Current Research

The Zinc Budget within an Active Glacial Fiord: Preliminary Data by SYED A. ALI, Department of Geology, Rensselaer Polytechnic Institute, Troy, New York, and DAVID C. BURRELL, Institute of Marine Science, University of Alaska, College, Alaska.

Introduction

Over the previous several years, several methods have been developed for the trace determination of zinc and other transitional metals within the marine environment. This report applies this methodology to a partial determination of the zinc budget of an active glacial fiord; namely, Queen Inlet in Glacier Bay, S.E., Alaska (Fig. 1). Queen Inlet is a typical glaciated fiord because it has high rock walls, a receding valley glacier and an outwash fan characterized by braided meltwater streams which join Carroll Glacier through an intertidal zone to the inlet proper.

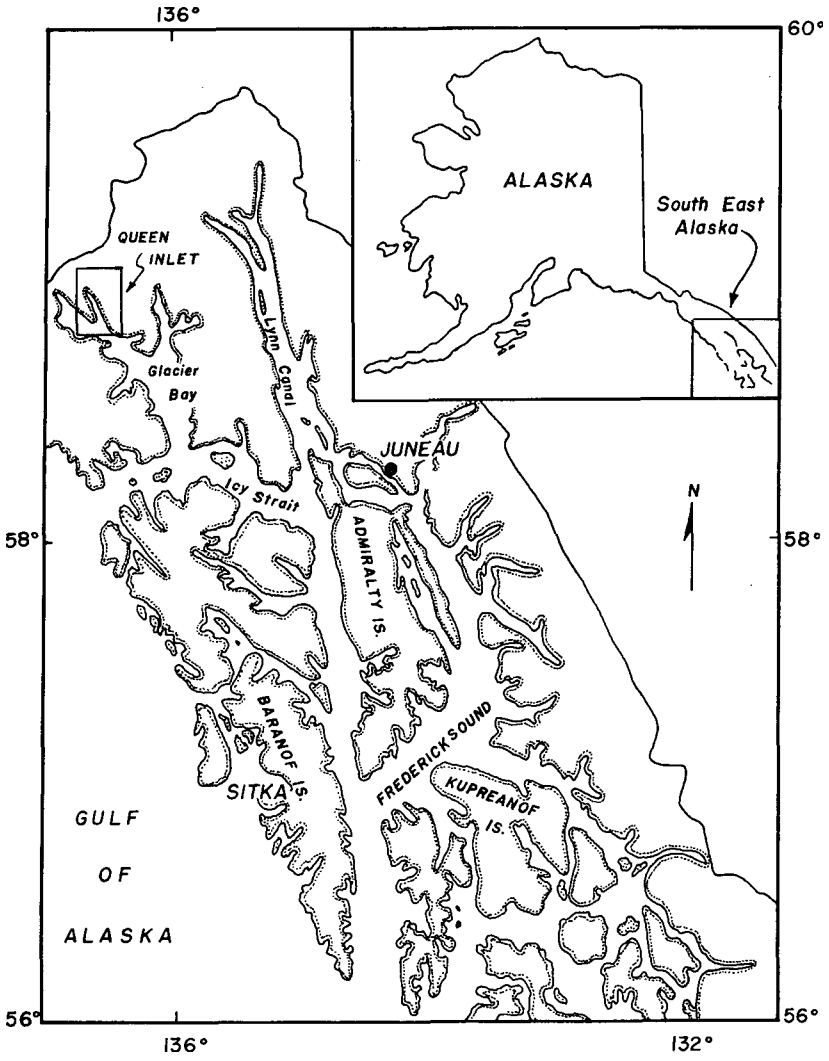

Figure 1: Index map showing location of Queen Inlet within Glacier Bay, South East, Alaska

Sample Locations

Three piston-core samples were collected at Stations 3A, 7 and 8 (Fig. 2) and were subdivided according to the schematic shown in Figure 3. At Station SS samples of a large volume sample of surface marine water and coexisting particulate sediment was taken and at Station TF a specimen of exposed intertidal sediment suspension. In addition, two samples of morainal sediment from immediately adjacent to Carroll Glacier were recovered.

