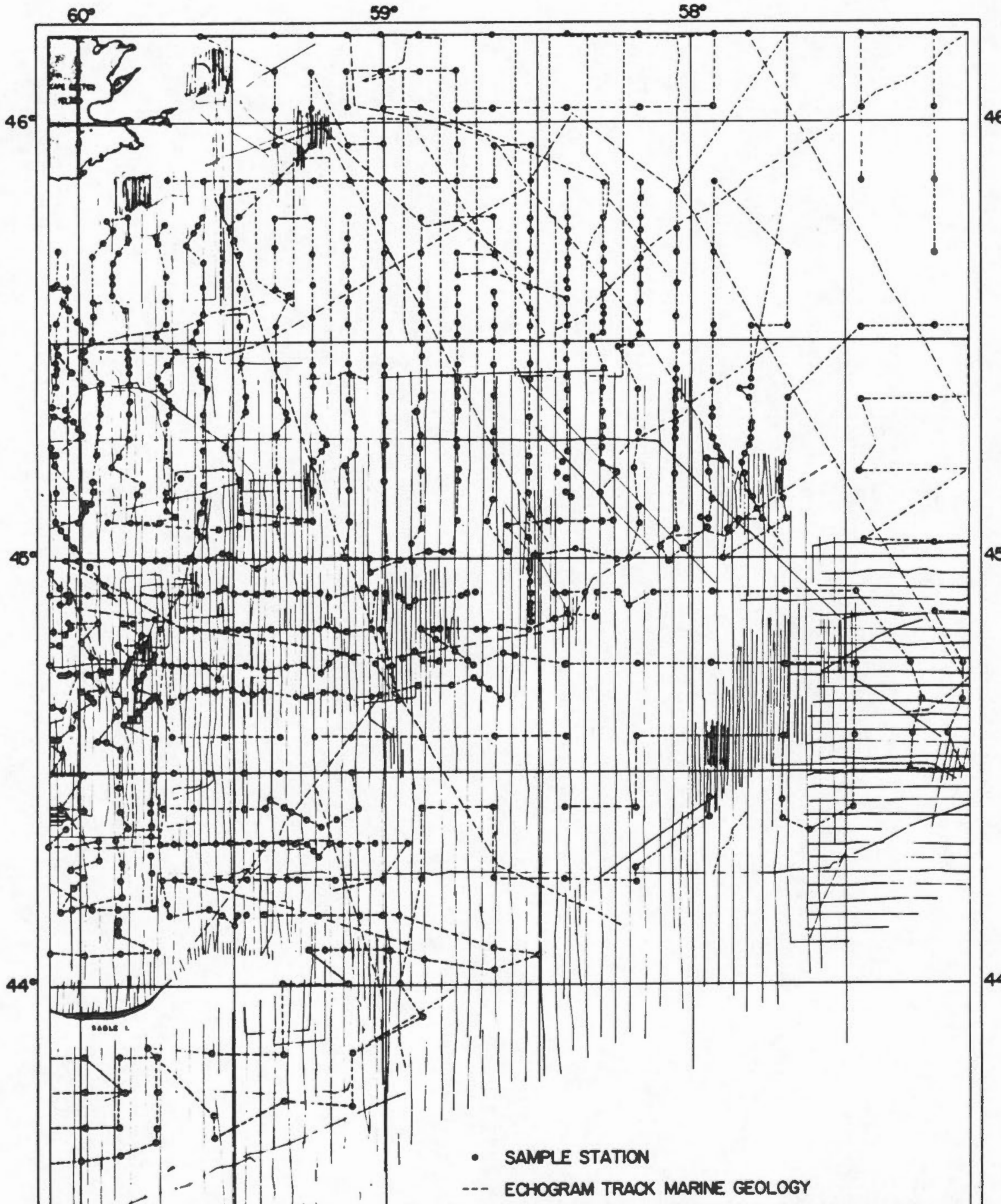
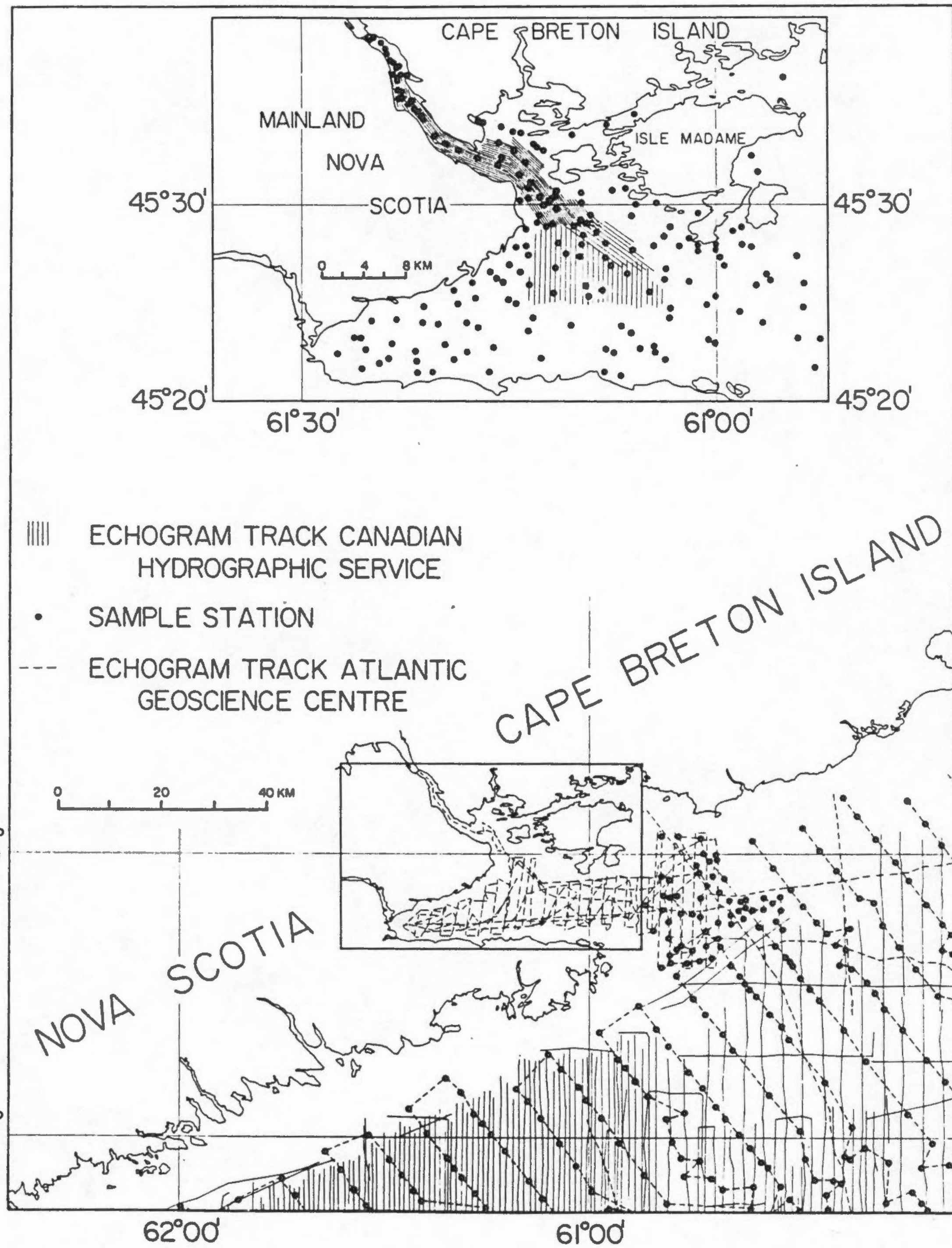

60°
59°
58°
46°
45°
44°
SABLE I.
SAMPLE STATION
ECHOGRAM TRACK MARINE GEOLOGY
ECHOGRAM TRACK CANADIAN HYDROGRAPHIC SERVICE

Figure 9

MacLean et al's. (1977a) index map in the Canso Bank area showing the grid of coverage of 12 kHz echosounder recorda available for analysis. The black dots represent the bottom grab samples, cores or camera stations taken to calibrate the acoustic data. The white zone along the coast with no data was left because of the difficulty in bringing the deep draft open-ocean survey vessels in close to a coast replete with nearshore shoals. These areas are covered with smaller vessels and launches at least for bathymetry. On the inset map only every other hydrographic track is shown.


CAPE BRETON ISLAND
MAINLAND
NOVA
SCOTIA
ISLE MADAME
45°30'
45°20'
61°30'
61°00'
0 4 8 KM
ECHOGRAM TRACK CANADIAN HYDROGRAPHIC SERVICE
SAMPLE STATION
ECHOGRAM TRACK ATLANTIC GEOSCIENCE CENTRE
CAPE BRETON ISLAND
NOVA SCOTIA
0 20 40 KM
45° 30'
45° 00'
62°00'
61°00'

MAPPING OF SURFICIAL GEOLOGY AND BATHYMETRY (continued)

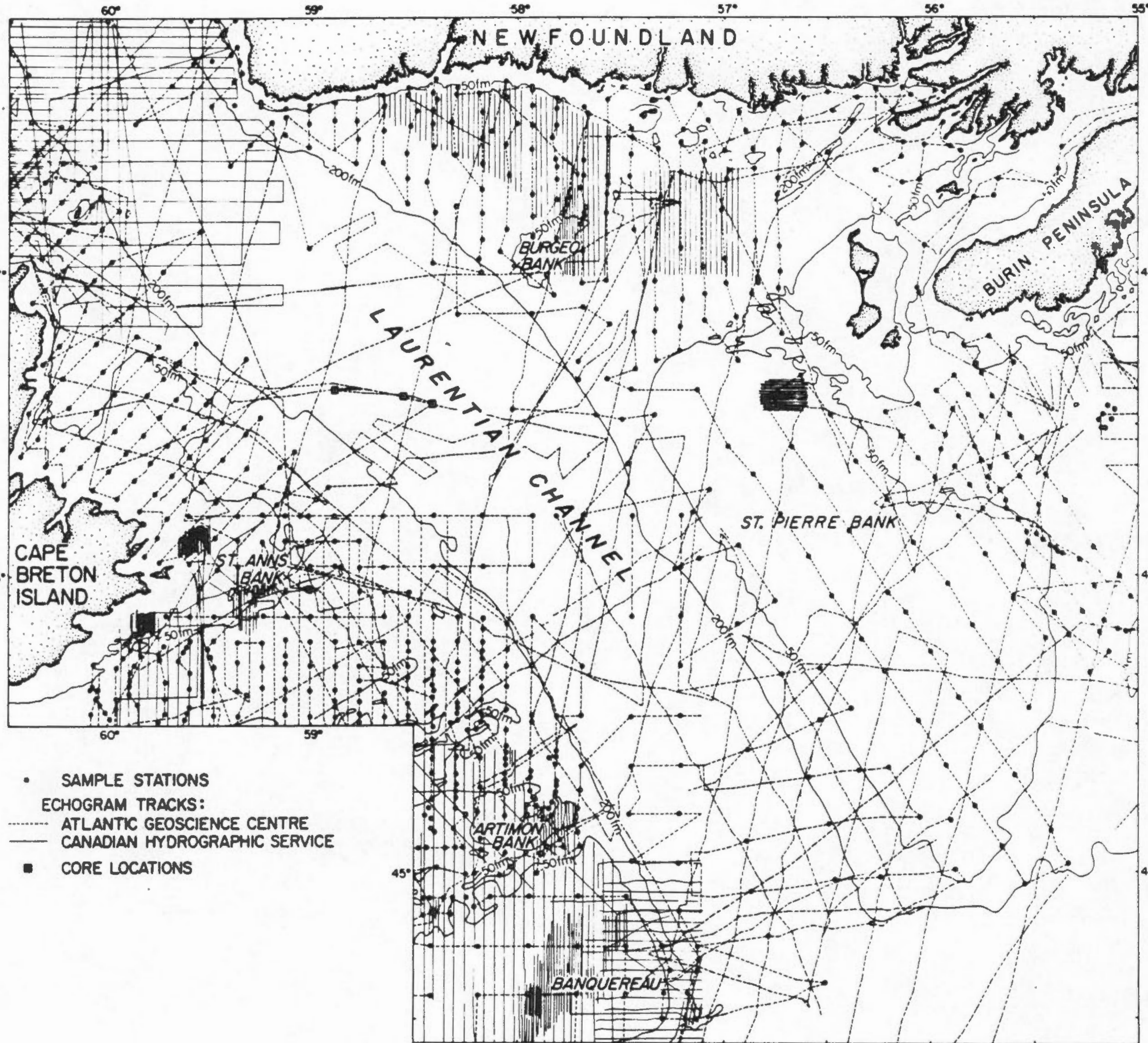
together the regional picture (King, 1980; King and Fader, 1986; King and MacLean 1970; 1974a;b; 1976; King et al., 1972).

The progressive mapping of the surficial geology of the shelves by AGC was diverted in part by the significant discoveries of oil on the Grand Banks in 1979 and by attention paid to other areas such as the Labrador Shelf. Work in the study area was somewhat intermittent. In 1981 AGC released an Open File Map (Fader et al., 1981) followed by the report and final map in 1984 (Fader et al., 1982; 1984). This compilation and publication involved data from more than 65 cruises over a period of 25 years (Figure 10)(Buxton, 1987).

To the east of the St. Pierre Bank sheet the surficial geology map is not yet published or available as an AGC Open File. A contract report and a series of index maps and a surficial geology map are available through the AGC (Ruffman and Wilson, 1987). This report contains a complete review of the early survey work of the area south of Placentia Bay and southeast of the Avalon Peninsula east to 52°W including the massive 3160 piston core program of Pan American Petroleum Corporation (now AMOCO) in 1969 from the M/V THERON (Swift, 1966; 1969; 1970). Roger Slatt at Memorial University later used the uppermost portion of a number of the Pan Am piston cores to look at the origin of the sediments (1973; 1974; 1977). Sen Gupta (1967) and Sen Gupta and McMullen (1969) had earlier mapped the surficial geology for an area along the southwest side of Grand Bank using grab samples.

Figure 10

Fader *et al's*. (1982) index map across St. Pierre and Burgeo Bank, Banquereau, Artimon Bank and Laurentian Channel showing the lines of acoustic and bottom sampling control in the area southwest of the Burin Peninsula. The black dots represent bottom grab samples, cores or camera stations taken to calibrate the acoustic data. The densely surveyed rectangle immediately southwest of the islands of Saint Pierre et Miquelon resulted from data gathered during a sidescan sonar search for the wreck of the SEAFORTH JARL (Whitaker, 1986).



NEWFOUNDLAND
LAURENTIAN CHANNEL
BURGEO BANK
BURIN PENINSULA
ST. PIERRE BANK
CAPE BRETON ISLAND
ST. ANNS BANK
ARTIMON BANK
BANQUEREAU
60°
59°
58°
57°
56°
55°
47°
46°
45°
50fm
200fm
• SAMPLE STATIONS
ECHOGRAM TRACKS:
ATLANTIC GEOSCIENCE CENTRE
CANADIAN HYDROGRAPHIC SERVICE
CORE LOCATIONS

MAPPING OF SURFICIAL GEOLOGY AND BATHYMETRY (continued)

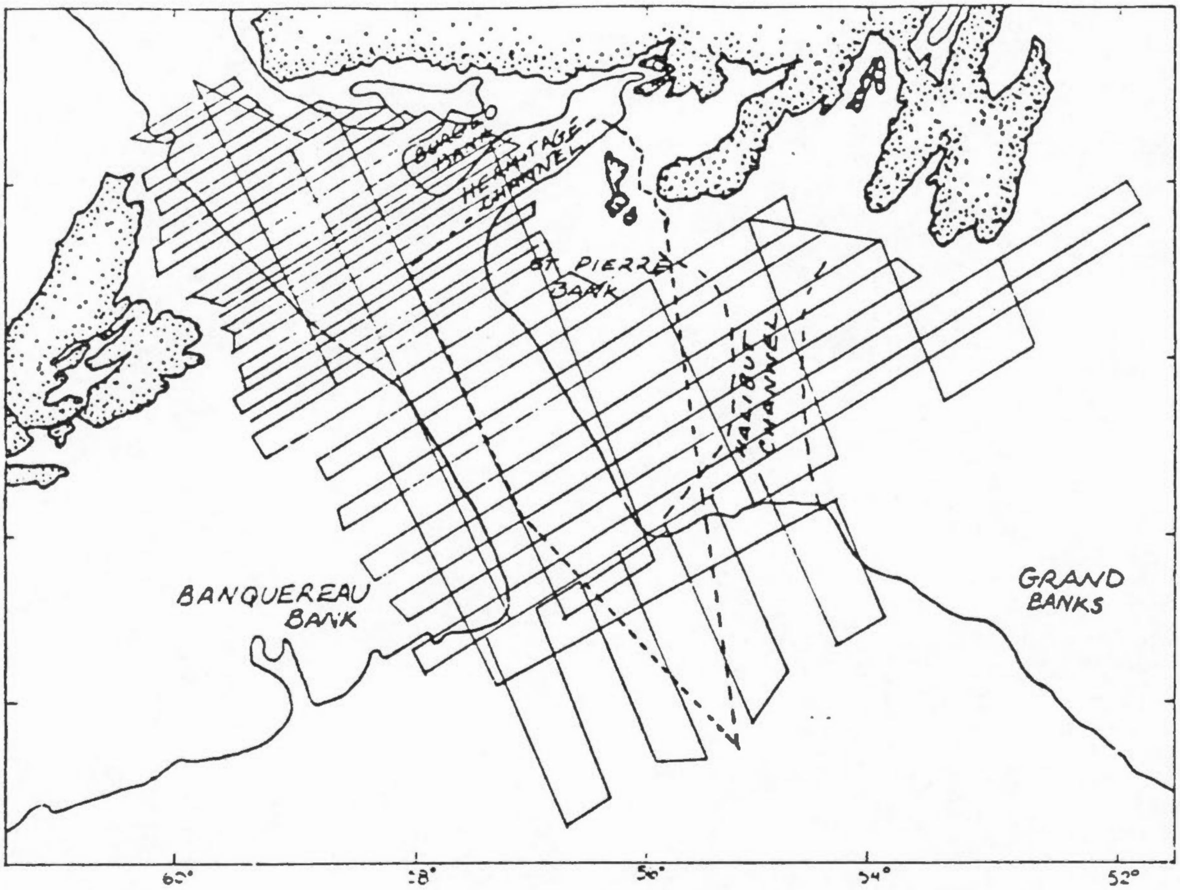
The mapping of the St. Pierre Bank area was further augmented in the 1984-1986 period by the Bilateral Boundary Studies Programme, which began a study of St. Pierre Bank to supplement earlier reconnaissance data and to address specific scientific questions (Buxton, 1987). CSS BAFFIN ran two major multidiciplinary cruises in the area under the Program (Figure 11) in 1984 and 1985. From these data CHS (1986a;b) published two revised Charts 4045 and 4047 which stand as the best charts available of the area from Halibut Channel west to The Laurentian Channel over all of St. Pierre Bank (Figure 12). The second of the BAFFIN's cruises gathered some 24,850 km of high resolution continuous seismic profiling data as well as adding grab samples to the data base (Henderson, 1985). These data have recently been integrated by AGC with the earlier work of Fader et al. (1982; 1984) on St. Pierre Bank (Fader and Miller, 1986).

