

CURRENT RESEARCH

Planktonic Foraminifera - Their Significance in Water Masses and Bottom Sediments from the Grand Banks to the Caribbean Sea by G. A. BARTLETT, G. VILKS and A. T. S. RAMSAY

The following is a general resume of preliminary results obtained from core, dredge and plankton-net samples during the 1968 Bedford Institute cruise to the Caribbean on board CSS "Hudson".

The relationship of recent planktonic foraminifera to particular watermasses was readily determined from oblique and vertical plankton tows. This investigation was facilitated by the cooperation of physical oceanographers (Dr. C. R. Mann, Bedford Institute), who provided immediate information on particular watermass characteristics.

Definite Labrador Current water characterized by Globigerina pachyderma and G. bulloides was not determined during the present study. Slope water containing G. bulloides, G. pachyderma, G. falconensis, G. quinqueloba and Globorotalia inflata is the dominant watermass immediately south of the Grand Banks. The Gulf Stream is characterized - in addition to Slope Water forms - by the presence of Globorotalia hirsuta, G. truncatulinoides, Globigerinella aequilateralis, Pulleniatina obliquiloculata and Hastigerina pelagica. Typical Labrador Current and Slope Water species are absent from the Sargasso Sea. Furthermore, only three forms Globorotalia truncatulinoides, Globigerinella aequilateralis, and Globigerinoides ruber (white) dominate the Sargasso Sea fauna. Also present are Globigerina falconensis, Globorotalia hirsuta, Hastigerina pelagica, Globigerinoides ruber (pink) and Globigerinoides conglobatus. A transition between Sargasso Sea water and Caribbean Sea water is noted by the addition of significant numbers of Globigerina dutertrei, Globorotalia tumida, Globigerinoides trilobus trilobus and Orbulina universa. This transition zone represents the northern cooler waters of the North Equatorial current. Caribbean Sea water - the warmer portion of the North Equatorial Current - contains five additional species, namely Globorotalia menardii, Globorotalia crossaformis, Globigerinoides trilobus sacculifera, Candeina nitida and Sphaeroidinella dehiscens.

It is obvious from the present investigation that northern watermasses are characterized by the dominance of Globigerina faunas whereas southern watermasses are dominated by species of Globorotalia and Globigerinoides. Also, there is a progressive increase in species numbers from north to south. A knowledge of recent planktonic foraminiferal distribution at each station facilitated rapid determination of faunal changes in cores.

The Pliocene-Pleistocene boundary was determined in three cores, one north of Bermuda and two south of Bermuda. The boundary is marked by (1) the evolution of the non keeled Globorotalia tosanensis to Globorotalia truncatulinoides the former 98% right coiling, the latter 95% left coiling, (2) the evolution of the robust rugose coccolith Ceratolithus aff. C. cristatus to the delicate non-rugose Ceratolithus delicatus and (3) the disappearance of Discoasters with the dominance of G. truncatulinoides.

Three definite cooling and warming trends were noted in Pleistocene sediments from cores north of Bermuda. However, only one dominant cooling trend was noted in sediments considered to be of Pleistocene age south of Bermuda. Cooling trends were determined by changes in coiling directions of planktonic foraminifera, increases in Globigerina pachyderma populations and marked variation in the Globigerina - Globorotalia ratio.

Several reports by G. A. Bartlett, A. T. S. Ramsay and G. Vilks are now in preparation and will be published as soon as the cruise has terminated.

Seismic Surveys in the Gulf of St. Lawrence - Geological Survey of Canada, Ottawa, by G. D. HOBSON

Since 1964, the Geological Survey of Canada has conducted a modest reconnaissance program of marine seismic refraction surveying in the Gulf of St. Lawrence, designed broadly to define the attitude and thickness of sedimentary strata overlying "basement" and to identify these strata where possible by correlating seismic velocities with lithology. Two ships have generally

been used with one, the shooting ship, maintaining a constant shot location, while the recording vessel tows a cable and hydrophone array through the shot location, stopping to record at selected distances from the shot. A completely reversed profile is not obtained although velocities in two opposite directions are obtained. Data obtained to date reveal the presence of as many as eight velocity layers overlying the crystalline basement within the Gulf itself.

