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Marine Geology Studies on the Scotlan Shelf and Slope

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RECENT SEDIMENT STUDIES

Marine Geology Studies on the Scotian Shelf and Slope

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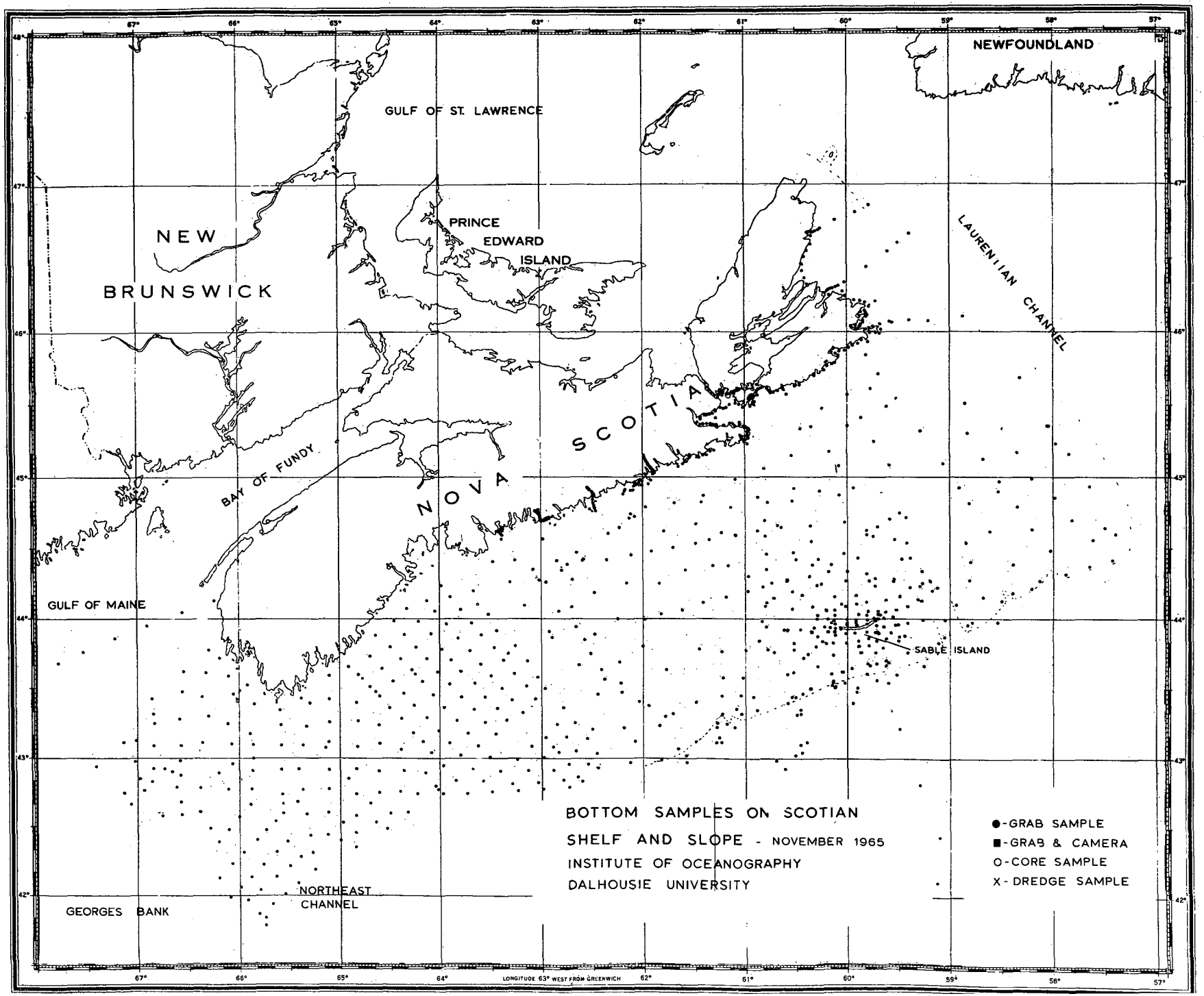
Introduction

Marine geologists at the INSTITUTE OF OCEANOGRAPHY, DALHOUSIE UNIVERSITY have been engaged during the past 5 years in a comprehensive submarine geology study of the Continental Shelf and Slope off Nova Scotia. This long term program, being conducted by staff members and graduate students (in the form of M.Sc. and Ph.D. theses), contributes to our knowledge of this still poorly known portion of the continental margin. The kind co-operation and support of the DEPARTMENT OF GEOLOGY, DALHOUSIE UNIVERSITY and of the BEDFORD INSTITUTE OF OCEANOGRAPHY, Dartmouth, N. S. has made this project possible.