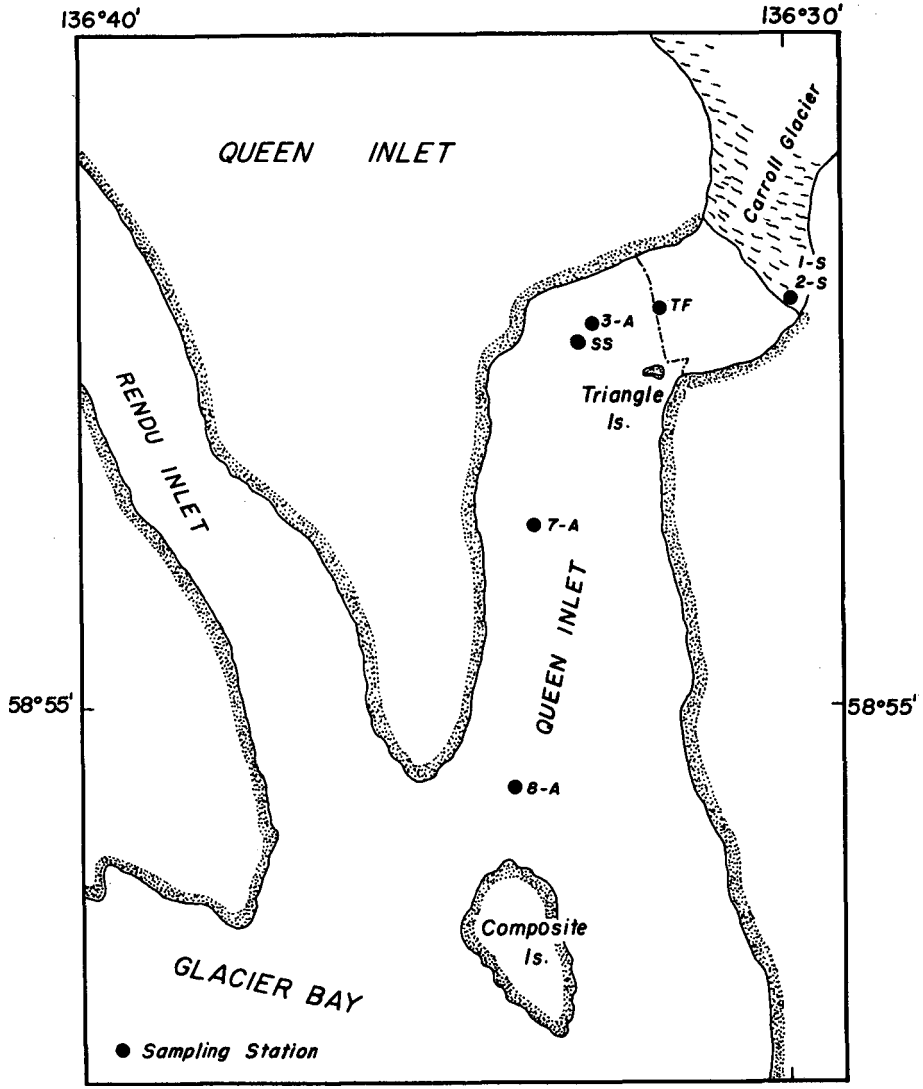

Figure 2: Location of sampling station in Queen Inlet

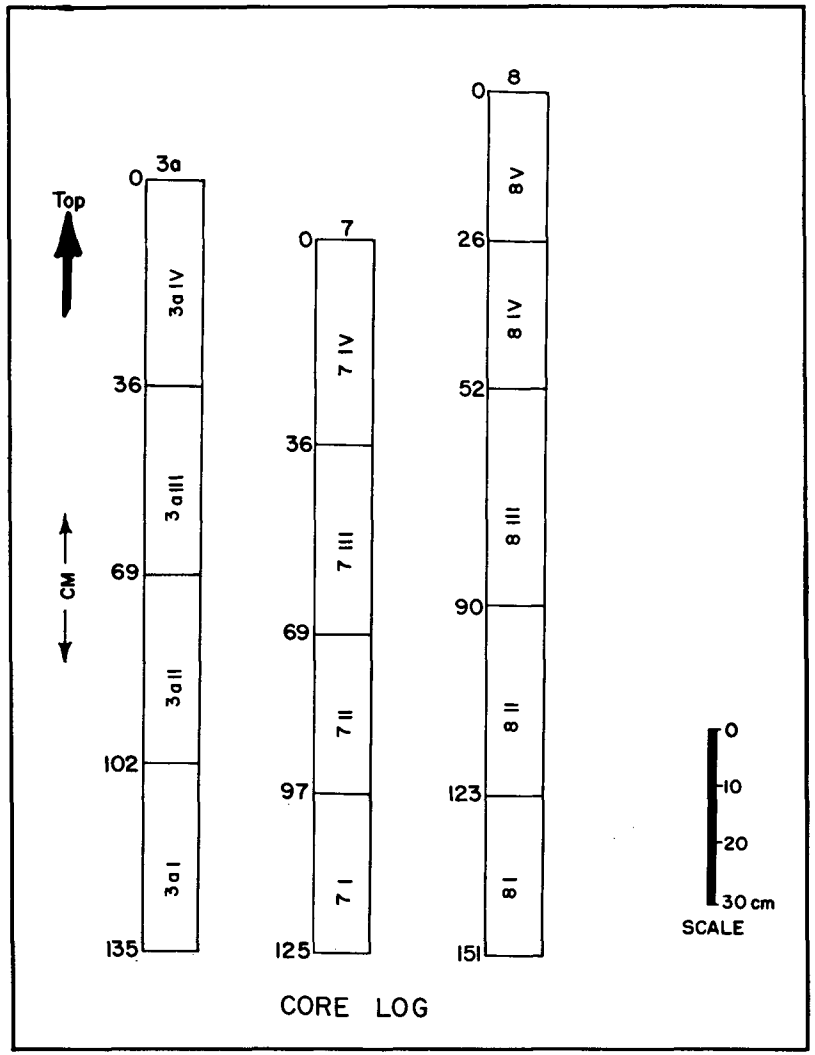

Figure 3: Sample designation for piston cores

Sample Treatment

After core samples were extruded and subdivided, pH measurements were taken. Individual samples were then squeezed to recover interstitial water using a non-metallic gas activated squeezer. Adjacent samples were also retained frozen for later laboratory determination of percent water content. The salinities of the interstitial water samples were determined aboard ship immediately upon recovery. All water and sediment samples were kept frozen following this initial treatment prior to further laboratory examination.

The zinc content of the interstitial water samples was determined using a modified atomic absorption spectrophotometric technique. Following the procedure of Riley and Taylor (1968), the interstitial water zinc were concentrated by passing the samples through a small resin column and acid eluting. The treated samples were then introduced to the spectrophotometer via a syringe pump (Ali and Burrell, 1970). The extractable zinc contents of a series of water samples from the glacial fresh water stream down the fiord were obtained using a chelation-solvent extraction to bring concentrations into a range suitable for atomic absorption analysis (procedure adapted after Brooks et al., 1967). These data were also duplicated using a recently developed direct procedure (Burrell and Wood, 1969), but final results are not currently available. No further discussion of this material is therefore possible at this time.

Two treatments were applied to remove zinc held on weakly bonded sites of the sedimentary material. The conventional ammonium acetate buffered to seawater pH was used to elute this fraction from the sediment and also a cupric acetate solution of the same molality. Cation exchance capacities were determined following the technique outlined in Jackson (1958).

Table I - Sediment and Interstitial Water Major Parameters

Sample No.	Sediment pH	Water Content %	I.W Salinities °/oo
TF	--		
3A IV	7.1		32.3
3A III	--	30.1	
3A II	--	33.0	
3A I	7.1		31.5
7 IV	7.2		31.5
7 III	--	22.4	
7 II	--	27.6	
7 I	7.1		31.4
8 V	--		35.8
8 IV	7.2	36.1	
8 II	--	32.8	
8 I	7.1		31.6

I.W = interstitial water

Table II - Sediment and Interstitial Water Zinc Data

Soluble Zn - ppm; Cation exchange data - m.eg./100 g sediment

Sample	I.W Total Soluble	Sediment Exchangeable Zn		Sediment Cation Exchange Capacity for Zn	
		A	B	A	B
TF	n.d	0.03	0.07	13.1	21.2
SS	-	0.65	1.08	60.5	75.0
3A IV	0.08	0.03	0.08	45.4	68.0
3A I	0.09	0.03	0.10	48.8	83.1
7 IV	0.13	0.05	0.08	30.1	71.5
7 I	0.21	0.03	0.8	39.0	73.0

A = Exchangeable cation data using IN ammonium acetate; B = Exchangeable cation data using IN cupric acetate; n.d. = not determined

Table III - Sediment Size Data

Wt % - ϕ unit intervals

Sediment Type	Interval	TF	SS	3A IV	3A 1	7 IV	7 I
		Sample No.					
	4.0 - 4.5	42.2	13.6	13.0	26.9	13.0	10.0
	4.5 - 5.0	7.35	5.4	1.3	0.5	0.6	0.6
Silt	5.0 - 5.5	13.2	21.3	10.6	11.4	15.4	14.6
	5.5 - 6.0	7.7	18.1	12.9	24.7	10.2	10.9
	6.0 - 6.5	2.4	11.2	13.5	21.1	12.8	15.1
	6.5 - 7.0	1.7	16.1	10.7	1.3	6.4	8.3
	7.0 - 7.5	1.6	4.5	13.7	12.7	27.1	13.1
Clay	8.5 - 11.0	23.9	10.0	24.6	1.6	14.8	27.1

Analytical Results

The mineralogy of the samples was determined to be essentially as found for adjacent areas (see Burrell and O'Brien, 1970). Chlorite predominates over illite. Hornblende and quartz are minor constituents. Size fractionation data are tabulated in Table III. A fuller discussion of the size spectra of Queen Inlet bottom sediments has been given by Hoskin and Burrell (1968).

Salinities, pH values and percent water contents of the core samples are given in Table 1 and soluble zinc contents of the core interstitial water in Table II. The values obtained in exchangeable zinc contents by the two procedures are also shown in Table II.

A standard pipette analysis to fractionate the silt-clay sized sediment was also performed, and the mineralogy of both bulk samples and of the clay sized fraction was determined by X-ray defraction analysis.

Discussion

This project is still very incomplete and the data presented here only preliminary. No significant conclusions are therefore possible at this time. Of some interest however, are the results obtained for the cation exchange experiments. It should be noted that exchange capacities obtained by saturating exchange sites with a transition metal are considerably higher than when the conventional alkali metal is used. It is apparent that the term "exchangeable ion" has a very different meaning for the alkali and alkaline earth ions as compared with, for example, the complex transition metal ions. An analysis of completed program will be presented at a later date.