Ongoing surficial geology work is occurring in the study area by graduate and honours geology students at Memorial University of Newfoundland who are working in the nearshore zone and in some of the major bays along the south coast of the Island of Newfoundland. The surficial geology of the deeper parts of the study area is not as well mapped, partly because these areas are of lesser commercial concern by the fishing or resource exploitation industries.

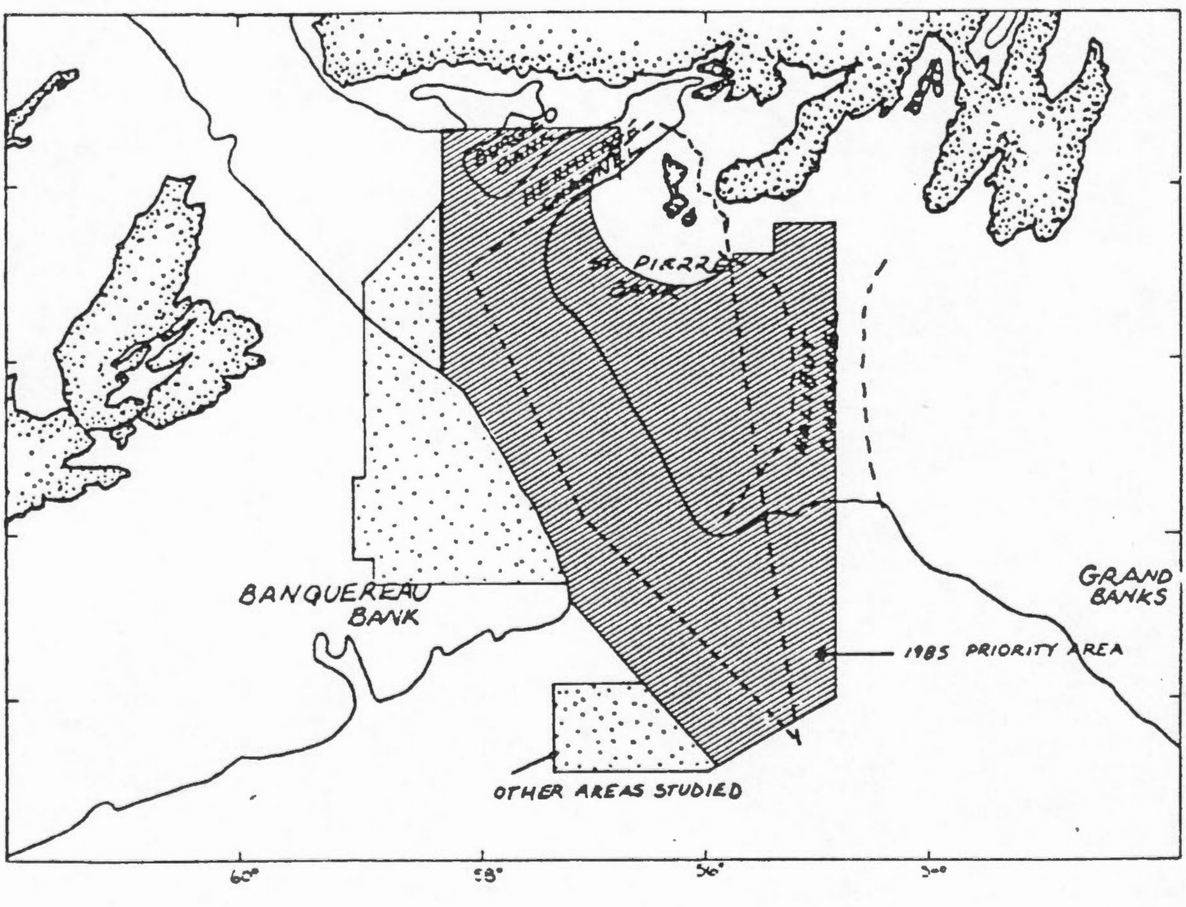
Interest has centred on the site of the November 18, 1929 "Grand Banks" earthquake (44° 41.5'N, 56° 00.4'W; Dewey and Gordon, 1984) and its down-slope regions. This earthquake was of a magnitude of 7.2 and immediately following the event a massive slump and turbidity current occurred that

Figure 11

Two-part figure taken from Buxton's (1987) Figure 4.2a and 4.2b. The top figure shows the 1984 CSS BAFFIN tracks while the lower figure shows the area investigated in 1985. The area close to the islands of St. Pierre et Miquelon was not mapped. The dashed triangular-trapezoidal area shows approximately the disputed area.



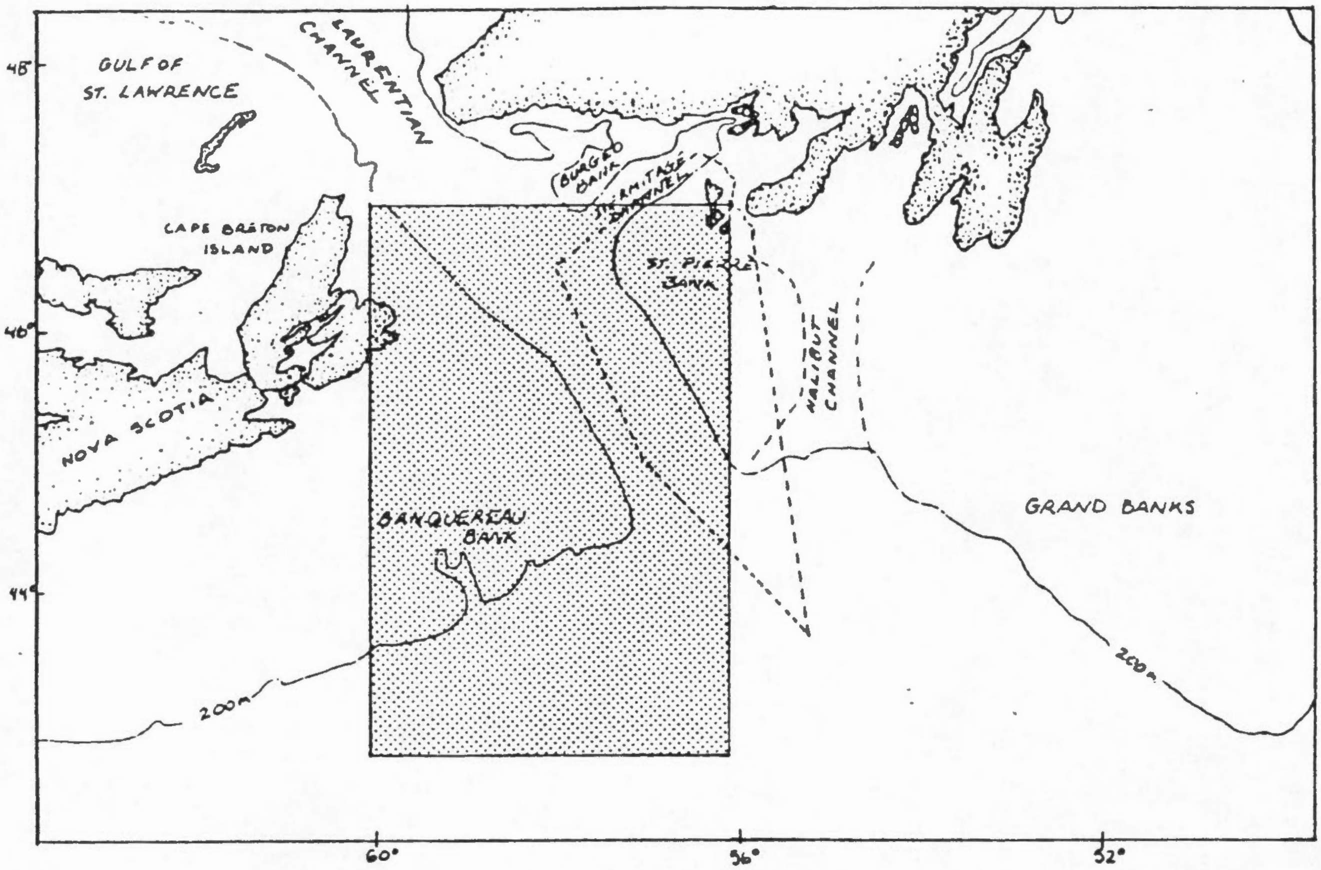

CSS Baffin - 1984 cruise - track plots



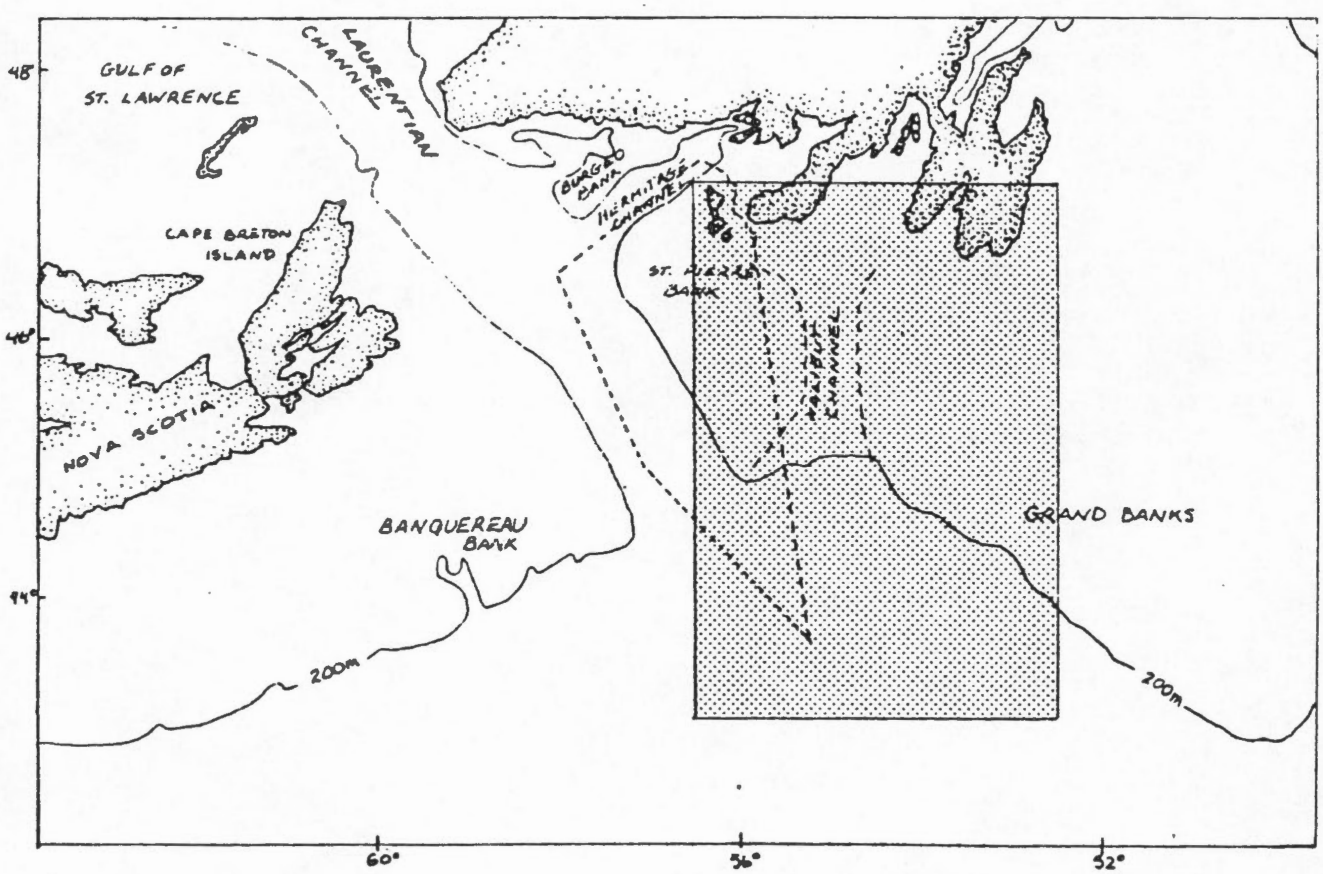

CSS Baffin - 1985 cruise - area covered

Figure 12

Two-part figure taken from Buxton's (1987) Figure 4.3a and 4.3b showing the latest CHS charts No. 4045 and No. 4047 over the study area.




Area covered by CHS chart #4045




Area covered by CHS chart #4047

severed 12 marine telegraph cables (Doxsee, 1948; Gregory, 1929; 1931; Hodgson and Doxsee, 1930; Keith, 1930). Once the turbidity current mechanism was recognised, (Heezen and Ewing, 1952; Heezen et al., 1954; Kuenen, 1952) little further work occurred until recently when David Piper of the Atlantic Geoscience Centre teamed up with American colleagues and a Dalhousie graduate student and his professor to quite thoroughly map the area. A full range of equipment has been used from echosounding and sampling tools to sub-bottom profiling, to SEAMARC transects (Figure 13) and Seabeam coverage (Figure 14) through to first hand examination of the seafloor via submersible dives by D/V PISCES and D/V ALVIN. A large number of papers have appeared (13+), including a more recent review paper by Piper et al. (1988) and a PhD thesis by John Hughes Clarke at Dalhousie (1988) along with an A.G.C. Open File reports by Piper et al. in 1985 and by Hughes Clarke in 1986. Papers by Bonifay and Piper (1988), Hughes Clarke et al. (1989), Mayer et al. (1988), Normark et al. (1983), Piper (1989), Piper and Normark (1982, 1989) and Shor and Piper (1989) have detailed the scientific findings in the Laurentian Slope area.

Research into the sediments elsewhere along the continental slope of Nova Scotia have been confined to a few theses at Dalhousie University in the 1980's. Some ongoing cooperative work between AGC's David Piper and French scientists is occurring along the Newfoundland continental slope and rise on the east side of the study area. Lauchie Meagher (1984) has prepared one Open File contract report for AGC on the seismic stratigraphy of sediments on the continental slope off St. Pierre Bank.

Figure 13

Track plot of the 1983 SEAMARC data gathered on the HUDSON 83-017 cruise and index map to the 13 sidescan mosaic sheets in Geological Survey of Canada Open File 1131 (Figure 2 in Piper *et al.* 1985).