The Nova Scotian Continental Shelf covers an area of approximately 50,000 square nautical miles. It is almost 60 miles at its southern extremity near the Northeast Channel; the Scotian widens toward the northeast along its 400 mile length to about 120 miles at the Laurentian Channel. Large, deep basins and linear troughs with depths exceeding 200 fathoms are present on the Shelf proper. Shoal banks are also common, and one emergent point, Sable Island, is located on the outermost part of the Shelf. The steep Slope and the Rise includes numerous channel-like depressions, and one particularly deep canyon, the Gully, located a few miles east of Sable Island.

Studies initiated by D. J. G. NOTA at the Institute, now at the LABORATORIUM VOOR GEOLOGIE, Wageningen, The Netherlands, included investigations of the pebbles (Grant, 1963) and heavy minerals (Nolan, 1963) in the tills along the coast and beaches of Nova Scotia. These coastal studies are providing us with useful information as to the source of sediments and the role of ice transport on this continental margin. Geophysical studies carried out concurrently in the DEPARTMENT OF PHYSICS and I. O. DAL. are continuing to supplement studies of the bottom topography and of the sediment distribution. These geophysical studies, particularly sparker surveys, serve as an essential base for this project (see, for example Barrett and others, 1964; Blanchard and others, 1965).

Numerous bottom samples (nearly 1000 grabs and short cores), as well as bottom photographs and depth profiles have been collected by I. O. DAL. during the past 5 years and are now being interpreted in graduate student theses and various research projects of the staff. The station locations are shown on the chart accompanying this text. Studies include those of Pezzetta (1962) and Drapeau (this report) on the western portion of the shelf, and those of Cok and of Grant


NEWFOUNDLAND
GULF OF ST. LAWRENCE
PRINCE
EDWARD
ISLAND
NEW
BRUNSWICK
LAURENTIAN CHANNEL
NOVA SCOTIA
BAY OF FUNDY
GULF OF MAINE
SABLE ISLAND
NORTHEAST
CHANNEL
GEORGES BANK
BOTTOM SAMPLES ON SCOTIAN
SHELF AND SLOPE - NOVEMBER 1965
INSTITUTE OF OCEANOGRAPHY
DALHOUSIE UNIVERSITY
●-GRAB SAMPLE
■-GRAB & CAMERA
O-CORE SAMPLE
X-DREDGE SAMPLE
LONGITUDE 63° WEST FROM GREENWICH

(this report) on the eastern portion of the Shelf. A review of the work to date is being reported upon at the 1965 annual meeting of the GEOLOGICAL SOCIETY OF AMERICA (Stanley and Cok, 1965).

We are now in the process of completing the first phase of the project which enables us to understand what is on the Shelf. Graduate theses and research projects currently being initiated and co-ordinated by D. J. STANLEY and D. J. P. SWIFT are concerned with solving more specific and "dynamic"-type problems in key areas of the Shelf and Slope. In this second phase of the Scotian program, most of the studies pertain to interpreting the various types of sediment transport processes, relict and presently active (examples are outlined in this report by James, Medioli, Silverberg and Stanley). The results of several investigations are now being prepared for publication. STANLEY expects to co-ordinate these Scotian studies with comparable ones undertaken south of Nova Scotia by the WOODS HOLE OCEANOGRAPHIC INSTITUTION (under the direction of K. O. EMERY and the U. S. GEOLOGICAL SURVEY).

Northeast Portion of the Scotian Shelf

ANTHONY E. COK has been studying the northeastern portion of the Scotian Shelf since 1961. The purpose of this study is to determine the origin and mode of dispersal of surface sediments from the Halifax area to the Cabot Strait. This relatively unknown portion of the Shelf has only recently been adequately sounded (Canadian Hydrographic Service Fisheries Chart 4040). In addition to charts, sounding data collected by A. E. COK served to aid the geological and morphological investigations on the Shelf.

The general morphology of the northeastern Scotian Shelf is complex. Areas of pronounced relief alternate with areas of smooth relatively featureless surfaces. The Shelf within a distance of 20 kilometers of land exhibits 'Ria'-like structures which reflect the embayed nature of the coastline. These structures gradually disappear seaward under a relatively thin mantle of flat lying sediments.