Acknowledgements

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Marine Geological Research, Bedford Institute, Dartmouth, Nova Scotia by B.R. PELLETIER.

This research is presently carried out under two broad objectives: 1) resources development dealing mainly with bedrock studies in which geological and geophysical surveys are undertaken, and (2) dynamic and environmental studies involving geochemical, micropaleontological, biological, sedimentological and hydrodynamic investigations. The projects include field and laboratory research, and are supported by developmental work on new technology and methodology. A summary according to scientific disciplines together with a listing of the projects, principal investigators and a statement of objectives follows.

Regional geological projects on the Scotian Shelf and adjacent areas including the Bay of Fundy, Gulf of Maine and Grand Banks by L.H. KING:

This work is being carried out by project leader L.H. King who is assisted by B. MacLean and G. Fader. Objectives of the project are as follows: to map the distribution of bedrock units and report on all aspects of the surface and sub-surface geology within the map-area; to prepare isopach, structural contour, and convergence maps within the map area; to map geomorphic and paleo-geomorphic surfaces showing topography, drainage and other related features; to prepare geological sections using processed seismic-reflection records, and other geological and geophysical data; to complete 1:1,000,000-scale maps where they overlap offshore areas; to delineate the distribution of surficial sediments, and to provide the Quaternary geological history, and to publish on certain geological aspects of broad interest involving geological principles and processes, unique discoveries, and discoveries of economic interest. Results of this work are numerous. They provide an inventory of the offshore resources which can be utilized by government and private agencies participating in the development of Canada's offshore resources, and contribute to our knowledge of the geological nature and framework of the continental margin which can be used by the scientific community and industry. They are used by fishermen for bottom roughness information; by engineers for plowing submarine cables, anchoring drilling platforms, designing production towers, planning pipeline routes, and planning for pollution problems. These results also provide an inventory of unconsolidated deposits on the continental shelf and therefore can assist entrepreneurs in the search for mineral placer deposits, as well as aid the marine biologist undertaking fisheries research.

Regional geological studies of Northumberland Strait, western Gulf of St. Lawrence by KATE KRANCK:

The objective of this study is to produce a surficial geology map of Northumberland Strait. Marine scientists such as biologists, environmental workers, fishermen, and marine construction engineers and exploration geologists will be the chief users of the results of this study.

Regional geological studies of the Canadian continental marine bordering the Labrador Sea including the area between Davis Strait and Flemish Cap as well as Hudson Strait by A.C. GRANT:

The main objectives of this study are as follows: to delineate the regional geology by means of seismic reflection, magnetic reconnaissance, geological sampling and interpretation of bottom photographs; to determine the geological structure in detail of certain critical areas such as Flemish Cap, Orphan Knoll and Hudson Strait; to determine the seaward extent of Paleozoic strata underlying coastal plain sediments; to establish the continuity and correlation of velocity interfaces indicated by seismic refraction results by means of "industry-quality" digital recording techniques; and to determine the extent to which the half-graben structure of Hudson Strait may have affected the depositional and structural development of the continental margin to the east. Principal users of the information from these studies will be the oil companies and the scientific community.

Regional geology of the Gulf of St. Lawrence by I.M. HARRIS:

This study is aimed at elucidation of the geology of the sub-sea bedrock units of the Gulf, but will not include Quaternary geology. The work is presently being initiated and will commence with a short drilling program in November, 1971 and a compilation of previous studies in order to organize a major project for 1972. The work will be of direct value to exploration firms and the scientific community.

Sedimentological and hydrodynamic studies

These projects include the complete spectrum of erosion, sedimentation and associated hydrodynamic vigour in areas from the shore zone across the shelf and slope, to the deep basins. These studies involve sediment sampling, oceanographic measurements and development of sedimentary models.

Coastal geodynamics, Atlantic coast of Nova Scotia by V. ASTHANA:

The objectives of this study are as follows: to gain an understanding of sedimentary processes in the littoral and sub-littoral environment; to prepare an inventory of the coastal

zone cataloguing the nature of the sedimentary processes, type and distribution of sediments, and characteristics of the shoreline; and to study the response of unconsolidated sediments to the prevailing hydraulic conditions in the tidal and sub-tidal zone by means of time-series experiments. The results will be a contribution to the study of nearshore geodynamics and the principal users of this information will be scientists, engineers and government agencies concerned with conservation and pollution of nearshore environments.

Seashore pollution and coastal geodynamics of Chedabucto Bay, Nova Scotia by G. DRAPEAU:

The main objective of this study is to continue the research related to the natural cleaning and geodynamics of seashores undertaken following the oil spill from the grounding of the tanker ARROW on Cerebrus Rock in Chedabucto Bay, Nova Scotia. This is an ideal area to correlate the geodynamic processes observed on the seashores with such phenomena as tide propogation, wave refraction, seiches and currents. Generally users of the results will be geologists, engineers, biologists and the public at large who are concerned with oil pollution. Sedimentologists interested in seashore processes will also have direct use of the data.

Dynamics of sediment transport in coastal waters by G. DRAPEAU:

This study is designed to correlate the texture of surficial sediments with the intensity of the currents and waves at the depositional site. The correlation will be made from a study of settling velocities in the laboratory and will be augmented by field studies involving underwater television and photography, direct viewing from a submersible, grab sampling, and observations on currents. Construction engineers and sedimentologists will be the main users of the data.

Sediment bed of herring spawning by G. DRAPEAU:

This study involves the correlation of sediment types with the geodynamic conditions that prevail on spawning grounds in order to help biologists to understand the phenomenon of herring spawning better. These results will be of great interest to governmental fisheries agencies, the fishing industry, and icthyologists and ecologists interested in fish stocks.

Intratidal sedimentation in Minas Basin, Nova Scotia by J. KNIGHT:

This study is being carried out in a major embranchement of the Bay of Fundy and was initiated to gain a better understanding of the movement of sediments in an extremely high energy environment. Structures and textures of sand bodies will be correlated with observations on current velocities. Because of earlier proposals to construct a tidal-power dam in this area, the results of the study will be valuable to construction engineers, environmental specialists and sedimentologists.

Sedimentary hydrodynamics in Northumberland Strait, western Gulf of St. Lawrence by KATE KRANCK:

The objective of this study is to describe the present-day sedimentary environment in terms of the dynamic marine processes and the geological history. Marine scientists such as biologists, environmental workers, fishermen, and marine construction engineers will find immediate use of the results of this study.

The coastal environments of the southern Gulf of St. Lawrence by E.H. OWENS:

This is a new project to commence in 1972 which will involve the following aspects: 1) Zonal study - to provide a description and analysis of the major features and characteristics of the southern Gulf coast; to provide an assessment of areas of deposition and erosion; and to indicate patterns of sediment transport and rates of deposition and erosion. 2) Miramichi Bay study - to define the processes of sediment transport and the direction, pattern, and volume of sediment movement; to assess form and profile changes during the investigation period and relate these to marine and littoral processes; and to explain the depositional history of the area since the Pleistocene and project future developments. 3) Erosion study - to define rates of erosion in terms of volume of sediment and shoreline retreat; to define patterns of cliff retreat in profiles; to relate erosion to wave; and subaerial processes; and to indicate directions of movement of sediment released by erosion. Comparative study - to relate the character of the southern Gulf coast to other coastal environments of the world; and to discuss the coast of the southern Gulf in the context of the regional character of eastern Canada and eastern North America.