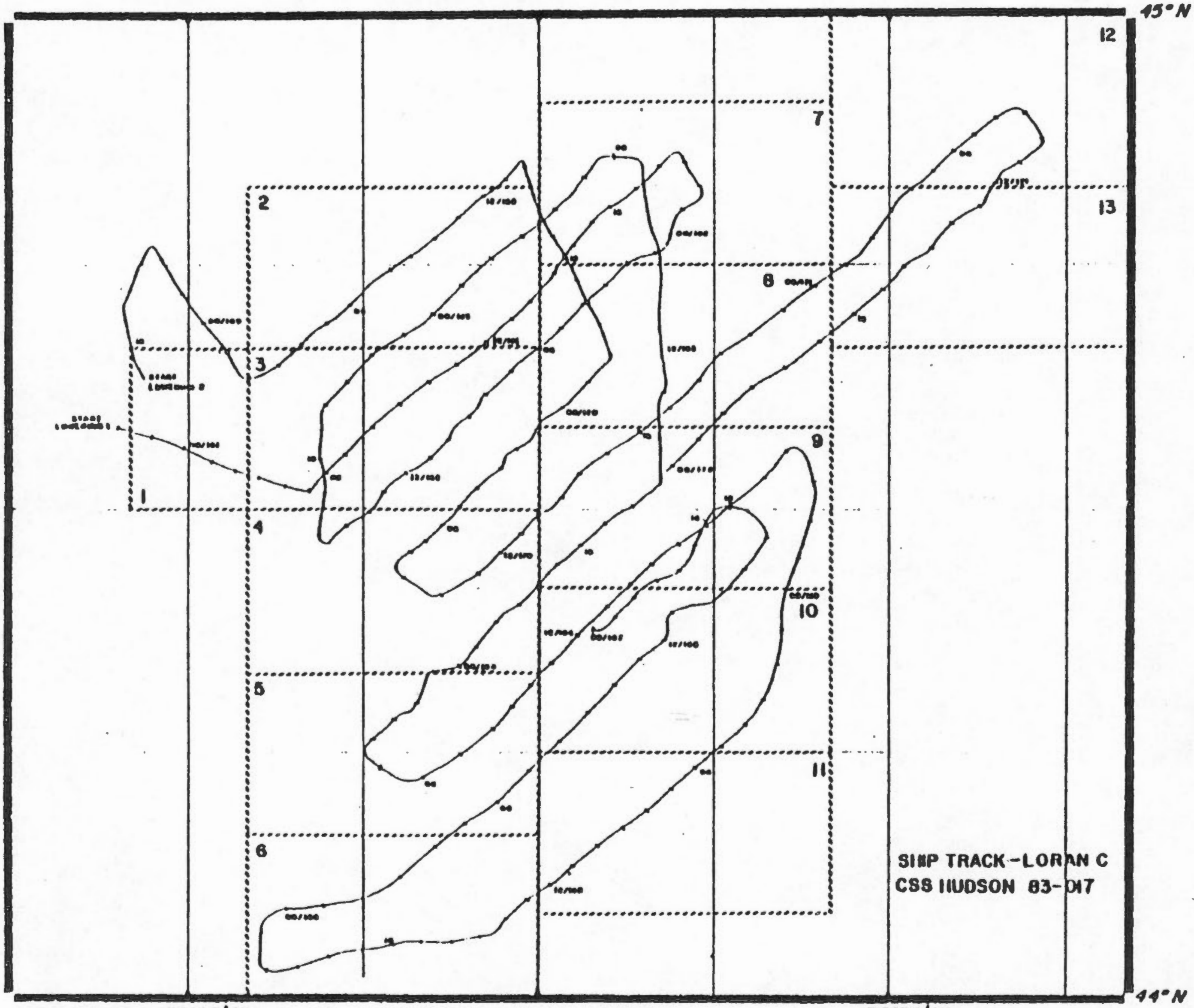

45° N
44° N
56°30' W
55°30' W
1
2
3
4
5
6
7
8
9
10
11
12
13
SHIP TRACK—LORAN C
CSS HUDSON 83-017

Figure 14

Atlantic Geoscience Centre and Canadian Hydrographic Service reconnaissance shiptrack coverage used in the compilation of John Hughes Clarke's bathymetry map (1988). The shaded area represents Seabeam data gathered cooperatively with the Americans. This Figure was figure 2.1b taken from John Hughes Clarke's thesis (1988).


57° 0'W
56° 0'W
55° 0'W
45° 0'N
45° 0'N
44° 0'N
44° 0'N
43° 0'N
43° 0'N

MAPPING OF SURFICIAL GEOLOGY AND BATHYMETRY (continued)

The 1929 earthquake caused a serious tidal wave (Jones, 1975; Robinson, 1976) that affected southern Newfoundland, Saint Pierre and Nova Scotia. Some 27 lives were lost in Newfoundland with one death in Nova Scotia; no lives were lost in St. Pierre et Miquelon. This event is presently under investigation by the author as part of the Canadian Hydrographic Services' COWLIS project.

## MAPPING OF GEOPHYSICAL PARAMETERS

### General

The first geophysics done offshore of Nova Scotia and Newfoundland was probably done by the oil industry with deep seismic and airborne magnetic data for the evaluation of the thickness of the sedimentary wedge on the continental shelf beginning in about 1958. Some academic refraction seismic work occurred in the study area in the mid 1950's, but seismic refraction work by Dalhousie Institute of Oceanography did not begin until the early 1960's. The Geological Survey of Canada began aeromagnetic surveys offshore in the area in the late 1950's and the former Earth Physics Branch began offshore bottom gravity measurements in the area in the mid 1960's. The Bedford Institute of Oceanography began its multidisciplinary surveys on the HUDSON and BAFFIN in about 1964. Thus, by 1965-66 the Atlantic Geoscience Centre (AGC) was in the marine geophysics business and was feeling its way toward setting up a digital geophysics data repository for Eastern Canada.

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

## Gravity Data

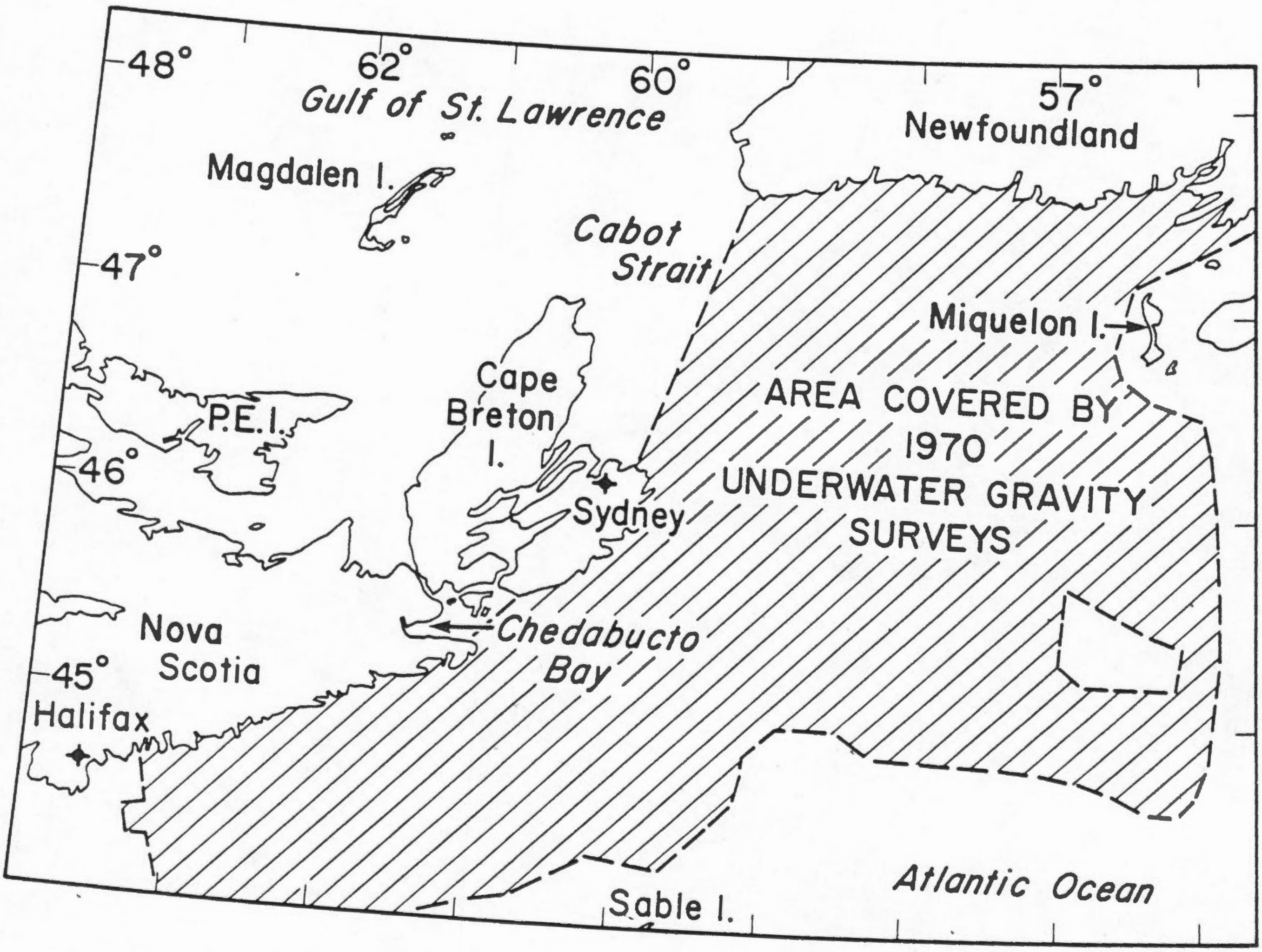
The Atlantic Geoscience Center, through Bosco Loncarevic, acquired a seaborne gravity meter shortly after CSS HUDSON was added to the fleet in 1963. Initially, and while experience was gained with the new equipment, data was gathered mainly on reconnaissance lines. The study of the Orpheus Gravity Anomaly was one of AGC's first areal gravity mapping programs (Loncarevic and Ewing, 1967). About 1965, the Earth Physics Branch acquired a seabottom gravimeter and Alan Goodacre began a program from CNAV SACKVILLE to map the gravity field in the Gulf of St. Lawrence at about a 15 km spacing (Goodacre and Nyland, 1966; Goodacre _et al._, 1969). Later in 1970, Goodacre's group mapped the bottom gravity over most of the continental shelf in the study area west of 56°W (Figure 15, Goodacre _et al._, 1973).

When AGC ran one of its first multidisciplinary surveys in the eastern Gulf of St. Lawrence in conjunction with CHS on the CSS BAFFIN in 1968-69 the area earlier mapped by the Earth Physics Branch with the seabottom meter was repeated (Haworth and Watts, 1973). Comparisons were done between the data sets and a debate began as to which tool was better; it is a debate that to some degree continues today.

The Atlantic Geoscience Center continued to gather reconnaissance gravity data in the area south of Newfoundland over the next twenty years with some more detailed work in 1979 and 1982. In 1984, CSS BAFFIN carried out a major multidisciplinary program on St. Pierre Bank (Figure 11, top) and gravity data were gathered on over 11,200 km of track to greatly density

Figure 15

Index map to the Earth Physics Branch's 1970 seabottom gravity survey on the Scotian Shelf, St. Pierre Bank and Burgeo Bank. Figure is taken from Goodacre _et al._'s (1973) index map.


48°
62°
60°
57°
Gulf of St. Lawrence
Newfoundland
Magdalen I.
Cabot
Strait
47°
Miquelon I.
Cape
Breton
I.
P.E.I.
AREA COVERED BY
1970
UNDERWATER GRAVITY
SURVEYS
46°
Sydney
Nova
Scotia
Chedabucto
Bay
45°
Halifax
Atlantic Ocean
Sable I.

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

Gravity Data (continued)

the gravity coverage (Henderson, 1984; Macnab et al., 1985). These new data have in part allowed more detailed interpretations to be made of crustal structure (Reid, 1987).

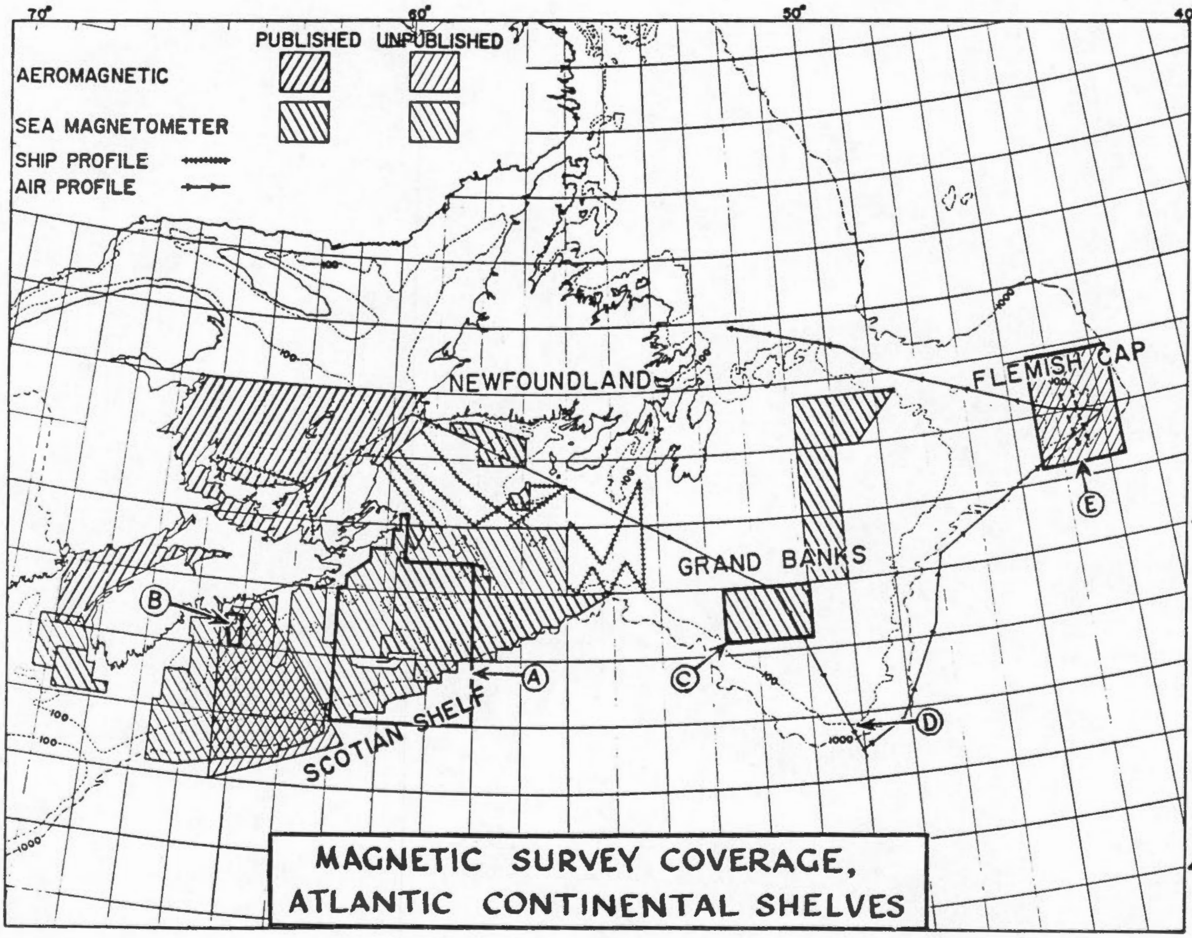
Commercialy-gathered shipborne gravity data is generally gathered along most deep seismic lines where a client opts for the minimal add-on price. A glance at the index map to deep seismic lines that follows in this section (Figure 23) will show that there is a major gap in oil company gravity coverage in the 1967 Moratorium Area. Macnab, Plasse and Graves (1985) have prepared an index of commercially available potential field data; this publication comes from an Open File report prepared by Plasse and Graves (1985) and lists magnetic and gravity data.

Magnetic Data

Canada has regularly flown airborne aeromagnetic data over onshore areas for several decades as part of the country's resource evaluation program. Airborne fluxgate magnetometer data was first gathered offshore in 1958 (Hood, 1966a). Proton precession sea magnetometer data were first gathered by CSS KAPUSKASING offshore of Nova Scotia and across the St. Pierre and Burgeo Bank areas (Figure 16) in 1959 (Bower, 1961; 1962). The National Aeronautical Establishment and Royal Canadian Air Force in 1962 also flew virtually all of the Scotia Shelf using military oriented magnetic airborne detector (MAD) surveys (Hood, 1966a;b) that were intiated by

Figure 16

1965 index map to magnetic survey coverage of the eastern Canada continental shelves from Hood (1966b). Area A was surveyed by CSS KAPUSKASING and Area C on the eastern side of the study area was the first magnetic survey done by CSS BAFFIN in 1963 as the Bedford Institute of Oceanography took over the sea magnetometer work in late 1963. The long profile marked by D was flown by an Argus aircraft in January of 1963 (Hood, 1966b; Hood and Godby, 1965) and continued through the study area over St. Pierre Bank.