The central portion of the northeastern shelf is characterized by greater relief. Most topographic features in this central portion lie at a depth of 90 meters or more; depths as great as 400 meters are encountered. These highly dissected zones are elongate and parallel structural trends on the continent and may be directly related to these trends.

The outermost shelf is dominated by two large relatively featureless banks: Sable and Banquereau banks which are separated by a large canyon, the Gully, cutting into the Shelf. The northeast Shelf may be contrasted to the southwestern portion of the Shelf which is dominated by smaller banks and large smooth basins.

In addition to the sounding data, at least 600 bottom samples have been collected both on the open shelf and in the coastal environments. These sediments collected, during five cruises, have been examined petrologically. Color determinations, textural and

mineralogic and heavy mineral studies are now complete. In addition, unusual components of the sediment such as glauconite, nodules, coal fragments, and iron-stained grain groups have been investigated.

The sediments of the northeastern Shelf are not easily related to those found on mainland Nova Scotia. Both resistant and relatively non-resistant heavy mineral species differ between the coast and outer Shelf. While the unconsolidated sediments on the mainland are almost exclusively of Pleistocene origin, there is an indication that sediments and structures of Tertiary age are locally exposed on the open Shelf. Textural studies also point to a recent important influx of sediments via current and ice rafting agencies from the Gulf of St. Lawrence area. These sediments are slowly being deposited as a thin veneer over much of the eastermost Scotian Shelf. A synthesis of the data presently at hand is expected to be available in the coming spring in the form of a Ph.D. thesis. D. GRANT, presently with the GEOLOGICAL SURVEY OF CANADA, will continue to work on cores and samples of the Cape Breton Shelf and Laurentian Channel, (Ph.D. thesis) upon his return to I. O. DAL. later this year.

Southwest Portion of the Scotian Shelf

GEORGES DRAPEAU is presently studying the southwestern section of the Scotian Shelf. The purpose of this study is to determine the origin and evolution of this portion of the Shelf. Most previous hypotheses suggest an essentially glacial origin.

Over 200 bottom samples (grabs and cores) have already been collected. They should provide adequate information as to the sediment distribution and relation to morphological features in this area. Large scale Canadian Hydrographic Survey charts provide the accurate bathymetric information needed for such an investigation.

The present study deals mainly with granulometry, provenance and dispersal of sediments. A Rapid Sediment Analyser, similar to the model developed at the WOODS HOLE OCEANOGRAPHIC INSTITUTION, greatly facilitates the size analysis of the sands. A digital computer (IBM Fortran II) program is being worked out to study the grain-size distribution of the sediments. Once the computer program is complete, it will be possible to compare the numerous textural and mineralogical parameters with environmental parameters systematically ("closeness of fit", etc.).

Provenance and dispersal of the shelf sediments is being interpreted, in part, by means of a pebble lithology and heavy mineral study. The pebble lithology of the tills of Nova Scotia has already been studied (Grant, 1963) and the heavy minerals of the Atlantic shore analyzed (Nolan, 1963). The distribution of pebbles and heavies on the mainland and coast will be compared with those on the Shelf.

A continuous reflection profiling survey (Sparker type) is providing a third dimension to this study. These records will be correlated with the sediment and morphological studies. Bottom

photographs, dredgings, and additional cores will be collected at key positions in future cruises in order to obtain more information on the influence of current and wave transport. As some aspects of the microfauna contained in these sediments are unusual, fossil studies are also being carried out.

Sable Island and Sable Island Bank

NOEL P. JAMES commenced a study of Sable Island Bank and Sable Island proper in the spring of this year. This region is located approximately 160 miles southeast of Halifax at a position 44 00 North by 60 00 West (See the chart). This study was initiated because of Sable Island's unique position as one of the only known emergent points on an outer shelf located so far from the mainland. A study of this point will undoubtedly provide some valuable information as to the sedimentologic and stratigraphic history of this part of the Scotian Shelf. Many of the sediments in this area are of relict glacial, fluvial, and wind-blown origin. At present, Sable Island, as a source of sediments, is also affecting sedimentation of the surrounding Sable Island Bank. The immediate purpose of this study is a dynamic one, that is, to find out to what degree, and how, these relict sediments are presently being reworked and what is their direction of transport in the vicinity of the island and the adjacent submarine canyon known as the Gully.

A sample net was set up on the bank using Sable Island as a base. Samples were collected in a circular pattern with the distance spacing between these concentric circles being logarithmic and increasing away from the island. A total of 114 samples were obtained during the I. O. DAL. May'65 cruise on CNAV SACKVILLE (collected from the ship and from a small motor cutter located by radar from the ship). A VanVeen type grab sampler was used at most stations but a few Phleger cores were also obtained. Bottom photographs were taken with an Edgerton underwater camera on about 30% of the stations.