Sediments, submarine physiography and sedimentary-hydrodynamic models for Canadian marine waters by B.R. PELLETIER:

This study covers several areas in order to carry out different objectives as follows: to map the distribution of surficial sediments and relate their textures to the hydrodynamic environment at the depositional site; to show the distributional patterns of various aspects of the sediments and relate these to the hydrodynamic system in the area; to complete a reconnaissance

bottom sampling program for the purpose of making an inventory on the nature of bottom materials; to examine submarine geomorphic features in order to outline the regional physiographic development of these marine areas; to make a comparative study on sedimentary models for different areas such as the ice-covered seas (Beaufort Sea), the partially ice-covered sea (Baffin Bay and Canadian Archipelago and Hudson Bay), the open sea and embayments (Atlantic Ocean and Bay of Fundy) the intertidal zone (Bay of Fundy and Minas Basin); to report on special aspects of sedimentation, such as the occurrence of black muds beneath oxidized muds in Hudson Bay; and to report on special aspects of submarine physiography such as submarine pingos, ice-scouring, and submerged drainage features. The results of this study will be of immediate use to construction engineers in the marine area, particularly those involved with sea-floor installations and tidal projects. Environmental specialists, navigators, the scientific community and the public in general will also have an interest in these results.

Geochemical Projects

These studies are subdivided into the fields of inorganic and organic geochemistry and include both laboratory and field studies. Although the overall direction of the geochemistry laboratory is under M.A. Rashid, the projects in inorganic geochemistry are led by D.E. Buckley with the assistance of his associate R.E. Cranston, while organic chemistry is led by M.A. Rashid with the assistance of his associate J. Leonard.

Geochemical interactions of major cations with layered silicates in sea water by D.E. BUCKLEY:

The field work for this project was carried out in a fiord adjacent to the Gulf of Alaska, for the following purposes: to determine the chemical stability of layered silicates as they pass from freshly weathered environments into brackish estuaries and eventually into normal marine environments; to determine the exchange of major silicate cations with sea water; and to determine the silicate diagenesis before deposition. The information from this study will aid scientists in government and industry in the water-quality agencies, fisheries, and mining.

Geochemical partition of trace elements in sea water, suspended particulate matter and bottom sediments by D.E. BUCKLEY with R.E. CRANSTON:

The field work for this study is presently being carried out in the LaHave river and estuary, and the Bedford Basin all of which are located on the Atlantic coast of Nova Scotia. The main objectives of this study are to measure the abundance of Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, Cd, Sb, Hg, and Pb in solution with organic and inorganic suspended particulate matter, and in bottom sediments in order to relate these quantitative values to the physical chemistry of the elements and the nature of adsorbing material. An additional objective is to be able to predict the activity of trace elements in sea water and thus determine better values for residence times of these elements. The principal users of this information will be as follows: other scientists, particularly geochemists and biologists; certain industries such as manufacturing and resource development; water-quality agencies such as pollution detection and control; and municipalities particularly those working on problems of waste disposal and treatment.

Pathways of mercury in a river and estuary system, and sources of mercury pollution by D.E. BUCKLEY with R.E. CRANSTON, M. BEWERS and D. LORING:

This project is being carried out in two phases with distinct but related objectives: 1) to measure the concentration of mercury in a rural river (LaHave River, Nova Scotia), small municipality (LaHave, N.S.) and river estuary in order to determine the background levels of mercury from geologic sources, from municipal waste and atmospheric fall out; to relate these sources to the chemical alteration of mercury forms in rivers and sea water; and to construct a pathway model for mercury which will account for mercury content in solution and in sediments; 2) to measure the mercury content from several industrial sites (northern New Brunswick and Boat Harbour, N.S.), and to make observations on the dispersal, of high levels of mercury while considering processes such as adsorption on particulate matter, complexing, and reduction-methylation. In addition to the users listed in the previous project other bodies concerned with these studies will be provincial health authorities, the pulp and paper and the chemical industries, and the newly formed federal Department of the Environment.

Laboratory techniques and methodology by D.E. BUCKLEY and others:

Three sub-projects have developed in this laboratory program: 1) With R.E. Cranston - analytical methods for multi-element analyses of small samples of alumno silicates. In phase I of this study the objective is to develop a simple quantitative method for sensitive analyses of small samples of suspended particulate silicates and to have the method developed for as many elements as can be determined by atomic absorption spectroscopy. Phase II is designed to develop a nondestructive technique for elemental analyses of silicates combined with electron imaging of the particulate particle, and to investigate the capabilities of energy-dispersed X-rays. 2) With R.E. Cranston and G. Winters - combined chelation and solvent extraction of trace elements

from natural waters and analyses by atomic absorption spectroscopy. The purpose of this work is to establish methods which will allow trace elements to be extracted with a combination of several chemical chelates; to determine the optimum extraction and sensitivity conditions for each element; to obtain comparative data from other laboratories and other methods; to determine the best storage conditions for water samples; and to design quality-control criteria for sampling.
3) With T.C. Loder and D.A. Walker - mechanics and efficiency of filters as particulate matter separators. The objectives of this project are as follows: to test the pass and retention characteristics of several types of filters including membrane, metallic, fibre, and bombarded polycarbonate; to test drying characteristics, chemical stability and weighing properties; and to test certain results by means of scanning electron microscopy. Results from these sub-projects can be utilized by the following: geochemists, agronomists, biologists, geologists and chemists in general, certain industries such as mineral exploration, chemical manufacturing and mining, the scientific community and in particular the universities and government agencies dealing with water quality, agriculture and economic geology and finally some effort will be in the area of international chemical oceanography.

Interaction of marine humic compounds with clay minerals and natural sediments by D.E. BUCKLEY with M.A. RASHID and K.R. ROBERTSON:

This study is designed for the following purposes: to define better the role of humic compounds in the transport and deposition of the associated metals; to determine the quantitative aspects of adsorption of humic compounds on minerals and sediments; and to determine the chemical conditions for the adsorption process,and determine the stability of the complexes and the mechanisms of the process. The chief users will be those listed in the previous project.

Diagenesis of organic matter by M.A. RASHID:

This project is designed to characterize the organic matter in marine sediments, and to obtain geochemical information regarding its conversion to hydrocarbons. The principal users of the information and results will be geologists, geochemists, coal and soil scientists; petroleum chemists, limnologists, and pollution workers.

Organo-metal complexes by M.A. RASHID with D.E. BUCKLEY and K.R. ROBERTSON:

This project includes the role of humic acid in complexing di- and tri-valent metals, and in the solubility of insoluble metals. Its aim is to ascertain the geochemical role of humic compounds in accumulation of various metals, and to determine the nature of organo-metal complexes. The principal users of the data will be mineral exploration workers, geologists, geochemists, pedologists, marine biologists (for mineral nutrition of marine organism), soil scientists and pollution chemists.

Organo-clay complexes by M.A. RASHID:

This study will involve the effect of pH and monovalent cations on adsorption of humic acids or clay minerals, and the nature of their interaction; it will also include the role of divalent metals in the formation of organo-clay complexes. These studies are designed to obtain information about: 1) the catalytic effect of clay minerals in diagenesis of organic matter (conversion of organic molecules to hydrocarbons); 2) the modifications introduced in engineering and industrial properties of clay minerals due to the association with organic matter; 3) trace out the fate of marine pollutants. The data will be used chiefly by geologists, geochemists, the ceramic industry, construction engineers, soil scientists and pollution chemists.