70°
60°
50°
40°
50°
45°
40°
PUBLISHED UNPUBLISHED
AEROMAGNETIC
SEA MAGNETOMETER
SHIP PROFILE
AIR PROFILE
NEWFOUNDLAND
FLEMISH CAP
GRAND BANKS
SCOTIAN SHELF
A
B
C
D
E
100
1000
MAGNETIC SURVEY COVERAGE,
ATLANTIC CONTINENTAL SHELVES

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

Magnetic Data (continued)

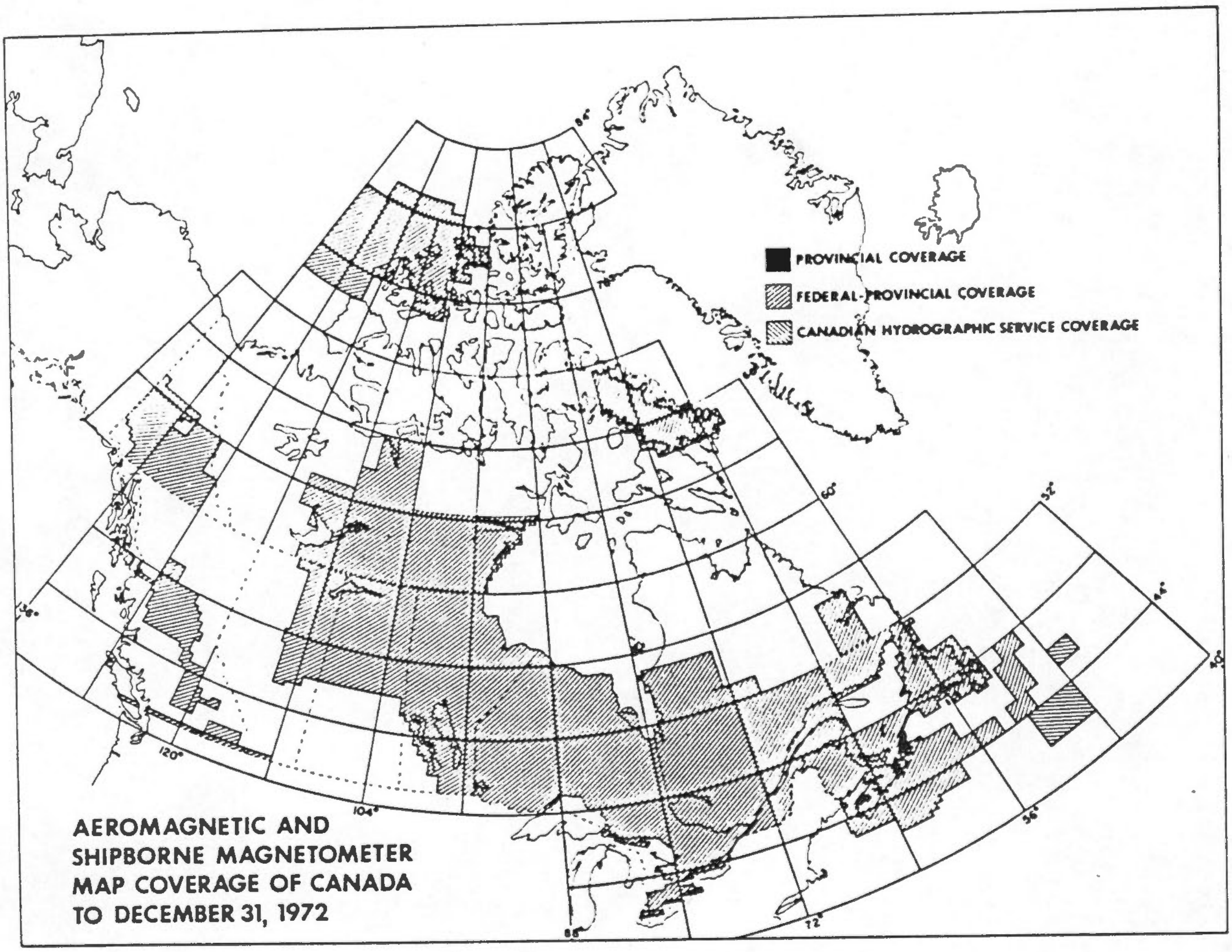
the military's desire to map wrecks and other targets on the seafloor. The MAD surveys could also be used for geological interpretations (Hood, 1966a;b).

CSS KAPUSKASING had surveyed the eastern part of the Scotian Shelf east of 61°W to 58°W in 1961 using a sea magnetometer. Late in 1963, the shipborne magnetometers were transferred from the Geological Survey of Canada in Ottawa to the newly-formed Bedford Institute of Oceanography and the predecessor to the Atlantic Geoscience Centre began to carry out sea magnetometer surveys in 1963-64, shortly after its formation.

The CSS BAFFIN surveyed an area of the Grand Banks on the eastern side of the study area in 1963 (Hood, 1966a). However, by the end of 1972 there were still significant holes in the publically-available offshore magnetic data south of Newfoundland, (Figure 17; McGrath et al., 1973) including parts of St. Pierre Bank. This gap was picked away at over the next 13 years with reconnaissance tracks and some more detailed work in 1979 and 1982. In 1984, BAFFIN returned to the St. Pierre Bank area and gathered 11980 km of magnetic track in a major multidisciplinary survey done under the Bilateral Boundary Studies Program (Henderson, 1984; MacNab et al., 1985). The next year, a major offshore airborne aeromagnetic program was flown under contract to cover some 120,000 sq km south of Newfoundland including all of St. Pierre Bank (Figure 18). Patterson, Grant and Watson Ltd. were contracted to interpret the data (1986).

Figure 17

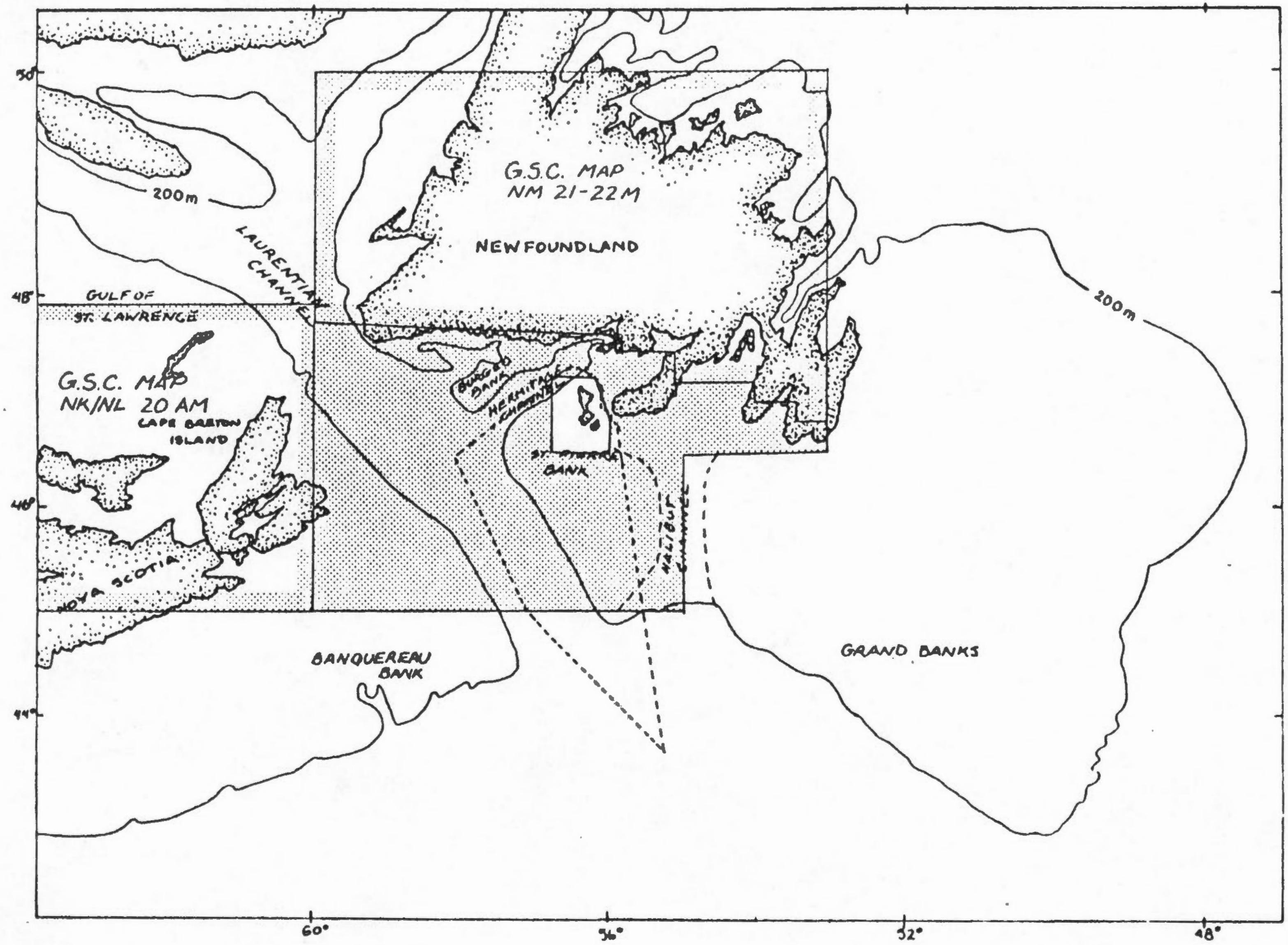
Index map to aeromagnetic and shipborne magnetometer data available in Canada to the end of December 1972. Map is taken from McGrath *et al.* (1973). A significant hole in the data is shown in the study area south of Newfoundland.




AEROMAGNETIC AND SHIPBORNE MAGNETOMETER MAP COVERAGE OF CANADA TO DECEMBER 31, 1972

Figure 18

Index map to the area which was covered by the aeromagnetic survey flown under the Bilateral Boundary Studies Program in 1985 (shaded area). The index map was taken from Figure 4.5 in Buxton (1987). The survey was planned to merge with available onshore coverage and was planned so as to not intrude into a 24 n mi zone around the islands of St. Pierre et Miquelon. A second survey has now been flown to the east of Halibut Channel out onto the Grand Banks.


G.S.C. MAP
NM 21-22M
NEWFOUNDLAND
200m
LAURENTIAN CHANNEL
GULF OF ST. LAWRENCE
G.S.C. MAP
NK/NL 20 AM
CAPE BRETON ISLAND
NOVA SCOTIA
BURGEO BANK
HERMITAGE CHANNEL
ST. PIERRE BANK
HALIBUT CHANNEL
BANQUEREAU BANK
GRAND BANKS
200m
50°
48°
46°
44°
60°
56°
52°
48°

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

Magnetic Data (continued)

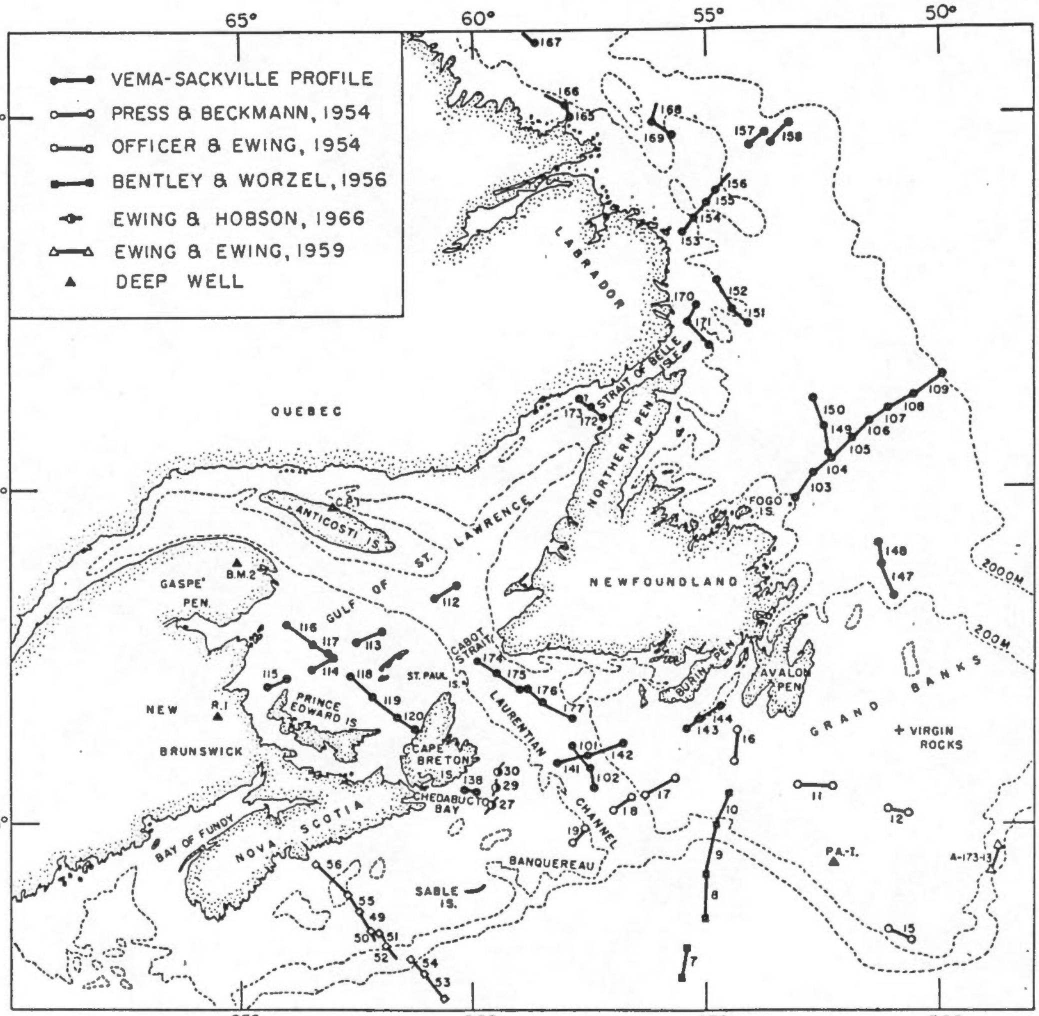
Some commercially-acquired magnetic data have been gathered in the study area in conjunction with deep seismic data. Thus, coverage to the east and west of the 1967 Moratorium Area is reasonable. However, commercial marine magnetometer data in the Moratorium Area is very thin because of the lack of seismic lines (Figure 23). Chevron Canada flew much of the St. Pierre Bank area in 1966 in advance of the 1967 land sale. This data set is the best commercially acquired magnetic data set in the study area. The Earth and Ocean index to commercially available potential field data lists the magnetic data available offshore (Macnab, Plasse and Graves, 1985; Plasse and Graves, 1985).

Seismic Refraction Data

Academic interest in the thickness of the sedimentary section on Canadian continental shelves focused on refraction techniques rather than reflection data. Refraction is a cheaper approach that requires less equipment and was therefore within the reach of earlier researchers; it also did not require expensive digital processing techniques. Willmore and Scheidegger (1936), Bentley and Worzel (1956), Press and Beckmann (1954) and Officer and Ewing (1954) did the first work off Eastern Canada that impacted on the study area (Figure 19).

Figure 19

Index map of Sheridan and Drake (1968) showing the early seismic refraction data in the study area.


VEMA-SACKVILLE PROFILE
PRESS & BECKMANN, 1954
OFFICER & EWING, 1954
BENTLEY & WORZEL, 1956
EWING & HOBSON, 1966
EWING & EWING, 1959
DEEP WELL
65°
60°
55°
50°
45°
QUEBEC
LABRADOR
STRAIT OF BELLE ISLE
NORTHERN PEN.
ANTICOSTI IS.
GULF OF ST. LAWRENCE
GASPE' PEN.
B.M.2
NEW BRUNSWICK
R.1
PRINCE EDWARD IS.
CAPE BRETON IS.
ST. PAUL IS.
CABOT STRAIT
LAURENTIAN CHANNEL
NEWFOUNDLAND
FOGO IS.
BURIN PEN.
AVALON PEN.
GRAND BANKS
VIRGIN ROCKS
CHEDABUCTO BAY
NOVA SCOTIA
BAY OF FUNDY
SABLE IS.
BANQUEREAU
P.A.-1.
A-173-13
2000M
200M

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

Seismic Refraction Data (continued)

Dalhousie Institute of Oceanography graduate students under the leadership of Michael J. Keen got deeply into crustal seismic refraction in the early 1960's initially running several lines across and along the Scotian Shelf at the western side of the study area (Figure 20; Keen and Loncarevic, 1966). Later Dalhousie ran some refraction data between Newfoundland and Nova Scotia in the Gulf of St. Lawrence and south of Newfoundland.

American university personnel teamed up with Canadian workers in 1960-1961 to shoot joint refraction profiles from CNAV SAKVILLE and R/V VEMA (Sheridan and Drake, 1968) and data was shot in the Laurentian Channel in the study area (Figure 19). The SACKVILLE also continued to be a workhorse for the Canadian government's seismic refraction programs that were run under the direction of George Hobson for six years in the 1960's beginning in 1964. This refraction work was mainly centred in the Gulf of St. Lawrence but on one occasion SACKVILLE gathered data in the study area (Figure 21; Hobson and Overton, 1973). The Geological Survey of Canada's program in the Gulf of St. Lawrence was aimed at mapping the thickness of the Palaeozoic section with a potential for hydrocarbons rather than mapping the full crustal thickness.

Some additional seismic refraction data were collected in the Laurentian Channel and on the continental slope during the Bilateral Boundary Studies Programme (Buxton, 1987) with ocean bottom self-recording seismometers used (Figure 22; Reid, 1987) to obtain the velocity structure of the sedimentary section. Good velocity control is essential to a full understanding of seismic reflection data gathered in an area.

Figure 20

Index map to the early crustal seismic refraction lines shot by Dalhousie University's Institute of Oceanography on the Scotian Slope and Shelf taken from Keen and Loncarevic (1966).