Initial results confirm that bottom sediments of the bank are composed mainly of sand, although local variations are present. Pebbles are concentrated in depressions and along the shelf edge indicating that the primary depositional mechanism is not the same as the one active at present. Detailed textural and mineralogical data is expected to shed more light on the type and movement of these sediments; this will be supplemented by faunal studies on the same samples (see Microfaunal section later in this report). Bottom photographs indicated that the sand is being reworked by abundant bottom living organisms. Directional data recorded from these photos is also providing information as to bottom current directions and intensities.

Three weeks were spent on Sable Island in order to sample, to investigate the morphology and to complete a sediment facies map of the island. The island was also rigourously sampled on a grid pattern so that representative samples from all environments (foreshore, beach, berm, back-beach, dunes, etc.) could be analyzed. A total of 150 samples were collected. The presence of a peaty paleosol, recognized as early as 1899 by MACOUN was confirmed and the sands above

and below as well as the paleosal were sampled. The age of the paleosal is being determined by C^{14} data. Mineralogical data indicates that the sands below (probably Pleistocene wind-blown sands) and above the paleosol differ somewhat mineralogically (Medioli, Stanley, James, in press).

The persistance of Sable Island seems to be due, in large part, to the resistant properties of the paleosol. The influence of currents on the on the island is not yet clear but wind and wave data indicates that the greatest attack is from the west and southwest, moving sediment to the northeast, and "piling" heavy mineral concentrations on the southern part of the island. Preliminary studies indicated that the island may not be moving toward the East as recently reported (Grosvenor, 1965). Wind and wave attack are actively eroding the west and south portions more rapidly reducing the dunes on this portion of the island. This shortning on the west makes it appear that there is a net eastward movement. This illusion is enhanced by the continued and periodic shifting of the bars at both extremities of the island.

Slope Studies

NORMAN SILVERBERG, presently at the UNIVERSITY OF WASHINGTON, has examined a section of the continental slope off Sable Island Bank. A bathymetric chart was compiled from soundings released by the Canadian Hydrographic Service. The slope in this area is dissected by numerous valleys in the region directly adjacent to Sable Island Bank but changes abruptly to a featureless terrain in the region off the southwestern limit of the bank.

During cruises aboard the CSS KAPUSKASING and the CNAV SACKVILLE, a total of 21 piston cores were obtained. Analyses of the sediment cores included visual description, investigation of internal structure through X-radiography, textural analysis, petrographic examination of the coarse fraction, heavy minerals, and clay fraction, and investigation of the distribution of foraminifera.

This reconnaissance study has revealed three sediment types on the continental slope. The sediments are very similar mineralogically and are probably derived from material transported from northern Nova Scotia and the Gulf of St. Lawrence region by glacial processes.

Several periods of sedimentation are indicated on the continental slope. During the height of the Wisconsin lowering of sea level active erosion of the exposed shelf led to the rapid deposition of a sand and pebble-rich, brown mud on the continental slope. Following the rapid rise in sea level, the shelf was submerged, and the abundant supply of sediment wascut off. Slow deposition of fine sand and mud subsequently formed a layer of grey sediment on the slope. Continued removal of fines from the shelf, and increasing bottom currents, produced a gradual increase in the proportion of sand being deposited on the slope. A thin layer of relatively clean sand, found at the surface in many parts of the slope, suggests the intensification of this process in Recent time.

D. J. STANLEY and D. J. P. SWIFT are examining a line of cores collected southeast of Sable Island on the slope, rise and Sohm Abyssal Main. Coarse fraction, heavy mineral, textural and clay analyses are being conducted. A study of the primary sedimentary structures is also underway. The aim of this study is to obtain an understaning of transport processes active in transferring sediments downslope. Problems of source, mass-gravity transport, and stratigraphy are also being considered. This program will be continued and additional cores of the free-falling type are to be collected during the course of this coming year.

Microfauna on the Scotian Shelf and Slope

FRANCO MEDIOLI, formerly at the UNIVERSITY OF PARMA, has recently joined the INSTITUTE of OCEANOGRAPHY and is presently working on microfaunal problems on the Scotian Shelf and Slope. His studies include a survey of the fauna, living or fossil, in this area. This work supplements previous investigations in this zone (Bartlett, 1964; Parker, 1948; Harrington, 1955). F. MEDIOLI is interested in the Pleistocene-Holocene boundary(in SILVERBERG, 1965)and in reworked faunas of this region.