Nature of amino acids associated with marine sediments and humic compounds by M.A. RASHID:

This project is designed to obtain a quantitative and qualitative estimation of various amino acids associated with sediments in order to provide additional information about the nature of organic matter and its diagenesis leading to the formation of hydrocarbons; and it is also to gain information that will also be useful in determining the age of sediments and the rate of their deposition. Geologists, geochemists, biologists and soil scientists will be the principal users of the information.

Ecologic significance of humic compounds by M.A. RASHID with A. PRAKASH:

This project deals with the nature of organic exudates of the benthic algae, and the isolation and characterization of organic components responsible for biological properties. The purpose of these studies is to obtain information about the nature of humic compounds, their effect on marine organisms, and the mechanism of their action. Users of this information will chiefly be biologists, limnologists, pollution chemists and water chemists.

Micropaleontology Projects

These studies include both the modern fauna and those found in fossil form. The foraminiferal studies are supported by laboratory experiments on living specimens. Planktonic and benthonic species are being investigated chiefly on environmental aspects.

Paraecology of benthonic foraminifera in nearshore and estuarine waters by C.T. SCHAFER:

The objectives of this study, which is being carried out in east coast Canada mainly, are as follows: 1) to distinguish environmental relationships (e.g. season variations) in species distribution and Foraminiferal Number in the upper decimeter of bottom sediment; to attempt to apply this information in establishing the paleooceanographic history (Quaternary) of coastal areas through micropaleontological analysis of cored sediment samples; and to apply this information in defining of the geographic extent of polluted nearshore environments; 2) to study the overall physical, chemical and biological interaction between estuarine water and sediment; and 3) to increase the ability of marine environment by providing guidelines in technology concerning the application of habitats, submersibles and diving techniques to underwater studies. Principal users of the information are government agencies concerned with the compilation of environmental quality inventories; also, scientists investigating the ecology of benthonic foraminifera for the ultimate purpose of providing data for paleoclimatic interpretations through analysis of fossil specimens in cored sediment samples.

Paraecology of planktonic foraminifera in equatorial and North Pacific waters by C.T. SCHAFER and R. BANERJI:

The main objectives of this project are: 1) to correlate the spatial distribution patterns of species with chemical and hydrologic parameters measured simultaneously, and to determine various ecological factors responsible for these patterns as well as observed morpho-structural changes in the test; 2) to establish the association of certain species with distinctive oceanic water masses. Scientists investigating the Quaternary paleooceanography of the equatorial and North Pacific waters will be the chief users of this information.

Temporal and spatial variation of planktonic foraminifera in surface waters off Bermuda by G. VILKS:

This project is designed to establish sampling errors in foraminiferal numbers of a standard plankton tow under ideal conditions; and to correlate foraminiferal populations with seasonal changes in surface waters of the northern portion of the Sargasso Sea. Interested users of this information will be paleontologists, marine scientists and research sections of oil companies.

Ecology of planktonic foraminifera in the Atlantic Ocean, Lat. 50°N to 55°S and Long. 10°W to 69°W by G. VILKS:

This project is designed to associate foraminiferal faunas with watermasses recognized by physical methods. The results will be used as a frame reference in paleooceanographic studies. (See G. Vilks above for users).

Ecology of planktonic foraminifera in the Canadian Arctic Archipelago and Beaufort Sea by G. VILKS:

The main objectives of this study is to determine the present oceanic influence and any change in the environment during the Holocene (See G. Vilks above for users and additionally, the Canadian Oceanographic Data Centre, Ottawa).

Coccolithophores of the Canadian Arctic by D.F. CLARK:

The objective of this project is to define the cold-water environment of calcite secreting Coccolithophoridae in association with paleoenvironmental work on cores and sediment samples (See G. Vilks above for users).

Living foraminifera studies by D.A. WALKER:

Specimens for this study are obtained from the inshore waters of Nova Scotia and Bermuda in order to study in the laboratory the life habits (e.g. reproduction, physiology, morphology, feeding habits) of foraminifera and to relate these data to observed environmental conditions in order to provide guidelines for micropaleontological studies. The principal users of the data will be scientists concerned with the biological aspects of foraminifera for the purpose of providing supporting laboratory data for ecological, paleoecological and paleoenvironmental interpretations.

Canadian Arctic molluscs and benthonic foraminifera by FRANCES J.E. WAGNER:

This project covers three main areas: 1) Hudson Bay and approaches, 2) Beaufort Sea, and

3) the Arctic Archipelago. The objectives of the study are as follows: to determine the use of these fauna as ecologic and stratigraphic (Pleistocene) indicators; to determine the present distribution of the organisms and possible changes in distribution and in the environment during the Holocene and perhaps including late Pleistocene; and to interpret Pleistocene molluscan assemblages from raised marine deposits on the basis of the ecological information derived from the Recent collections. The main users of the information will be malacologists, Pleistocene paleontologists and geologists, ecologists and palaeoecologists (Government agencies and private individuals).

Special projects

In addition to the regular program of the laboratory, several additional peripheral and developmental projects have been undertaken as follows:

Topical subjects on the geology of the Scotian Shelf and adjacent areas by L.H. KING with B. MacLEAN and G. FADER:

The objective of this study is to publish accounts of certain geological aspects of the area e.g. 1) the features called "Pockmarks"; 2) a continuous seismic-reflection study of the Orpheus gravity anomaly; 3) the extension of the end-moraine complex; and 4) the geomorphic evolution of the Canadian Appalachian region.

Mollusca and foraminiferida of the Canadian Arctic by FRANCES J.E. WAGNER:

This is a compilation of the molluscs and foraminifers, Recent and Late Pleistocene, with particular attention to the area distribution of the various species, possible migration of species and changes in ecological conditions during the past 40,000 years approximately.

Paleooceanography and carbonate deposition along the crest of the Mid-Atlantic Ridge by C.T. SCHAFER with F. MEDIOLI of Dalhousie University and J.I. MARLOWE of Miami Dade College:

This study is being undertaken in order to determine the sequence in carbonate deposition and lithification during the Quaternary, and to relate these variations to paleoclimatic factors as delimited by microfaunal and oxygen isotope ratio changes in consolidated and unconsolidated cored sediment samples.

Development of submersible all-electric rock core drills by C.A. GODDEN with L. BROWN, C. GRANT and S. MacPHEE:

This drill is designed to obtain 10-foot cores of bedrock to water depths of 1400 feet. It is lowered over the side to the sea bottom and operates from the ships' power supply, and will be equipped with an orienting device, tilt-metre, camera and underwater television.

Feasibility studies with submersibles by B.R. PELLETIER with C.T. SCHAFER, G. DRAPEAU, L.H. KING, D.E. BUCKLEY and others:

This project is to assess the various uses of the research submarines under different conditions, and to carry out working projects where possible. Three different submersibles have been used to date, and a variety of equipment has been tested. This includes the diver lock-out facility, manipulators for recovering samples, cameras, television, and oceanographic sensors.

Marine geological data file by G. DRAPEAU:

This facility will provide a storage and retrieval system for geological data. File will enable a rapid search for data on the following categories: geography, year, cruise, bathymetry, investigator, broad sediment category, type of sample (core, grab, dredge, etc.).

Mathematical models applied to sedimentology by G. DRAPEAU:

In co-operation with L.H. King, the surficial sediments of the western portion of the Scotian shelf were mapped. Data from previous cruises are used to evaluate the method of factor analysis against this map. Trend surface analysis is being used to analyse the distribution of gravel, shape of sand grains, and distribution of carbonates on the Scotian shelf.