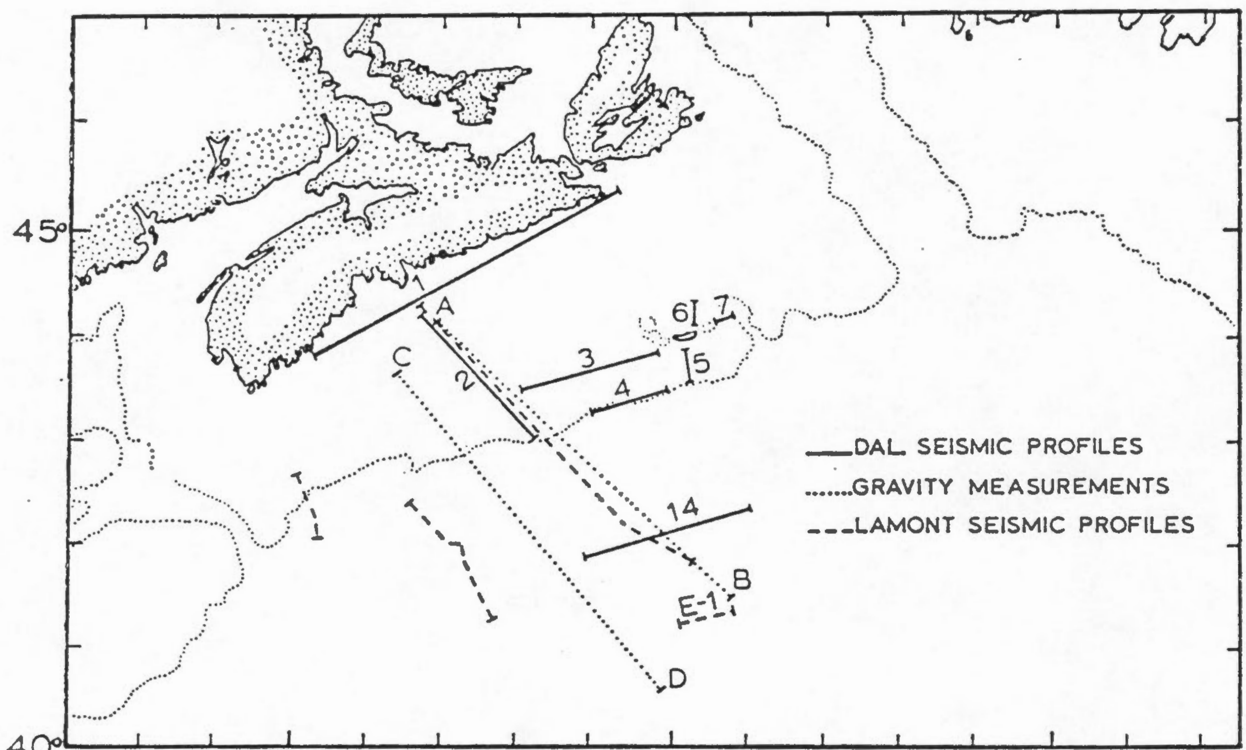
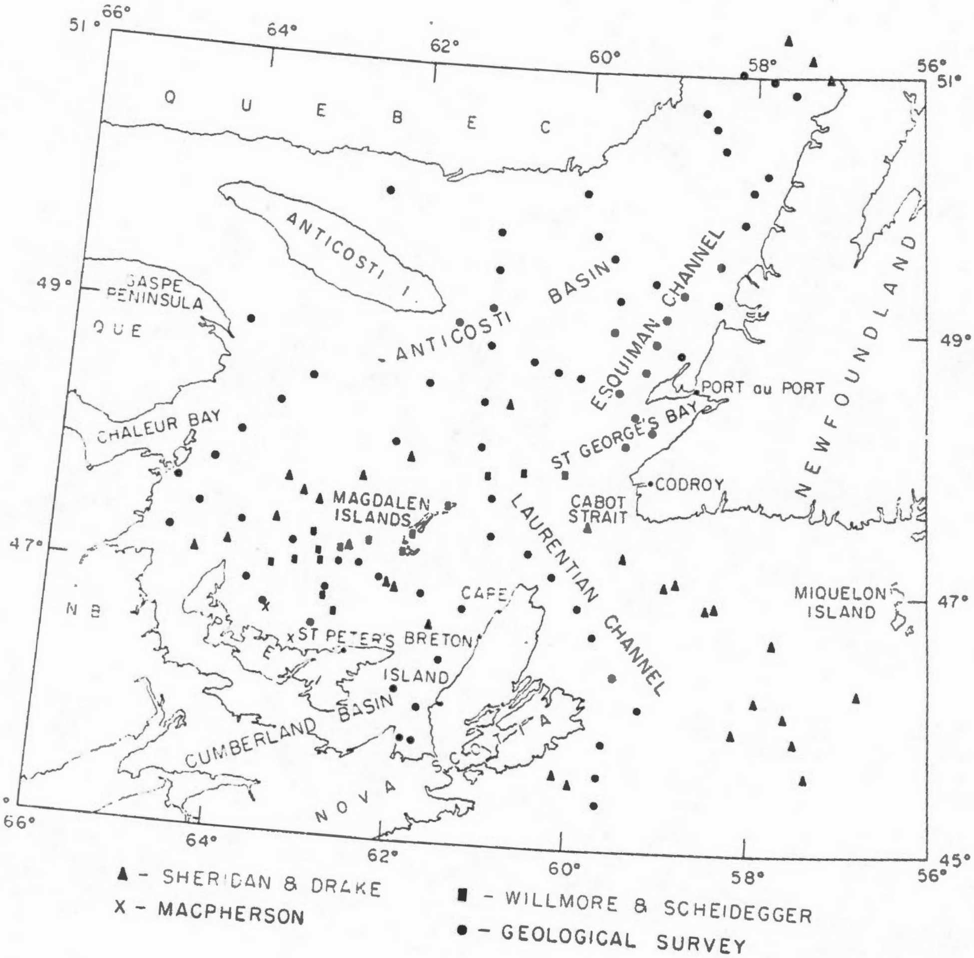

DAL SEISMIC PROFILES
GRAVITY MEASUREMENTS
LAMONT SEISMIC PROFILES
45°
40°
65°
60°
55°
1
2
3
4
5
6
7
14
A
B
C
D
E-1

Figure 21

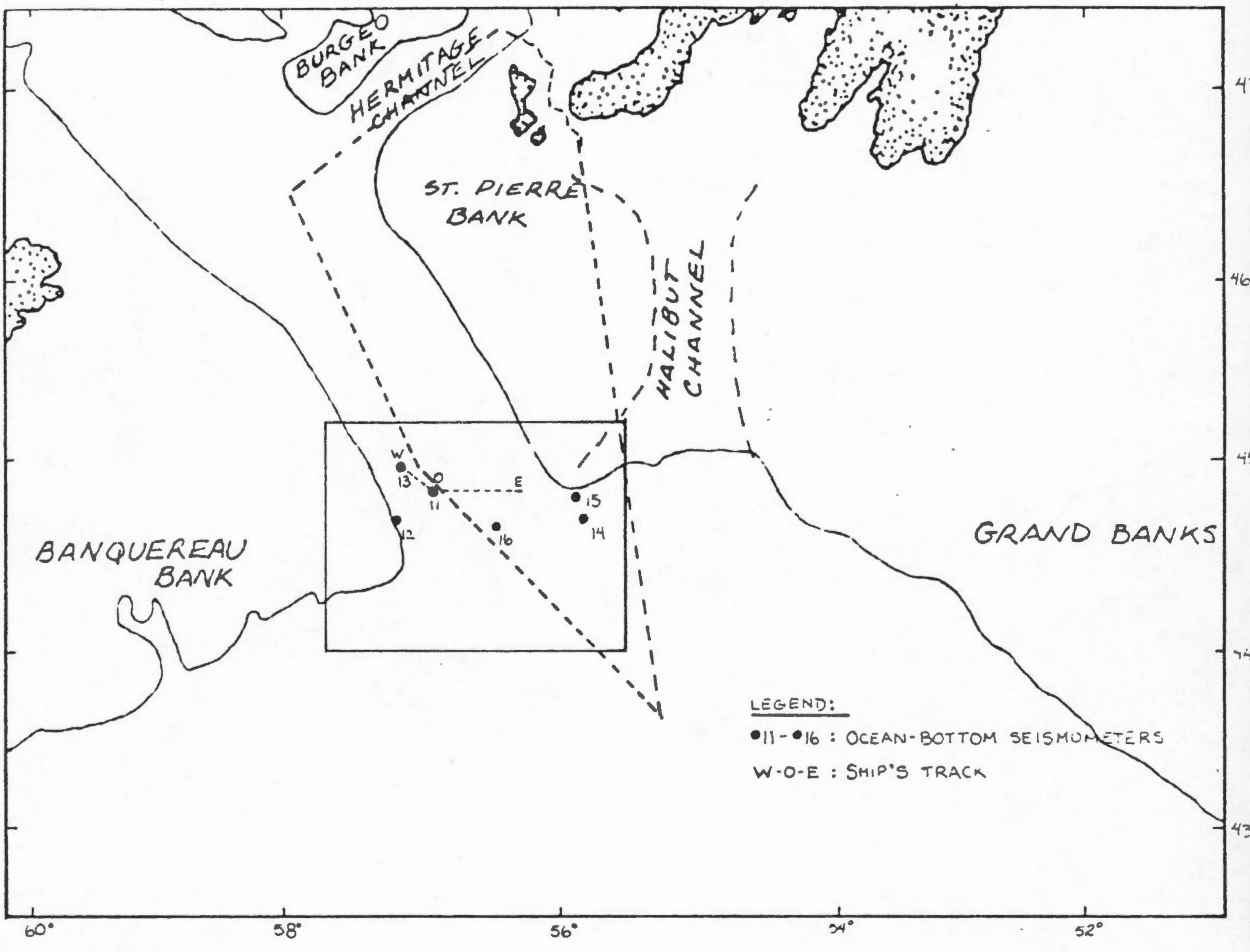
Index map to the 1964-1969 seismic refraction lines run by CNAV SACKVILLE taken from Hobson and Overton (1973). The index map also shows the ship to ship profiles of SACKVILLE and VEMA in 1960-61 (Sheridan and Drake, 1968) and Willmore and Scheidegger's (1956) early work in the Gulf of St. Lawrence at the northeast corner of the study area.



QUEBEC
ANTICOSTI I.
GASPE PENINSULA
QUE
CHALEUR BAY
ANTICOSTI BASIN
ESQUIMAN CHANNEL
NEWFOUNDLAND
PORT au PORT
ST GEORGE'S BAY
CODROY
CABOT STRAIT
MAGDALEN ISLANDS
LAURENTIAN CHANNEL
MIQUELON ISLAND
N B
P. E. I.
ST PETER'S
CAPE BRETON ISLAND
BASIN
CUMBERLAND
NOVA SCOTIA
▲ - SHERIDAN & DRAKE
X - MACPHERSON
■ - WILLMORE & SCHEIDEGGER
● - GEOLOGICAL SURVEY

Figure 22

Index map to seismic refraction data gathered during the Bilateral Boundary Studies Programme. Figure is taken from Buxton's (1987) Figure 4.7. The dots show ocean bottom seismometers placed on the seafloor to record seismic arrivals.


BURGEO BANK
HERMITAGE CHANNEL
ST. PIERRE BANK
HALIBUT CHANNEL
BANQUEREAU BANK
GRAND BANKS
W
O
E
11
12
13
14
15
16
LEGEND:
●11 - ●16 : OCEAN-BOTTOM SEISMOMETERS
W-O-E : SHIP'S TRACK
60°
58°
56°
54°
52°
47
46°
45
44
43

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

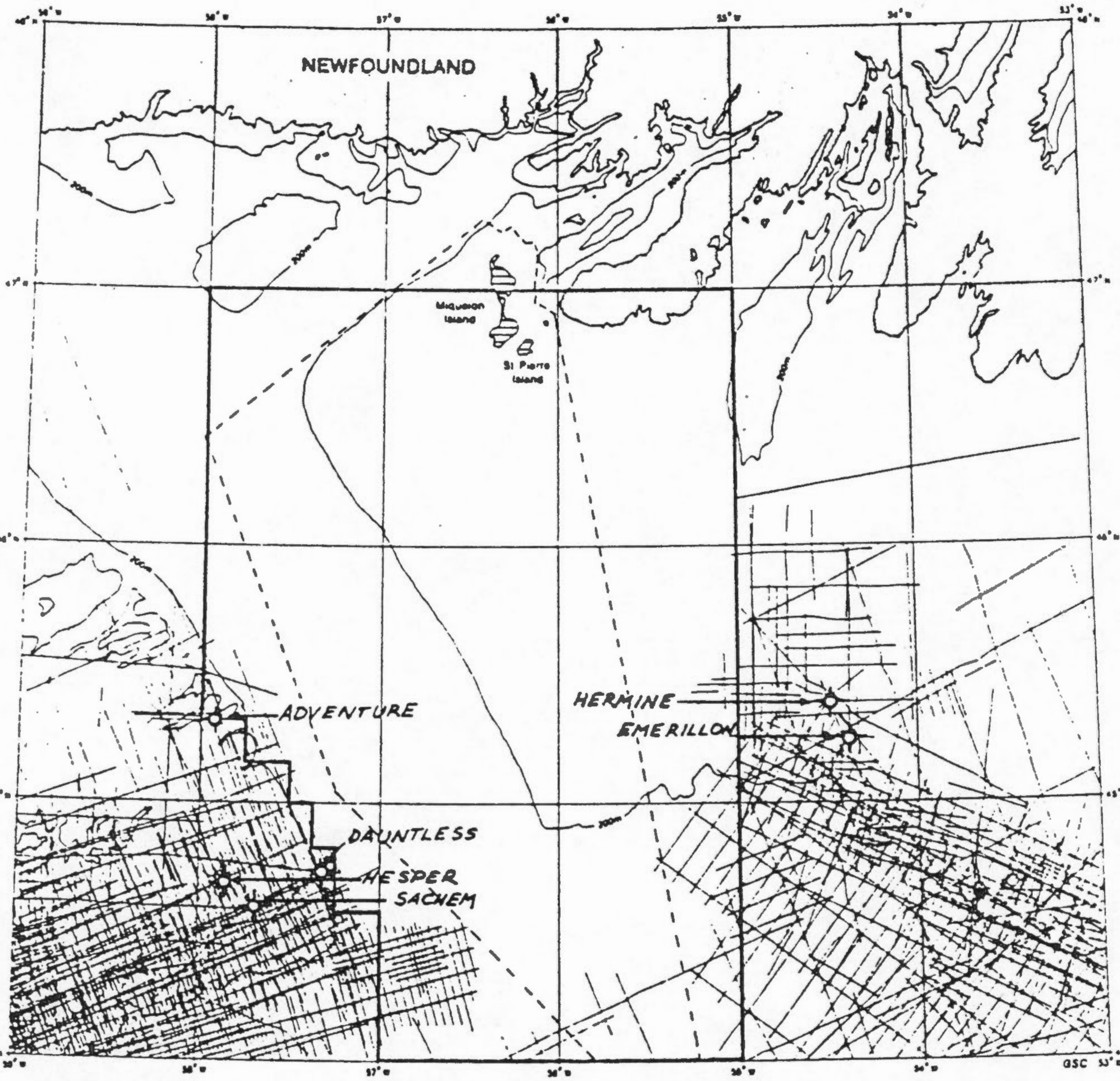
## Deep Reflection Seismic Data

Digital seismic reflection techniques are by far and away the method of choice for the oil industry when it comes to mapping the geological structure of areas with hydrocarbon potential. When the 1967 Moratorium Area was agreed to and France and Canada agreed to not permit the collection of commercial data in this area the moratorium was aimed at deep seismic reflection data. The moratorium was largely successful in preventing the collection of any deep seismic data from 1967 to 1983 (Figure 23). Only Shell Canada Resources Ltd. was permitted to survey within the Moratorium Area (but outside the area claimed by France) on its Exploration Agreement 110 that was found in the southwest corner of the Moratorium Area until it was dropped by Shell about three years ago.

The French research vessel CHARCOT ran a deep seismic reflection profile along the southwest edge of Grand Banks (Auzende *et al.*, 1970). CHARCOT ran a zigzag line up into the study area during the 1969 'Noratlante' expedition (Figure 24). The CHARCOT track briefly penetrated the 1967 Moratorium Area south of the Burin Peninsula (Figure 24).

Figure 23

Index map to all pre-1984, industry, deep seismic reflection lines available in the study area. The map does not show the 1983 French program of the LUCIEN BEAUFORT. The effectiveness of the moratorium is quite well shown by the total gap in the regional coverage on St. Pierre Bank and in much of the Laurentian Channel. The grid of lines run in the southwest corner of the Moratorium Area was run on Shell's Exploration Agreement 110. Figure was taken from Buxton's (1987) Figure 4.4.




PRE 1984 SEISMIC COVERAGE

Deep Reflection Seismic Data (continued)

W.H. (Bill) Elias' ill-fated marine deep seismic company, Caravel Exploration Ltd. of Calgary (formerly Catalina Exploration and Development Ltd.), ran its vessel CALGARY CATALINA into the study area in gathering some spec participation seismic lines (Elias, 1973). He had plans to gather more (Figure 25), but the firm had financial problems and Canada's first attempt at a marine seismic acquisition company failed. The CALGARY CATALINA became the J.J. JOHNSON of Geophysical Services Inc. and saw further service worldwide including in Canadian waters.

The total gap in the regional deep seismic coverage (Figure 23) meant that no tie could be made between the Scotian Shelf and southern Newfoundland banks; there was also no commercial well control and the 1965 D/V CALDRILL program of shallow coreholes did not sample the bedrock in the gap though some data were collected in 12 holes on the eastern side of the study area (Pan American Petroleum Corporation and Imperial Oil Enterprises Limited, 1965).

In August of 1983, the French broke the 16-year moratorium. The M/V LUCIEN BEAUFORT, a deep seismic vessel of Compagnie General de Geophysique, presumeably working for the Elf-Aquitaine consortium that holds the French-issued exploration rights (Figure 26), ran an extensive seismic program over much of area claimed by France and liscenced to the French consortium. The Canadian government became aware of the program by chance when David Ross, an employee of NORDCO, Inc. of St. John's, Newfoundland was on holiday in Saint Pierre. He spotted what was obviously a French deep seismic

Figure 24

Track of the French vessel CHARCOT during the Noratlante expedition in 1969 taken from Auzende _et al_. (1970). The vessel ran 10-second long, digital, seismic reflection records along a zigzag track over the southwest margin of the Grand Banks up into the study area to the northwest just south of the Burin Peninsula (thin line). The solid dark lines show the interpreted faults and fault zones.