The major project under investigation at this time is one relating fauna to depositional environment and sediment transport in the area of Sable Island. In the course of the Sable Island cruise (CNAV SACKVILLE, May, 1965) mentioned in an earlier section of this report, 124 samples were collected on Sable Island Bank. Many of those are now being studied from the ecological and palaeontological point of view.

Ecological studies around Sable Island are interesting because of Sable's location at the outer edge of the Shelf and its presence on a bank having such regular, well defined morphology. This type of situation is an ideal one for relating fauna with sediments and bathymetry and other environmental parameters. This study is expected to shed light on sediment transport processes in the Sable Island area. From the preliminary studies of these same samples, normally quite poor in fauna, about 100 species of forams and 6 species of ostracods have been determined. A statistical study of the fauna has been initiated and a number of parameters are being considered including the following: a) planktonic/benthonic ratio; b) living/dead ratio; c) arenaceous/calcareous ratio; d) percentages and ratios of diagnostic species and genera. A computer program is being worked out in order to analyze the micropaleontological and sedimentological data systematically and to select the significant data.

A special study of a paleosol horizon on Sable Island has recently been completed and was presented at the INQUA Congress in Denver (Medioli, Stanley and James, in press).

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ORRIN H. PILKEY left the UNIVERSITY OF GEORGIA MARINE INSTITUTE in January 1965 to join the Geology Department and Marine Laboratory of DUKE UNIVERSITY. The Duke University Marine Geology Program was initiated this year and centers around the new research vessel EASTWARD. Marine geologists at Duke are interested in many aspects of recent sedimentation in the Western North Atlantic including deep sea studies. At the present time O. PILKEY is involved in an investigation of several aspects of carbonate sedimentation on the shelf from Virginia to Florida. This fall geologists hope to obtain cores from the Bermuda apron as the initial step in studies of carbonate-bank-flank sedimentation. A student, JOHN LUTERNAUER, is investigating phosphorite distribution in North Carolina shelf sediments. Another student, BOB MORTON, is studying suspended sediment in Narragansett Bay, Rhode Island. GEORGE LYNTS, a new staff member at Duke, will soon begin investigations of benthic foraminifera distribution in near shore sediments of the Beaufort, North Carolina area.

MAURICE SCHWARTZ, Department of Geology, COLUMBIA UNIVERSITY, conducted a series of beach observations along Nova Scotia's east coast during this past summer to determine the pattern of tidal-cycle sedimentation in the littoral zone. Sandy pocket-beaches at Indian Harbour and Smith Cove in Guysborough County, were chosen as field sites because of their minimal shore-drift characteristics and very few visitors.

In the investigation, variously colored fluorescent tracers were injected in depth at locations on the beach profile. In the course of the tidal-cycle a series of samples were taken in sequence along the same profile. These were analysed in increments of depth for grain size and tracer particle distribution. The data collected, supported by profile measurements, is currently being studied. It is anticipated that two papers will be written on the results, one describing the new tracer technique and the other outlining the sedimentation.

BRIAN R. RUST, Department of Geology, OTTAWA UNIVERSITY, has been working with J. P. COAKLEY on sediment cores, water samples, and other data from Stanwell-Fletcher Lake, Somerset Island, N.W.T. Factors affecting past and present sedimentation in the lake will be investigated.

HUGH LILLY, MEMORIAL UNIVERSITY of NEWFOUNDLAND has just returned from studies in the Gulf of St. Lawrence where he has been working on the geoecology of the scallops, lobsters and seaweeds and also having a look at the offshore outcrops. A report on this work will appear in a future number of MARITIME SEDIMENTS.

ROBERT GREGGS, QUEEN's UNIVERSITY, Kingston, has sent the following information concerning recent sediment studies in his department. C. YORATH is working on some Scotian Shelf material for his Ph.D. This study includes examination of Forams, texture, mineral composition, $CaCO_3$, organic carbon, etc. Some 150 snapper samples were collected from a Navy ship this past summer. The project is supported and sponsored by the BEDFORD INSTITUTE OF OCEANOGRAPHY. R. HERZER, working on his B.Sc., is studying the bottom sediments of the Miramichi River in New Brunswick. Bottom samples, current readings, temperature, pH, and bottom echo profiles are being examined. The material was collected while working for the Bedford Institute on the suggestion of G. A. BARTLETT.