Scanning electron microscopic investigations by D.A. WALKER with D.E. BUCKLEY:

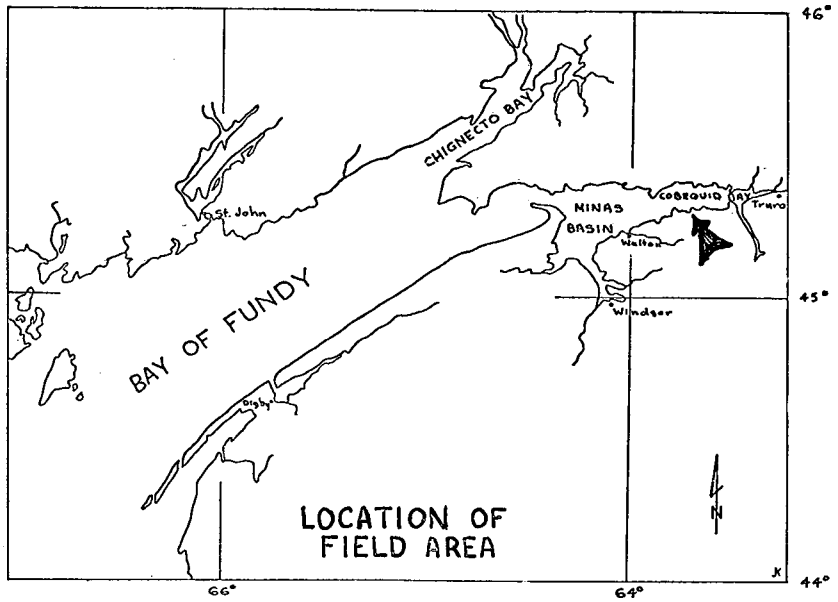
This project has three main objectives: 1) the development of applications of the scanning electron microscope to the various fields of marine science; 2) the development of specialized techniques in sample preparation; and 3) the application of peripheral equipment to obtain more information about the sample undergoing analysis.

Cobequid Bay Sedimentology Project - A Progress Report by R.J. KNIGHT, Department of Geology, McMaster University, Hamilton, Ontario.

Introduction

This report describes the studies carried out during the 1971 field season on the sedimentology of some intertidal sandbar complexes in Cobequid Bay, Nova Scotia. The objective of this project is to understand some of the depositional and dispersal dynamics of these sandbars through a study of the processes and the responses to these processes within the environment.

The project area is located in Cobequid Bay of Minas Basin, Nova Scotia (Fig. 1). The field area is covered on the Canadian Hydrographic Chart No. 4010, and on Map Sheet 11E/5E (1:50,000) from the Surveys and Mapping Branch, D.M.T.S. Tides in this area are semi-diurnal with a tidal range of 12 to 18 metres.



The base camp for the operation was established on May 30, 1971, at Noel, Nova Scotia, situated on the south shore of Cobequid Bay. Work was carried out by a two man party consisting of Miss K. Warner and Mr. J. Knight until August 25, 1971. Additional field assistance was provided by Messrs R.. Dalrymple and R. Featherstone, and personnel from Bedford Institute, Dartmouth, Nova Scotia.

The Field project was undertaken as a co-operative McMaster University-Bedford Institute project in an attempt to further the understanding of processes to responses with regard to sediment dispersal and deposition. Three major aspects of study were pursued: (i) the form of the sedimentary deposits; (ii) the erosional and depositional events that have given rise to the observed forms; and (iii) the environmental conditions under which these events occurred.

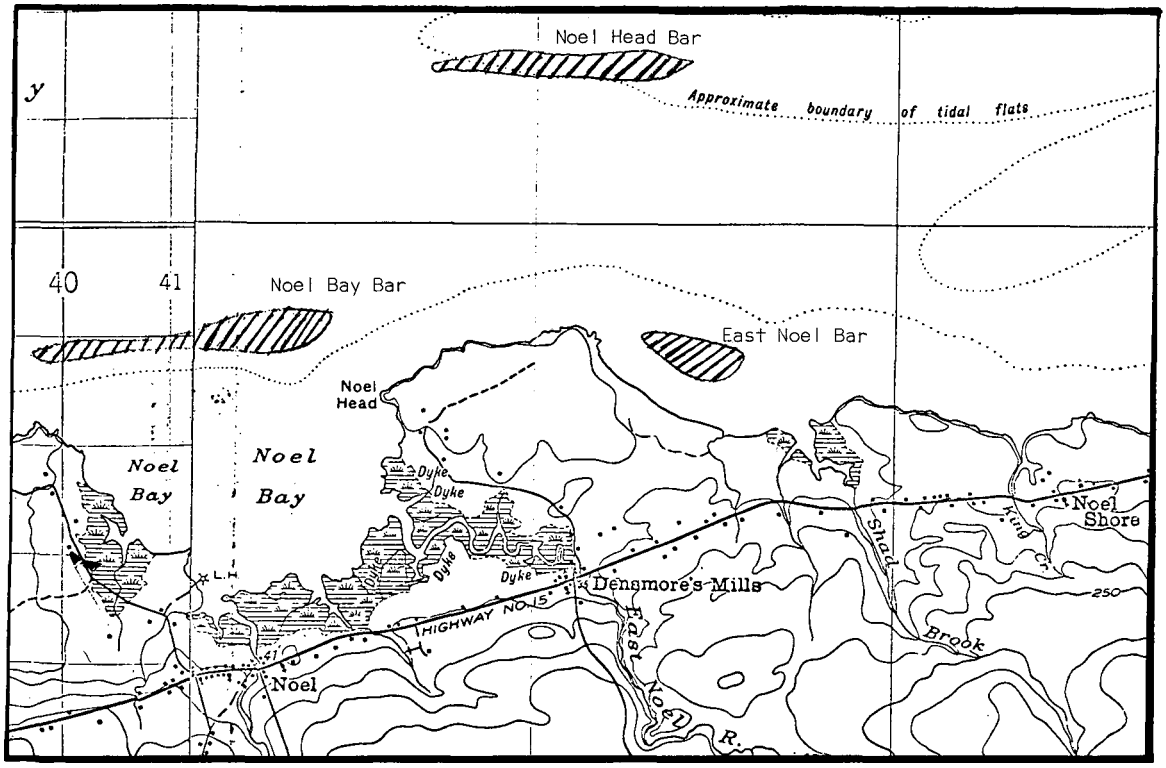
Field Objectives and Work Accomplished

A preliminary analysis of the sand complexes in Cobequid Bay was initially made from air photographs (National Air Photo Library, Ottawa) taken during the time period 1935 to 1963. Many of the air photographs taken during this period were unusable as they were flown during periods of high water and therefore showed nothing of the sandbar complexes. Those air photographs flown at or near low tide during this period gave an idea of the areal distribution of the sandbars and their progressive changes through time. The location of the field area was initially made from the analysis of these air photographs.

Early field reconnaissance showed that there had been considerable change in the areal distribution and configuration of the sandbar complexes. Confirmation of this fact was made in a low altitude (1000 to 2000 feet) flight over the proposed field area at low water on June 7 in a Cessna 175 owned and operated by Mr. K. Stephens of Tennycape, Nova Scotia. On the basis of the observations made during this flight, the field area was somewhat re-evaluated. A second flight was made over the area at the end of the field season on August 25 to re-photograph and note any changes in the area.