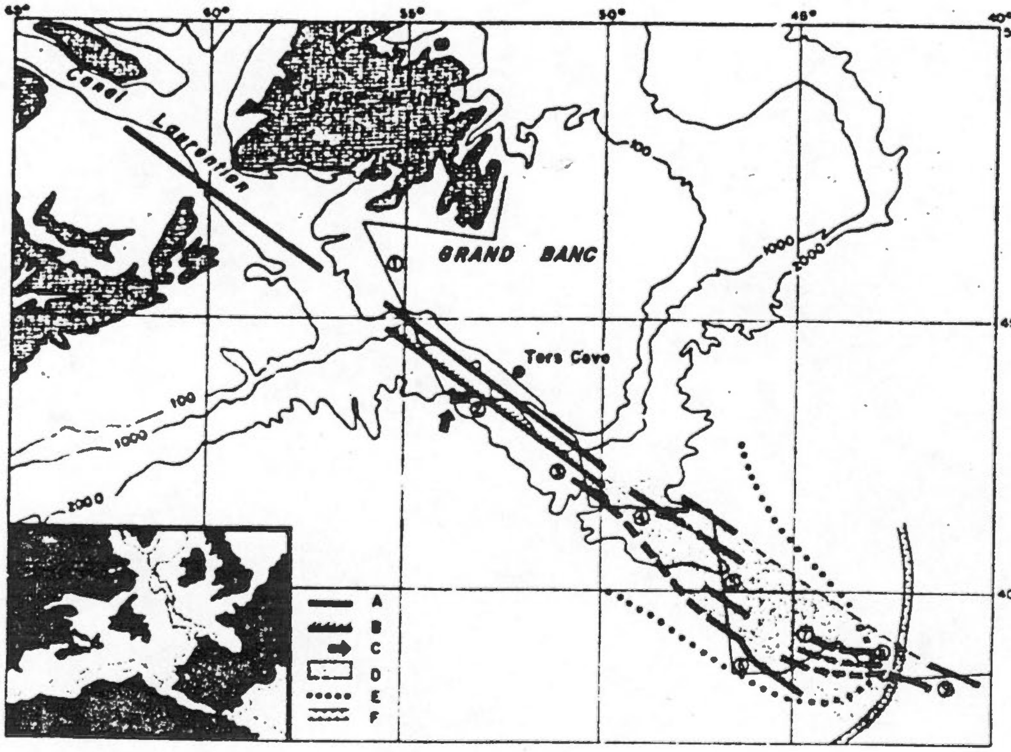

60°
55°
50°
40°
50°
45°
40°
Canal Laurentian
GRAND BANC
Tors Cove
100
1000
2000
A
B
C
D
E
F

Figure 25

Index map to the CALGARY CATALINA's deep seismic participation lines (Elias, 1973). The map also shows the proposed lines of Caravel Exploration Ltd; these were never shot. The 1969 program shows as heavy dashes; the 1970 program shows as heavy solid lines and the proposed program shows as lighter dashes.

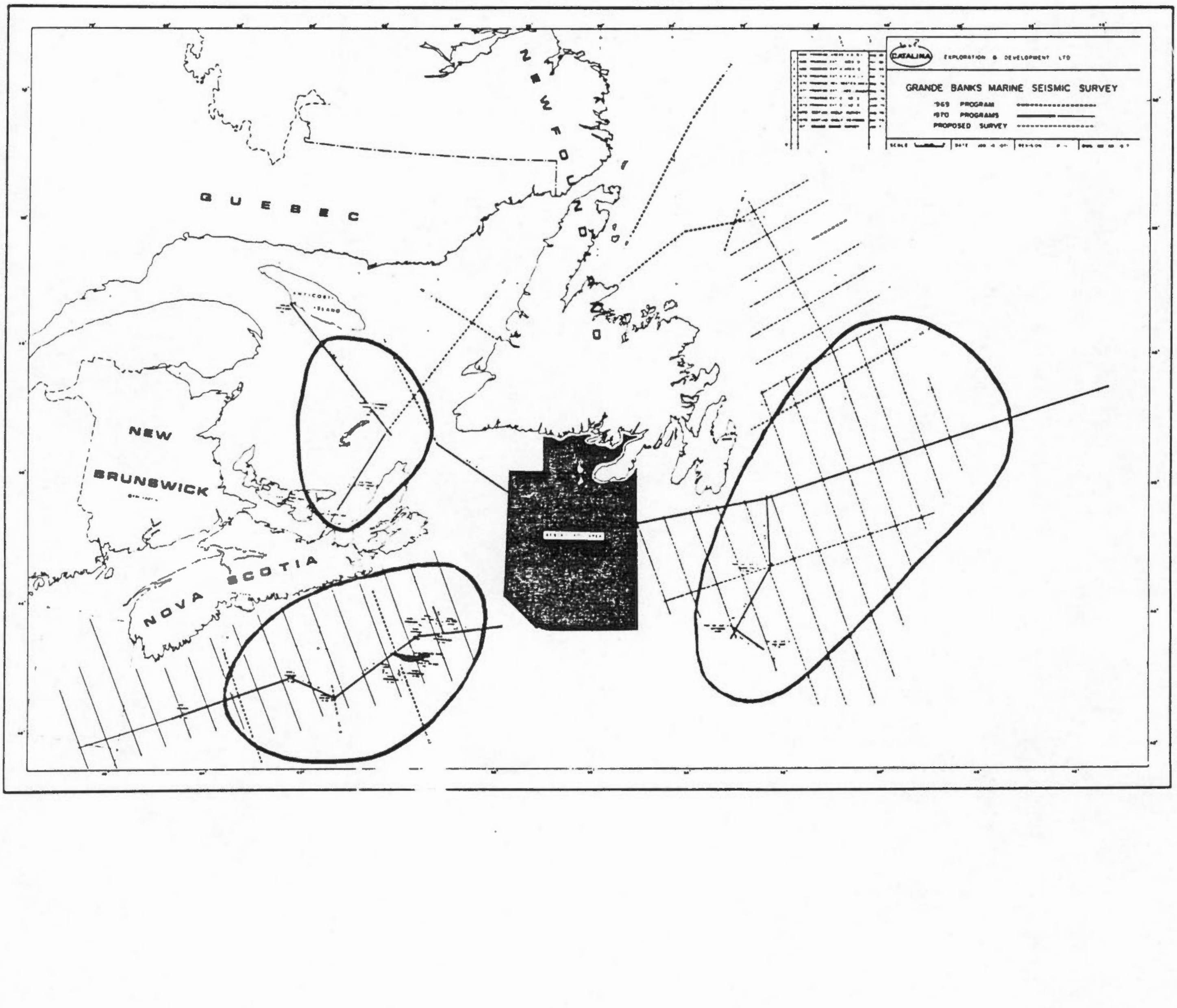
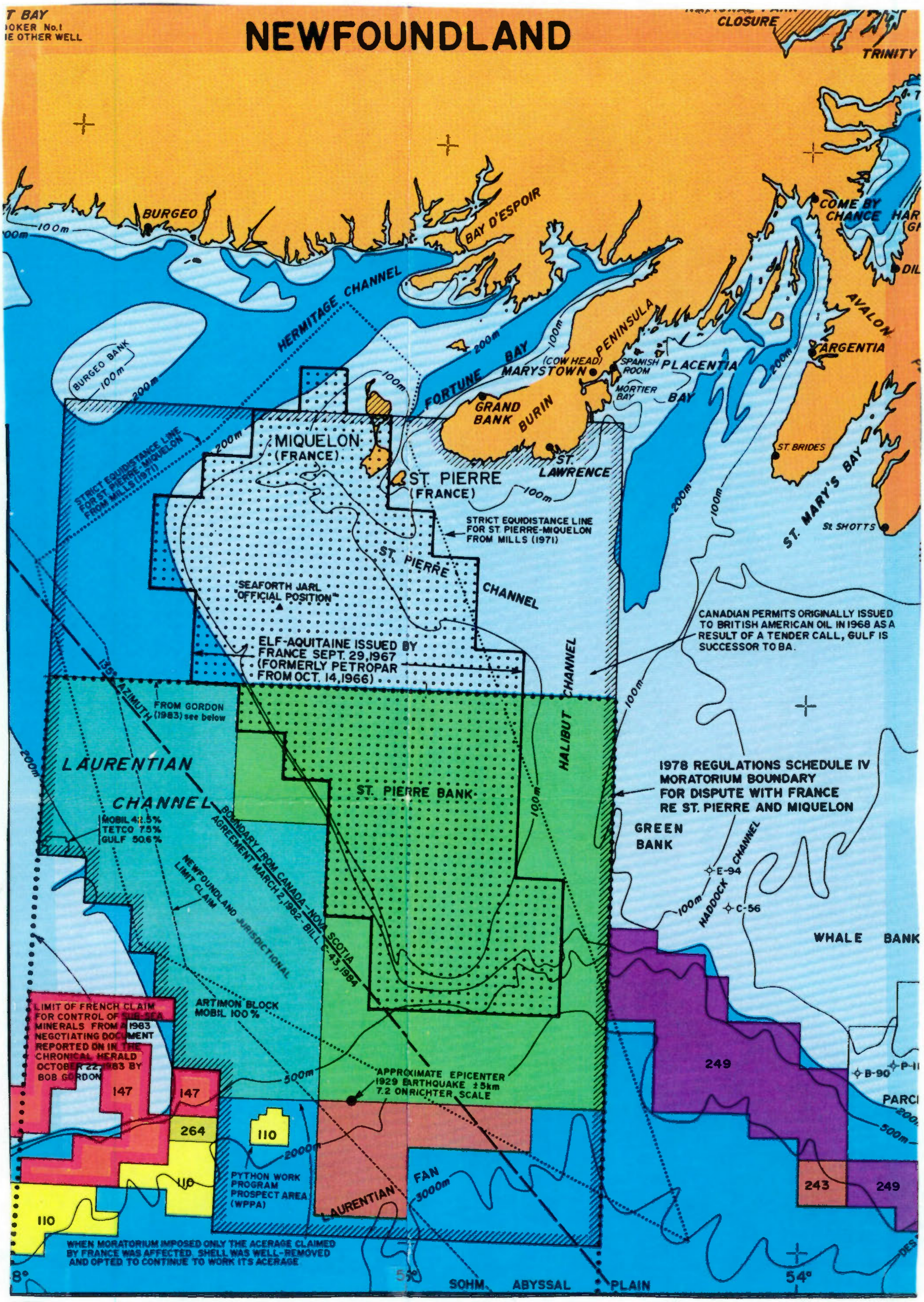

CATALINA
EXPLORATION & DEVELOPMENT LTD
GRANDE BANKS MARINE SEISMIC SURVEY
1969 PROGRAM
1970 PROGRAMS
PROPOSED SURVEY
QUEBEC
NEWFOUNDLAND
NEW BRUNSWICK
NOVA SCOTIA

Figure 26

Portion of the Geomarine Associates Ltd. (Ruffman and Kelly, 1985) map of the 1985 petroleum interests off Newfoundland showing as a black stipple the area issued by France to Elf-Aquitaine on September 19, 1967 (It was formerly held by Petropar from October 14, 1966). The 1967 Moratorium Area is shown outlined by a cross-hatched boundary.


NEWFOUNDLAND
CLOSURE
TRINITY
BURGEO
BAY D'ESPOIR
COME BY CHANCE
HERMITAGE CHANNEL
BURGEO BANK
FORTUNE BAY
PENINSULA
(COW HEAD)
MARYSTOWN
SPANISH ROOM
PLACENTIA
MORTIER BAY
BAY
AVALON
ARGENTIA
GRAND BANK
BURIN
MIQUELON (FRANCE)
ST. PIERRE (FRANCE)
ST. LAWRENCE
ST. BRIDES
ST. MARY'S BAY
St SHOTTS
STRICT EQUIDISTANCE LINE FOR ST. PIERRE-MIQUELON FROM MILLS (1971)
STRICT EQUIDISTANCE LINE FOR ST. PIERRE-MIQUELON FROM MILLS (1971)
ST. PIERRE CHANNEL
'SEAFORTH JARL OFFICIAL POSITION'
ELF-AQUITAINE ISSUED BY FRANCE SEPT. 29,1967 (FORMERLY PETROPAR FROM OCT. 14,1966)
CANADIAN PERMITS ORIGINALLY ISSUED TO BRITISH AMERICAN OIL IN 1968 AS A RESULT OF A TENDER CALL, GULF IS SUCCESSOR TO BA.
135° AZIMUTH
FROM GORDON (1983) see below
HALIBUT CHANNEL
LAURENTIAN CHANNEL
ST. PIERRE BANK
1978 REGULATIONS SCHEDULE IV MORATORIUM BOUNDARY FOR DISPUTE WITH FRANCE RE ST. PIERRE AND MIQUELON
GREEN BANK
MOBIL 42.5%
TETCO 7.5%
GULF 50.6%
BOUNDARY FROM CANADA-NOVA SCOTIA AGREEMENT MARCH 2, 1982 BILL C-43, 1984
NEWFOUNDLAND JURISDICTIONAL LIMIT CLAIM
HADDOCK CHANNEL
E-94
C-56
WHALE BANK
LIMIT OF FRENCH CLAIM FOR CONTROL OF SUB-SEA MINERALS FROM A 1983 NEGOTIATING DOCUMENT REPORTED ON IN THE CHRONICAL HERALD OCTOBER 22, 1983 BY BOB GORDON
ARTIMON BLOCK MOBIL 100%
APPROXIMATE EPICENTER 1929 EARTHQUAKE ±5km 7.2 ON RICHTER SCALE
249
B-90
PARC
147
147
264
110
110
110
PYTHON WORK PROGRAM PROSPECT AREA (WPPA)
LAURENTIAN FAN
243
249
WHEN MORATORIUM IMPOSED ONLY THE ACERAGE CLAIMED BY FRANCE WAS AFFECTED. SHELL WAS WELL-REMOVED AND OPTED TO CONTINUE TO WORK ITS ACERAGE
SOHM ABYSSAL PLAIN
54°

Deep Reflection Seismic Data (continued)

vessel, the LUCIEN BEAUFORT, and alerted the director of the Atlantic Geoscience Centre at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia.

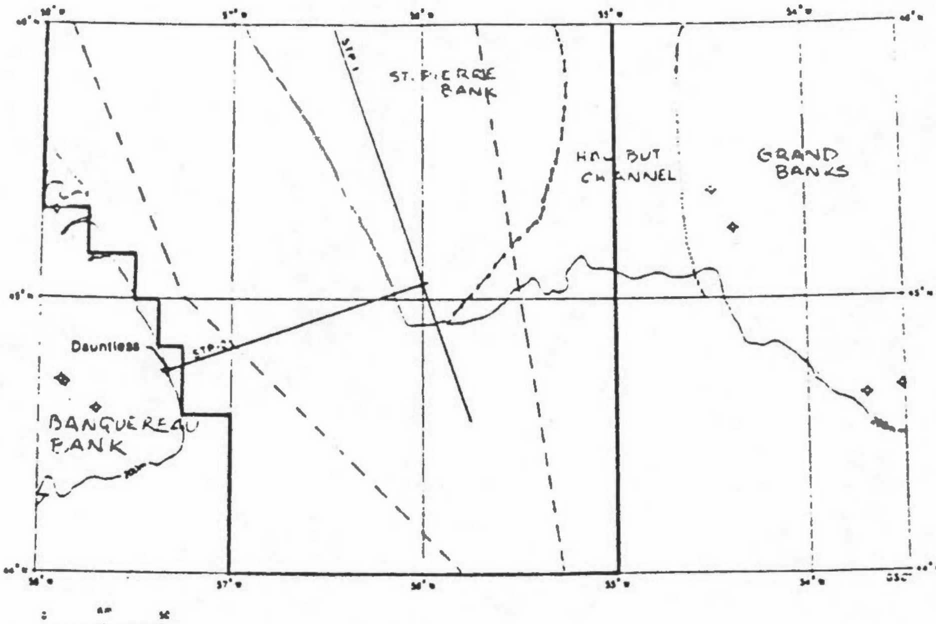
What followed will surely be remembered as one of the classic annals in Canadian marine geophysical exploration. Canada tracked the LUCIEN BEAUFORT and its French naval escort throughout its program using long range Argus patrol aircraft and radio positioning techniques to gain at least a general understanding of the areal extent and scope of the seismic program. The only other seismic data the French had run into the 1967 Moratorium Area were gathered on a scientific cruise of CHARCOT (Auzende et al., 1970) that had come up along the southwest side of Grand Bank. (Figure 24).

Canada then ran a three-part seismic program of its own inside the Moratorium Area. In March of 1984, a two-week long, 294 km program was shot (Figure 27, top) using GSI's vessel M/V FREDERICK J. AGNICH (Geophysical Services Incorporated, 1984a;b). Then the next year an extensive program was funded which ran from July 31 to September 14, 1985 from the M/V WESTERN VIKING (Figure 27, middle). This program gathered 2500 km of deep seismic data (Western Geophysical Company of Canada, 1986?; 1986). The 1984 and 1985 programs were funded under the Bilateral Boundary Studies Programme (Buxton, 1987).