The intertidal sand complexes within the field area occur in two areas: those areas

accessible on foot near the shore at low water; and those areas accessible only by boat in the offshore area of the Bay. It was considered that the field area should involve study from each of these areas for two reasons: (i) to provide an area accessible from shore as an alternative work area on days when weather would not permit work in the offshore; and (ii) to provide a second and possibly a third area (as time permitted) as a basis for comparative study between the inshore and offshore locations of the sandbars. This organization of the proposed field study area worked quite well during the field season as there was considerable adverse weather early in the season which curtailed offshore operations but not the inshore work.



The three study areas chosen were East Noel Bay, Noel Bay Bar, and Noel Head Bar (Fig. 2). These three sandbars were easily accessible from Noel where a 24-foot boat, owned and operated by Mr. A. Scott, was rented on a daily basis throughout the field season.

The first objective of the field program was to establish ground control in each of the study areas. This was accomplished with the use of a Wilde T2 theodolite and an 'Inshore' Ferrograph depth sounder provided by Bedford Institute. Positions were fixed to shore by sighted bearings on known reference points using a Brunton compass. In the case of the two offshore sandbars, further sounding work was carried out in the adjacent channels to determine the profile geometry of the sandbars in relation to the surrounding sea bed.

The morphology of the sandbars was studied in three particular respects. First, to study the characteristics of the sediment distributions on the sandbars, a sampling grid was established and samples were collected at the crests of the megaripple bedforms. Some debate might be raised concerning the location on these bedforms from which representative samples should be taken. It was considered that the crests of these bedforms presented the most unmodified surfaces for sampling as the troughs were prominantly characterized by cross-bar late stage runoff, which caused considerable reworking of the sediments. The backslope and foreslope of the bedforms were also considered but the definition of these specific areas posed a problem. The crest location of the samples was very easy to locate.

Sediment samples were taken from the channels surrounding the offshore sandbars but the number were limited due to the great difficulties encountered in trying to sample very coarse sediments in rapidly moving tidal currents. A Dietz-Lafond grab sampler provided the most consistent results although not entirely satisfactory. Owing to the size of the boat used as the sampling platform and the fact that any sampler had to be hand-hauled, this greatly restricted the type of grab sampler that could be used.

The external morphology of the sandbars was considered from two aspects: the overall shape of the sandbars and the distribution and shape of the superimposed bedforms. The first aspect of the geometry should become apparent in plotting up the data collected from the air photos, the ground surveys and the echosounding records. The morphology and distributions of the superposed

bedforms were studied using tapes and Brunton compasses, and incorporating Allen's (1963) bedform nomenclature. Photographs were taken at each sample point on the sandbars for later study and analysis to supplement the field notes.

Some detailed sampling was taken of the bedforms at various stations in order to ascertain any variations in the sediment distribution relative to the bedform crests.

The internal morphology of the bedforms was studied in all of the field areas but was generally found to be inconclusive due to the homogeneity of the sediments except on East Noel Bar where there appeared to be a wider range of sediment grain sizes and an abundance of shell fragments to delineate crossbedding. The size of the crossbeds, sets, laminae; the angle of dip of the foresets, and their structural characteristics were measured and photographed where possible.

Several stations were located both over the sandbars and in the adjacent channels to study the hydraulic regime of the environment. Positioning of these stations was governed by the bedform characteristics on the bar surface and bar geometry. A Kelvin-Hughes Direct Reading Current Metre, on loan from Bedford Institute, was used to measure the directions and current rates of the tidal currents. The current metre was suspended on a weighted, pre-measured and marked cable and safety line which attained angles up to 40 degrees or more in very strong currents. Depths were checked using the echosounder. A Pritchard-Burt Current Van constructed at McMaster University was not used as it could not be adapted for use from the boat used in the operations without considerable difficulty. Initially, considerable difficulty was encountered with the underwater electrical connections on this type of metre but these were eventually overcome and the instrument was used very successfully.

Current profiles were obtained at half-hour intervals over several 13-hour periods from high water to high water. During the low-tide period, work was down on the exposed portions of the sandbars. Temperature profiles and suspended sediment samples were taken simultaneously with the current-rate profiles using two Knudsen bottles with reversing thermometers. The water samples collected were filtered using high retension filter paper. Specific gravity of the water samples was also recorded for later computations.

A Plessey 'continuous recording' current metre was also used in the field area at three locations during a six week period. This metre was placed successively on the Noel Bay Bar surface, and in each of the channels to the north and south of the bar before being retrieved from the Bay. Due to the 500-pound base used in conjunction with this metre, considerable caution and observance of weather conditions had to be made when using this metre with a 24-foot boat. The data in this current metre is recorded in a binary code which can be computer-translated into current directions and rates.

Rates of bedform migration and sediment movement were made using sand grains coated with fluorescent paint, and stake measurements. In the first technique (Yasso, 1966) mentioned, a $2\frac{1}{2}$-inch by 24-inch plastic core, tube sample was removed from the site of the test. This sample was air-dried and coated with a particular coloured fluorescent paint. Some difficulty was encountered in the coating technique which produced an agglomeration of the sand grains that had to be disaggregated and sieved before they could be returned to the test site. These coated sands were replaced at the test site and left until one or two tidal cycles later when samples were taken along eight cardinal directions to a distance of 25 metres from the point source (48 samples per test site).

Rates of bedform movement were made using $\frac{1}{2}$-inch by 36-inch steel concrete reinforcing rods driven into the bedform crests. These stakes were situated at various positions over the bar surfaces, and were measured and relocated at regular intervals over the field season. Both the distance moved and the variation of the bedform amplitude was recorded.

Completion of the Project

Three stages of work will be necessary to complete this project: (1) Laboratory analysis of the field samples: grain size analysis of the sediment samples and the determination of the weight of suspended sediment per litre of seawater are to be made. There are approximately 140 sediment samples and 139 suspended sediment samples to be analyzed. This work is already in progress; (2) Reduction and analysis of the data derived from surveys, sample programs, and regular observation records: this work represents the main burden of the project and is in progress at the Department of Geology, McMaster University with extensive use of the university computing services proposed; and (3) Compilation of the final report: the study will initially be presented in the Department of Geology, McMaster University as a degree dissertation, and then to Bedford Institute as a government report.

Previous Work

There is relatively little published data concerning Minas Basin intertidal deposits until

fairly recently. Kindle (1917) published a detailed account of the geometry of ripples and their processes of formation along the Hants County, Minas Basin shore. Klein (1963, 1964, and 1967) summarized a reconnaissance of the sedimentary facies of the Bay of Fundy intertidal zone and has compared them to the Recent facies in the Dutch Wadden Sea (Klein and Sanders, 1964). Klein (1966a, b) reported on the relation of flow directions and flow parameters of depositional currents to the orientations of bedforms at Five Islands and Economy Point in Minas Basin, but it is not until 1970 that Klein has summarized and interpreted all of his data from this area.

Swift and McMullen (1967, 1968) and Swift et al (1966) described the sediment distributions from the Minas Basin, the origin of the sandbars, and the origin of the sandbar bedforms.

More recent work published is the Fundy Tidal Power Report (1969) in which very general comments are made about the sedimentology of Minas Basin. Pelletier and McMullen (in press) will deal more specifically with sedimentology patterns in Minas Basin.

General Descriptions

The sandbars studies are oriented in an east-west direction and are considerably longer than they are wide in that direction. In cross profile, the two offshore sandbars appear asymmetrical in shape with the steeper slope being on the south side and a more gradual slope being on the north side. There appears to be no significant difference in the longitudinal profile. The bar at East Noel Bay presents a similar east-west orientation but is more symmetrical in cross-section.

The south shore of the offshore bars are smooth and uninterrupted while the north shore of these bars are quite irregular and embayed. East Noel Bar shows no particular distinction in regard to this aspect of geometry.

A further difference between the nearshore bar and the two offshore sandbars is portrayed in the distribution of bedforms and grain sizes. East Noel Bar exhibits a decrease in bedform size and bedform crest irregularity in a symmetrical pattern outwards from the approximate geometric centre of the bar. The two offshore sandbars did not show such a regular distribution of bedforms. The sediment distributions appeared to be more homogeneous on the offshore bars as already noted in the difficulties encountered in trying to observe crossbedding in these sediments. The sediments of East Noel Bar appeared more variable both in size and content.

Bedforms measured and observed on the sandbars were predominantly ebb-oriented, but some flood-oriented sand waves were observed on the two offshore sandbars. In the latter case, these bedforms were overlain and modified by ebb-oriented megaripples. The wavelength of these larger flood-oriented features was of the order of 100 metres compared with the ebb wavelength order of 10 metres.

Sediment movement and bedform migration were noted to vary over the tidal cycles. Generally, greater movements was recorded in the larger, coarser grained megaripples.

General Interpretations

The distribution of sediments, bedforms and the geometry of the sandbars can be related to the hydraulic regime of the environment.

The shallower, lower slope on the north side of the offshore bars can be related to reduced current rates and lower frictional resistance values. The smooth, steeper slopes on the south side can, conversely, be related to increased current rates and higher frictional resistance values.

The geometry of the offshore sandbars and the distribution of grain sizes, and bedforms (orientation and size, etc.) is dominantly a function of the directions of current flow which is partly a result of the Coriolis Forces affecting the current flow. The predominance of ebb-oriented bedform features is a function of ebb-shielding on the sandbars resulting from a counter clockwise motion of the tidal currents from flood to ebb.

The differences noted between East Noel Bar and the two offshore sandbars is due to the former's nearshore sheltered position. This bar is greatly ebb-shielded due to Noel Head at the western end of the sandbar. Variations of grain size and sediment content are probably a function of this bar's proximity to the shore and source of sediment from the erosion of the Triassic sandstone headlands.

Differences in current rates were noted at various positions over the bar surfaces and in the channels and over different bedform surfaces. Preliminary results suggest the following sequence of bedforms with increasing current strength: linear ripples, lunate-linuoid ripples, linear megaripples, scour megaripples, planed-off megaripples and plane beds. The bedform type is governed by maximum flood and ebb velocities attained at a given location. Velocity asymmetry and

velocity duration are also important in determining the bedform morphology and the amount of cross-bedding bimodality.

The results of this project should allow interpretation of hydraulic regimes of ancient intertidal zones on the basis of bedform morphology and crossbedding, and help to define the hydraulic regimes and possible sedimentation problems that might be encountered with tidal power in the field area.

Acknowledgments

This project is under the supervision of Dr. G.V. Middleton of the Department of Geology, McMaster University.

Great appreciation is expressed to Dr. B.R. Pelletier and his co-workers at Bedford Institute, Dartmouth, Nova Scotia, for their direction during the field season and the logistics support of the operation.

The guidance and interest of Dr. R.G. Walker, McMaster University, in the formulation of this report is appreciated.

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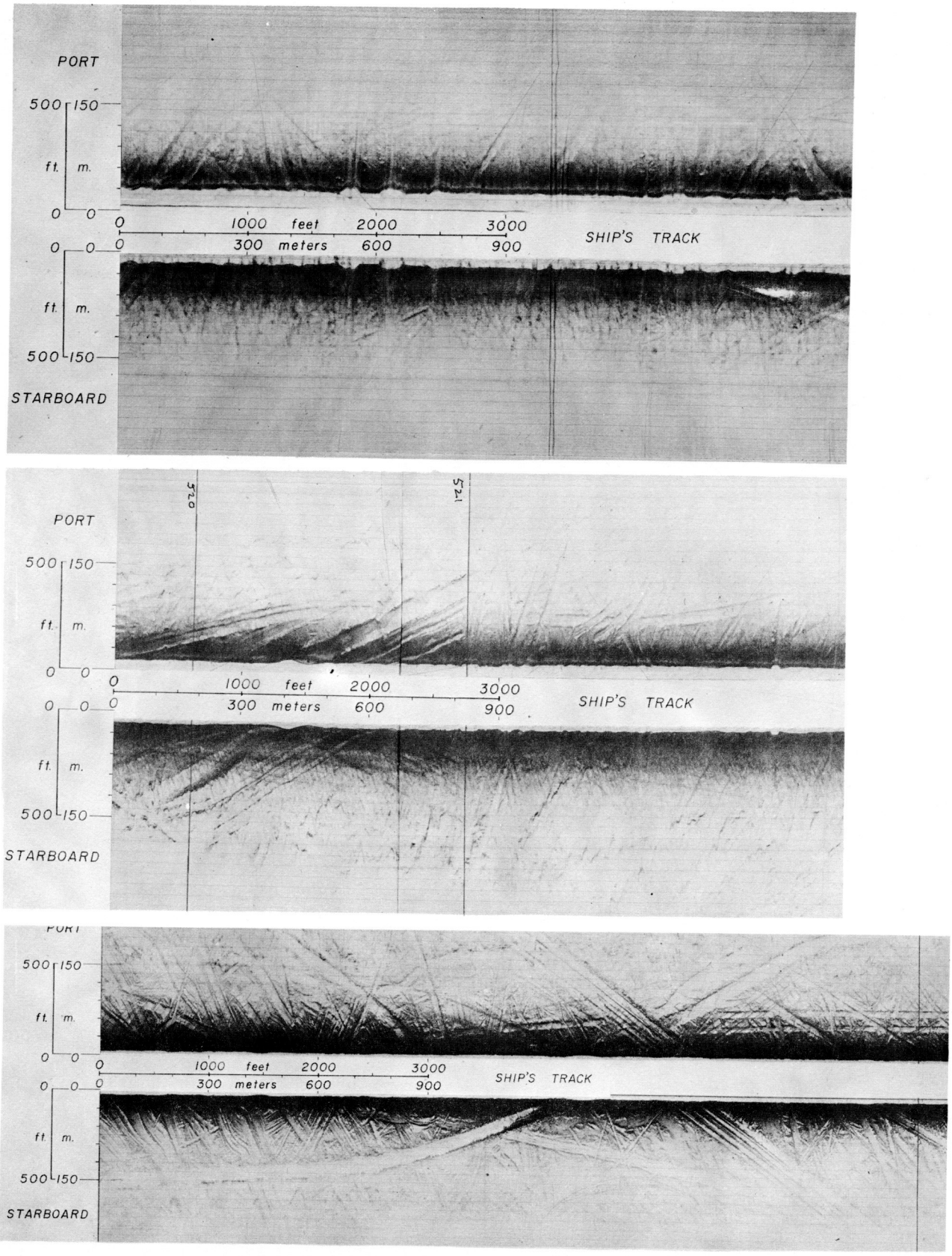

Side scan sonargraphs of ice scouring on the Arctic continental sholf beneath the Beaufort Sea, Northwest Territories, Canada. Research by J.M. Shearer (Geological Survey of Canada, Ottawa) and B.R. Pelletier (Bedford Institute, Dartmouth, Nova Scotia).

Oil pollution along the seashore Chedabucto Bay, Nova Scotia - A vista of the future? Photo by R. Belanger, Atlantic Oceanographic Laboratory.