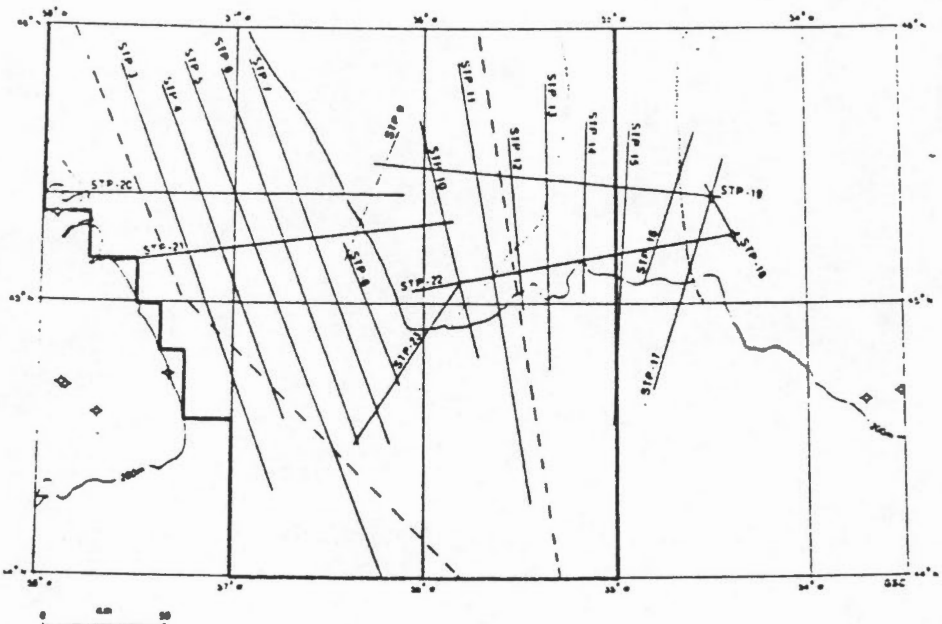
Finally, the following year a third, short, deep seismic program was run by GSI from the F.J. AGNICH in late September to early October, 1986 (Geophysical Services Incorporated/Geophoto Services Limited, 1986). This

Figure 27

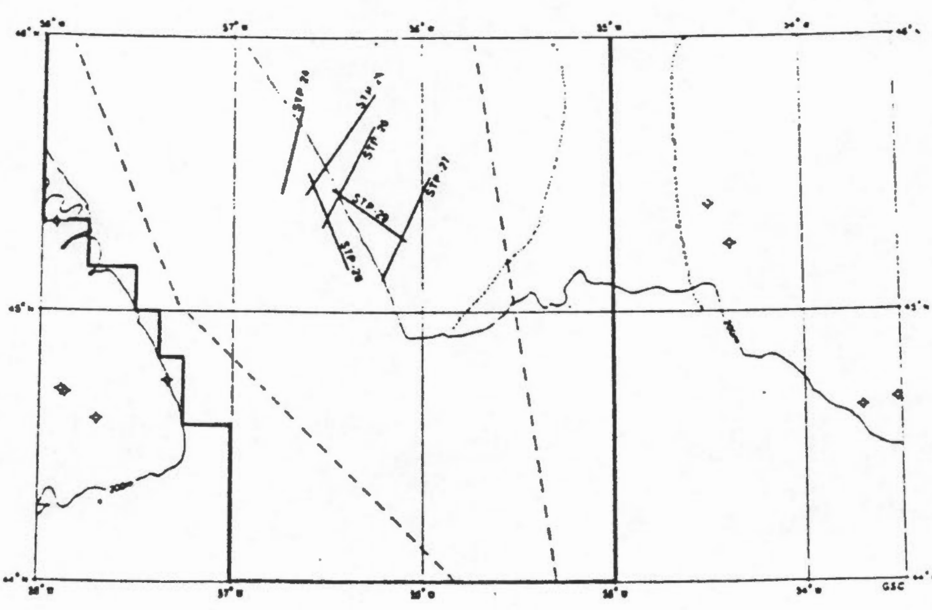
Three-part figure taken from Buxton's (1987) figures 4.6a(top), 4.6b(middle) and 4.6c(bottom). The top figure shows the 1984 Canadian deep seismic program with two reconnaissance lines. The middle map shows the main 1985 program and the bottom map shows the brief 1986 follow up program of six short lines.




1984




1985



1986

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

Deep Reflection Seismic Data (continued)

program ran 260 km of data on six short lines designed to check problem areas defined in the earlier work (Figure 27, bottom); it was processed by the same firm that did the major 1985 program (Western Geophysical Company of Canada, 1987).

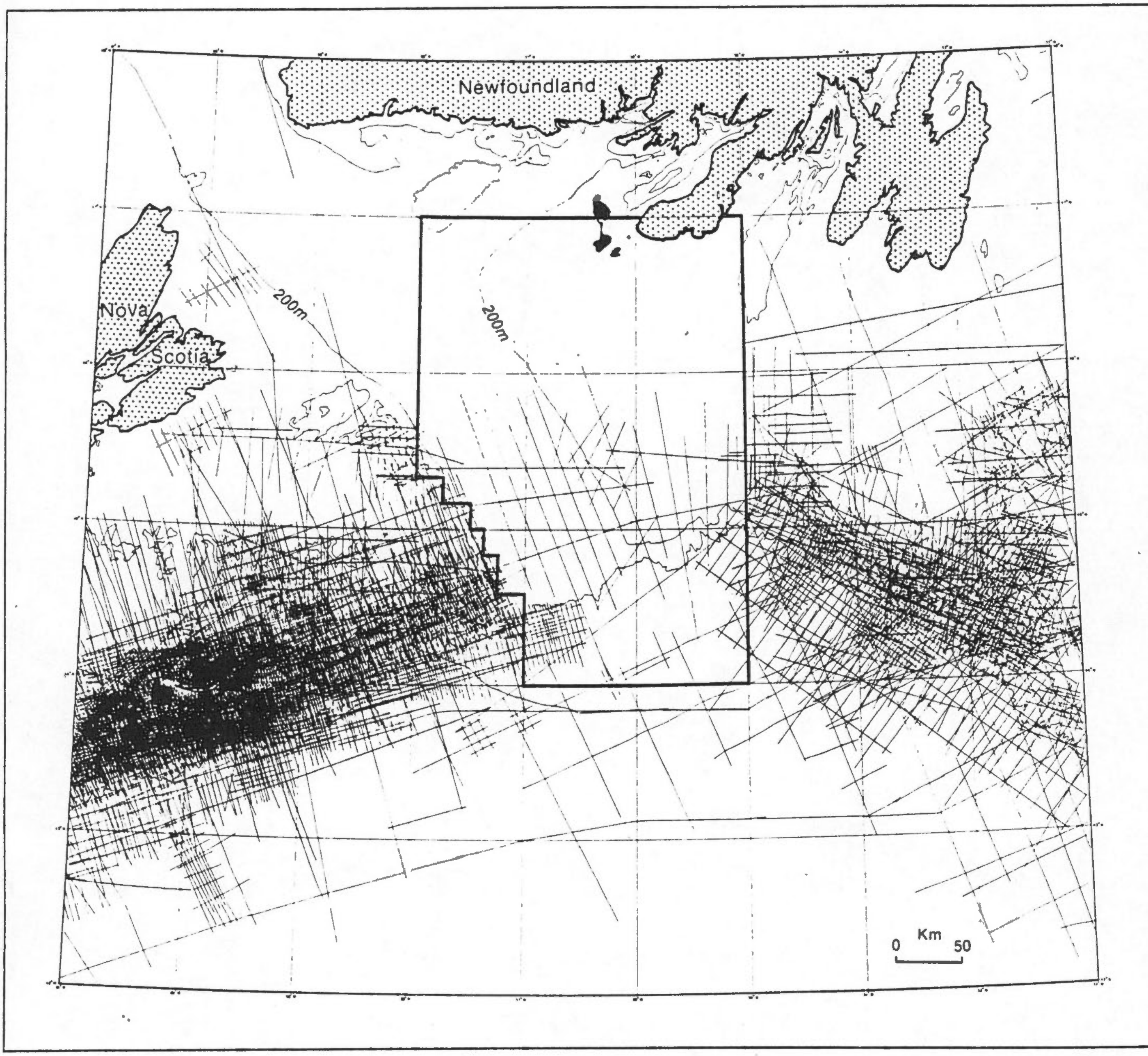
Thus, the present day map of combined seismic coverage (exclusive of the 1983 LUCIEN BEAUFORT lines) is shown on Figure 28. While at best Canada now had a sparse net of regional lines an interpretation could be made of the oil and gas potential. This was done by Bernie MacLean and John Wade (1986) in their May, 1986 preliminary report and in their 1987 more detailed follow up report (MacLean and Wade, 1987). Their report shows that the southern part of St. Pierre Bank has structures similar to those seen around Sable Island, thus the area has a reasonable potential for significant gas and some oil discoveries once wells can be drilled.

High Resolution Seismic and Sidescan Sonar Data

In some respects, these data have been covered in the earlier section on surficial geology. The index maps of Figures 7 to 10 and that of the 1985 BAFFIN cruise as part of the Bilateral Boundary Studies Programme (Figure 11, bottom) reflect as well the high resolution seismic profiling and sidescan sonar track coverage. Outside of Ruffman and Wilson's report (1987) none of the other earlier reports show index maps of just the high resolution seismic and sidescan coverage so it is difficult to separate these data out.

Figure 28

Combined index map to deep seismic reflection lines in the study area. The 1983 LUCIEN BEAUFORT lines gathered by the French are not shown (and it appears that the CALGARY CATALINA participation line running to the northwest out of the Moratorium Area is not shown as it is on Figure 25).


Newfoundland
Nova
Scotia
200m
200m
0 Km 50

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

High Resolution Seismic and Sidescan Sonar Data (continued)

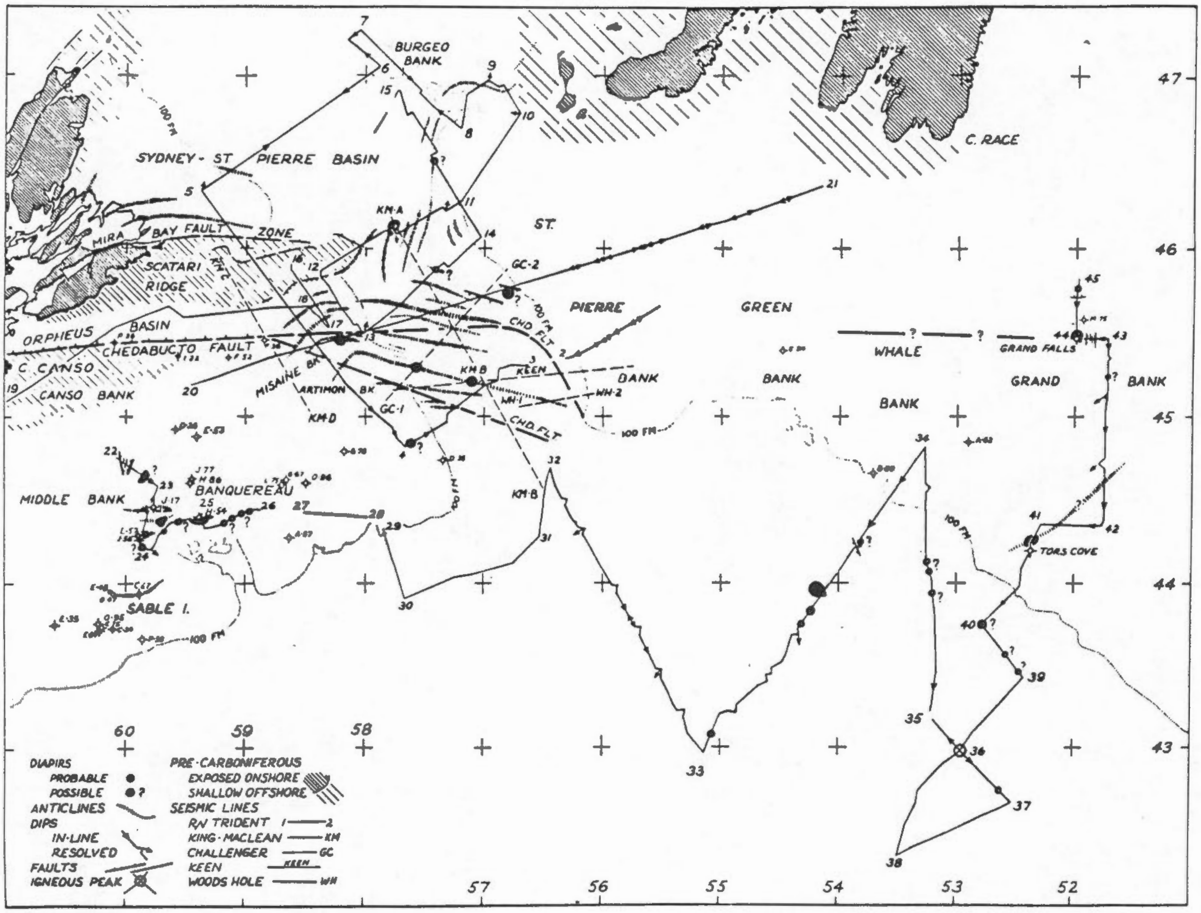
Suffice to say that Lewis H. King and his colleagues at BIO and the Dalhousie Institute of Oceanography began using the early EG&G sparkers as soon as they were available in the early 1960's. Bedford Institute graduated into airguns and various Huntec deep-towed, high-resolution profiling tools while Dalhousie's ongoing seismic profiling interest has been channelled into a deep-towed chirp sonar device.

There was early high-resolution sub-bottom profiling interest from Gregory Webb of the University of Massachusetts in the Scotian Shelf and Laurentian Channel (Figure 29). Webb mapped numerous diapir-like structures in the bedrock but took little interest in the overlying sedimentary section (Webb, 1973). Other lines of high resolution seismic data were collected in the study area by ships of opportunity such as the JOIDES vessel GLOMAR CHALLENGER in 1970 (Ruffman, 1972). Earth and Ocean Research Ltd. (1986) has done a major indexing of high resolution seismic and related bottom sampling data available on the Scotian Shelf in their 1986 Environmental Studies Revolving Fund report.

Since 1975, Canada has had a number of private marine geophysical survey firms that thrived on the 1978-84 revival of drilling and on the discoveries such as Venture gas at Sable Island and Hibernia oil on the Grand Banks. These firms supplanted the American, French and British firms that had worked on Canada's offshore prior to 1978. Each of the exploration wells drilled on Canada's offshore since 1977 has had some sort of a wellsite survey done before drilling approval was granted and Canadian

Figure 29

Gregory Webb's (1973) index map to the University of Rhode Island's R/V TRIDENT Cruise 73 in 1969, lines 1-19; Cruise 41 in 1967, lines 20-21; and Cruise 84 in 1976 (lines 22-45). The 1970 GLOMAR CHALLENGER airgun line is labled GC1-GC2. A Woods Hole Oceanographic Institution profiling line is labled WH1-WH2. Well locations are to January, 1972.


BURGEO BANK
SYDNEY - ST PIERRE BASIN
MIRA BAY FAULT ZONE
SCATARI RIDGE
ORPHEUS BASIN
CHEDABUCTO FAULT
C. CANSO
CANSO BANK
MISAINE BK
ARTIMON BK
ST. PIERRE BANK
GREEN BANK
WHALE BANK
GRAND BANK
GRAND FALLS
TORS COVE
C. RACE
MIDDLE BANK
BANQUEREAU
SABLE I.
CHD FLT
100 FM
KM-A
KM-B
KM-D
GC-1
GC-2
WH-1
WH-2
KEEN
47
46
45
44
43
60
59
58
57
56
55
54
53
52
DIAPIRS
PROBABLE
POSSIBLE
ANTICLINES
DIPS
IN-LINE
RESOLVED
FAULTS
IGNEOUS PEAK
PRE-CARBONIFEROUS
EXPOSED ONSHORE
SHALLOW OFFSHORE
SEISMIC LINES
R/V TRIDENT
KING-MACLEAN
CHALLENGER
KEEN
WOODS HOLE

MAPPING OF GEOPHYSICAL PARAMETERS (continued)

High Resolution Seismic and Sidescan Sonar Data (continued)

firms are now doing all of these surveys. High resolution digital seismic data is often prescribed on such surveys. In the study area, wellsite surveys have been run on drilling sites off the north end of Cape Breton Island, on Sable Island Bank, on Banquereau, on the Scotian Slope and on the continental slope just east of the Moratorium Area (Earth and Ocean Research, 1986).

The continental slope and rise off the study area has been mapped with various high resolution profiling tools (Hughes Clarke, 1988) and was mapped by the GLORIA swath mapper (Masson et al., 1985) on the DISCOVERY III cruise (Figure 30).

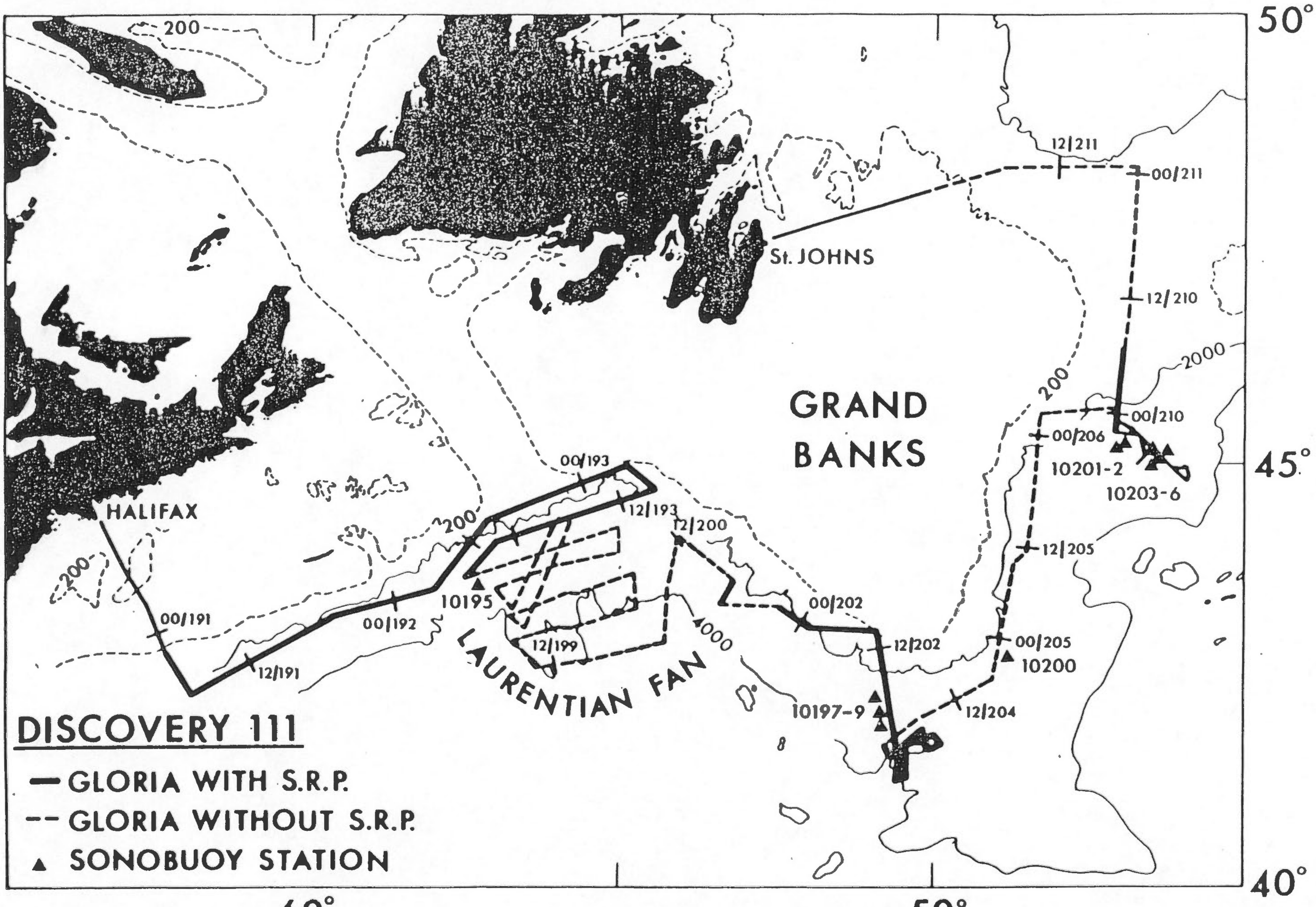
CONSLUSION

Canada's history of geological and geophysical investigations in the study area reflects the country's growth in the marine science field, over and above the nation's eighty-year hydrographic concern. The history outlined in the earlier pages tracks Canada's maturing over a brief 35-year marine science history. Canada made a conscious decision in the early 1960's to enter into the ocean research field by setting up the Bedford Institute of Oceanography and by supporting a vigorous University participation in the marine field.

While no production of either oil or minerals has yet been realized from the offshore (outside of sand and gravel) in fact, Canada has

Figure 30

Index map to the track of R/V DISCOVERY's Cruise 111 showing the survey tracks of GLORIA swath mapping data gathered on the continental slope and rise in the area of the 1929 earthquake and turbidity current. (Masson *et al.*, 1985)



50°
45°
40°
60°
50°
200
12/211
00/211
St. JOHNS
12/210
2000
200
GRAND
BANKS
00/210
00/206
10201-2
10203-6
00/193
12/193
HALIFAX
200
12/200
12/205
200
10195
00/202
00/191
00/192
4000
12/202
00/205
12/199
10200
12/191
LAURENTIAN FAN
10197-9
12/204
DISCOVERY 111
GLORIA WITH S.R.P.
GLORIA WITHOUT S.R.P.
SONOBUOY STATION

CONCLUSION (continued)

developed a very respectible understanding of the geology of its oceanic margins. This same statement applies to the study area despite the limitations of the Moratorium Area.

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## Appendix 1

Portion of the secret (geheim) Ubootshandbuch der Ostkuste Kanada (Atlas) produced by the Oberkommando der Kriegsmarine (1942a;b) for the use of U-Boat commanders in the Atlantic. Two surficial geological maps of the seafloor south of Newfoundland.

Prüf=Nr. 843



Geheim!

# Ubootshandbuch
der
# Ostküste Kanadas
(Atlas)

Berlin 1942

Herausgegeben vom Oberkommando der Kriegsmarine

M. Dv. Nr. 299, Atlas

# Inhaltsübersicht

# BÄNKE
## SÜDLICH VON
# NEUFUNDLAND

## Erläuterungen zur Grundbeschaffenheitskarte 19

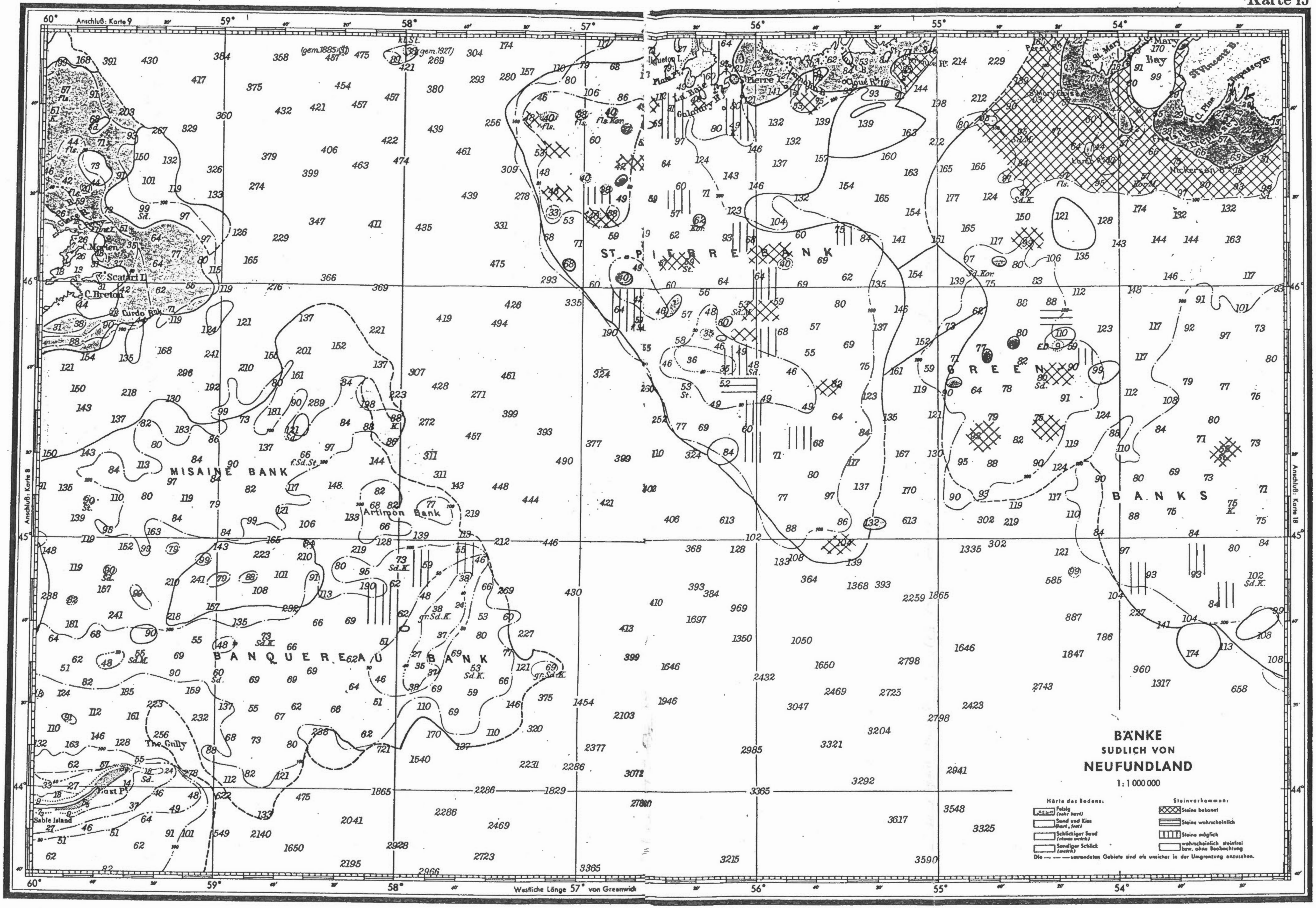
Der Boden der *Green Banks* hat vorwiegend grobsandige Ablagerungen. Schlickinseln sind über das ganze Gebiet verstreut, auch vereinzelte felsige Stellen und Steine kommen vor. Felsige Gebiete beschränken sich auf das Vorfeld der Südküste *Neufundlands.*

Die *Green Banks* sind von der *St. Pierre-Bank* durch eine Eintiefung mit Tiefen über 100 m getrennt; hier hat sich weicheres Material abgelagert, das sich nach Norden bis in die *Placentia Bay* fortsetzt (siehe Karte 20).

Die *St. Pierre-Bank* hat ganz ähnliche Bodenverhältnisse wie die *Green Banks,* jedoch ist das Fels- und Steinvorkommen hier häufiger. Unter der Südküste *Neufundlands* bemerkt man wieder den felsigen Boden.

*Misaine-Bank* und *Banquereau-Bank:* Die vorherrschende Bodenablagerung besteht wie bei den Bänken weiter östlich aus festem Sand und Kies. In den Eintiefungen hat sich Schlick angesammelt, im Norden nimmt diese Bodenart ein größeres Gebiet ein. Vor der Ostküste von *Breton* breitet sich felsiger Boden aus (s. Karte 9).

Krt. D. 445, D. 446, D. 447; Brit. 290, 893, 1134, 2727, 2915.


BÄNKE
SUDLICH VON
NEUFUNDLAND
1:1 000 000
Härte des Bodens:
Felsig (sehr hart)
Sand und Kies (hart, fest)
Schlickiger Sand (etwas weich)
Sandiger Schlick (weich)
Steinvorkommen:
Steine bekannt
Steine wahrscheinlich
Steine möglich
wahrscheinlich steinfrei bzw. ohne Beobachtung
Die — — — umrandeten Gebiete sind als unsicher in der Umgrenzung anzusehen.
Anschluß: Karte 9
Anschluß: Karte 8
Anschluß: Karte 18
Westliche Länge 57° von Greenwich
60°
59°
58°
57°
56°
55°
54°
46°
45°
44°
MISAINE BANK
BANQUEREAU BANK
Artimon Bank
ST. PIERRE BANK
GREEN BANKS
The Gully
Sable Island
East Pt.
C. Breton
Scatari I.
St. Mary's Bay
St. Vincent B.
Miquelon I.

## SÜDKÜSTE VON NEUFUNDLAND

# KAP PINE
## BIS
# JACQUES INSEL

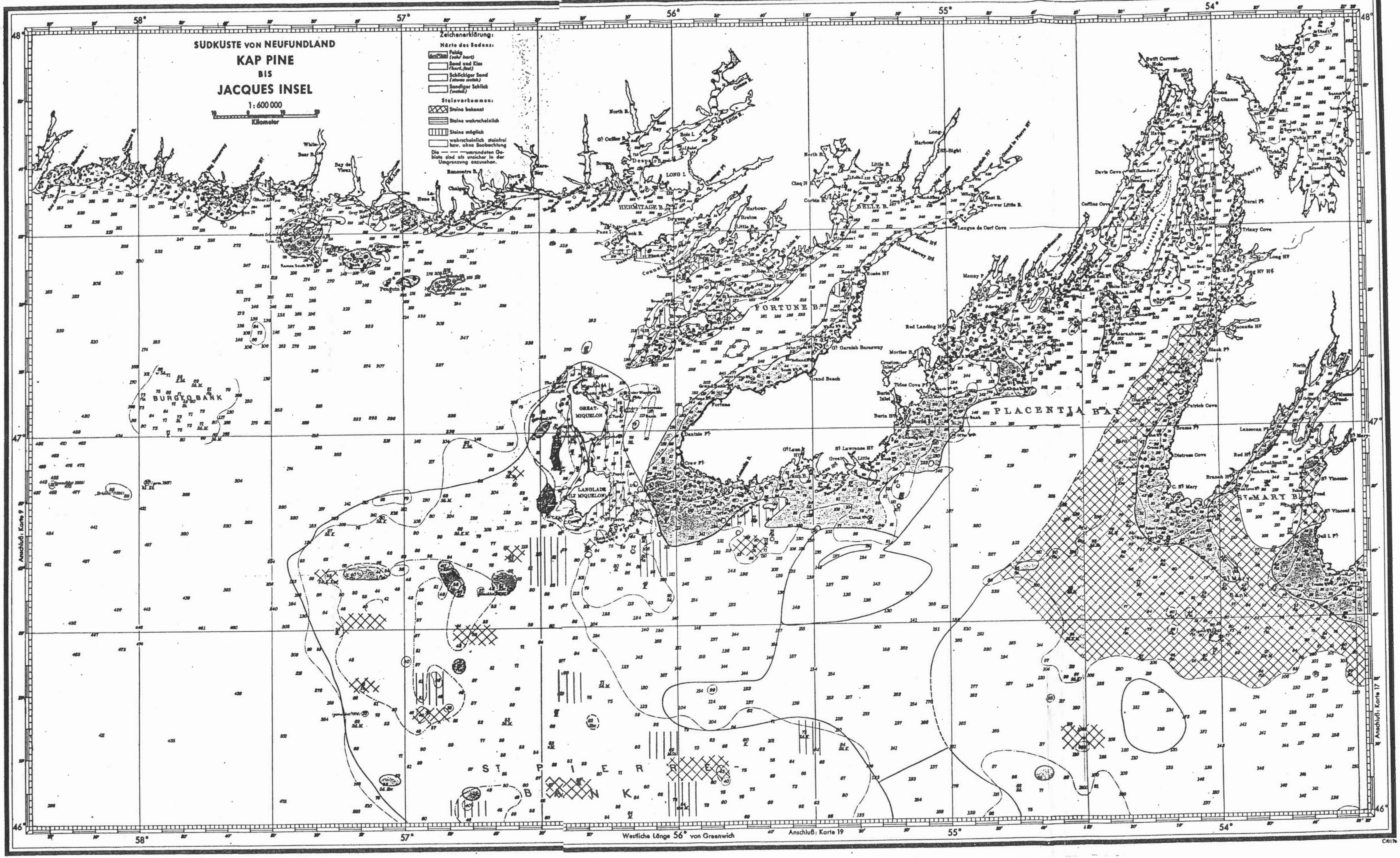
## Erläuterungen zur Grundbeschaffenheitskarte 20

Die Bodenbeschaffenheit der *St. Mary Bay* wird im wesentlichen durch eine Schlickmulde bestimmt. Beiderseits ist der Boden mit Sanden bedeckt.

Weiter westlich folgt wieder felsiger Boden, der bis in die *Placentia Bay* hineinreicht. An ihn grenzt ein Gebiet sandig-fester Ablagerungen mit Steinvorkommen. Die *Placentia Bay* zeichnet sich durch ein ausgedehntes Schlickgebiet aus, das nach Norden bis in die inneren Fjorde hineinreicht und sich andererseits weit seewärts erstreckt, von größeren Flächen schlickigen Sandes unterbrochen. Im westlichen Teil der genannten Bucht beginnt dann aufs neue felsiger Boden, der die Küste des halbinselartigen Landvorsprungs umrandet und in die *Fortune Bay* hinein nach Norden läuft. An den felsigen Boden grenzt ein schmaler Saum aus schlickigem Boden, ähnliche Verhältnisse bestehen an der Westseite der Bucht und vor der *Connaigre Bay*, wo felsige Stellen mit solchen von schlickigen und sandigen Ablagerungen bunt durcheinanderliegen. Im südlichen Seeraum bis zur *St. Pierre-Bank* ist der Meeresboden mit Sanden und Kiesen bedeckt und weist auch verschiedentlich sehr harte Stellen auf. Das gilt weiterhin für die westliche Umgebung der *Miquelon-Inseln*.

Die Südküste von *Neufundland* westlich der *Hermitage Bay* ist am Boden felsig, an einigen Stellen folgt weiter seewärts sandiger Schlick. Bei den der Küste vorgelagerten Inseln und Bänken bemerkt man ebenfalls sehr harten Boden.

Krt. D. 445, 446; Brit. 290, 893, 2141, 2142, 2143, 2915.


SÜDKÜSTE von NEUFUNDLAND
KAP PINE
BIS
JACQUES INSEL
1:600 000
Kilometer
Zeichenerklärung:
Härte des Bodens:
Felsig (sehr hart)
Sand und Kies (hart, fest)
Schlickiger Sand (etwas weich)
Sandiger Schlick (weich)
Steinvorkommen:
Steine bekannt
Steine wahrscheinlich
Steine möglich
wahrscheinlich steinfrei bzw. ohne Beobachtung
Die — — — umrandeten Gebiete sind als unsicher in der Umgrenzung anzusehen.
58°
57°
56°
55°
54°
48°
47°
46°
Westliche Länge 56° von Greenwich
Anschluß: Karte 19
Anschluß: Karte 9
Anschluß: Karte 17
BURGEO BANK
HERMITAGE B.
LONG I.
FORTUNE B.
PLACENTIA BAY
ST. MARY B.
GREAT MIQUELON
LANGLADE (L. MIQUELON)
ST. PIERRE BANK
Bay de Vieux
Rencontre B.
Chaleur
La Hune B.
White Bear B.
North B.
Connaigre
Grand Beach
Fortune
Dantzic Pt.
Crow Pt.
St. Lawrence Hr.
Burin Hr.
Red Landing Hr.
Mortier B.
Long Harbour
Langue de Cerf Cove
Swift Current
Come by Chance
Davis Cove
Coffins Cove
Trinny Cove
Long Hr.
Placentia Hr.
Black Pt.
Patrick Cove
Distress Cove
C. St. Mary
Branch Hr.
St. Vincent
Red Hd.
Lancecan Pt.