Four sedimentary velocities can be identified over the Orpheus gravity anomaly, adjacent to Cape Breton Island, Nova Scotia on the Atlantic coast, which indicate about 10,000 feet of sediment in-filling a graben. It is speculated that there may be some Tertiary sediments in this structure by extension of the formations adjacent to Chedabucto Bay. The end product of these investigations is intended to be a map of the eastern Canadian maritime region with the water removed.

Following is a roundup of research carried out at various institutes in eastern Canada. For this number of MARITIME SEDIMENTS geophysics is included because of its contribution to our knowledge of the crust, continental margins and shelves and associated sedimentary basins. Because the accounts are not detailed extensively we are presenting this section of the magazine by institutes and thus give our readers the opportunity to view the broad program of each.

Memorial University of Newfoundland, St. John's, Newfoundland by A. F. KING

Much of the faculty and graduate research in M. U. N.'s Department of Geology is concerned with stratigraphical, sedimentological and structural aspects of Newfoundland's regional geology. With the opening of the university's new Marine Sciences Research Laboratory, located at Logy Bay, near St. John's, there is new interest in both marine geology and marine biology.

Last year, Professor W. D. Brueckner published an account of the stratigraphy and structure of the autochthonous and klippe terranes of west-central Newfoundland in "Guide Book, Geology of Part of Atlantic Provinces", produced by the Geological and Mineralogical Associations of Canada. In 1967, he also contributed works on the geology of the eastern part of the Avalon Peninsula for the Gander Conference (copies of the field trip guide book can be obtained from: Department of Geology, Columbia University, New York, 10027; Proceedings of the conference will appear later).

Dr. R. D. Hughes is on sabbatical leave at Queen's University in Kingston.

Dr. V. S. Papezik is carrying out research on iron formation in the Ordovician volcanic belt near Springdale, central Newfoundland, and on sedimentary rocks associated with ash flow tuffs of Precambrian age in the Conception Bay area.

Three new members of the staff are interested in fields related to ancient and modern sediments: Prof. M. M. Anderson who came from Fourah Bay College, University of Sierra Leone, is primarily concerned with problematical fossils and other problems of Newfoundland palaeontology; Dr. M. J. Kennedy from Trinity College, Dublin, and recently a postdoctorate fellow with the Appalachian Section, Geological Survey of Canada, is involved in structural studies of the Fleur de Lys Group in the northern Burlington Peninsula; Dr. A. F. King from the Sedimentology Research Lab., Reading, England, currently working on Carboniferous stratigraphy and structure of flysch-like sediments in Cornwall and Devon, is interested in stratigraphic problems in the eastern part of the Avalon Peninsula.

Several of our M. Sc. students have recently completed their programme of sedimentary studies: A. C. Nautiyal submitted a thesis with emphasis on micropaleontology - "The Cambro-Ordovician sequence in the south-eastern part of the Conception Bay area, eastern Newfoundland"; R. K. Stevens presented a thesis on the - "Geology of the Humber Arm area, west Newfoundland" and contributed two itineraries for the Gander Conference - "Corner Brook - Humber Arm" and "Stephenville-Port-au-Port Peninsula". Stevens, now a Ph. D. student at the University of Western Ontario is continuing his studies on the stratigraphy and structure of western Newfoundland; J. Utting - "Geology of the Codroy Valley, southwestern Newfoundland, including results of a preliminary palynological investigation"; C. C. K. Fong - "Palaeontology of the Archaeocyathus bearing Forsteau Formation, southern Labrador".

At present, J. M. Shearer is completing a thesis on recent sediments in Port-au-Port Bay. His aim is to determine the grain size distribution of the contemporary layer of sediment in the bay and to relate the distribution to the strength of waves and tidal currents using statistical and mineralogical methods. Y. C. Hsu is studying late Precambrian fossils from the St. John's Formation, Avalon Peninsula, and is also attempting to isolate chemically organic compounds from the shales in which the fossils are found. S. B. Misra and I. S. Koh are working on sedimentological and structural problems on the south coast of the Avalon Peninsula between Trepassey and Cape Race.

Institute of Oceanography, Dalhousie University, Halifax, Nova Scotia.

The following is an abstracted account by the editor of the director's report (Dr. G. A. Riley) that refers chiefly to marine geophysical studies. The department of geology will be covered separately. M. J. Keen is concerned with propagation of elastic waves in inhomogeneous media and transition layers. Experimental studies in explosion seismology are centered around a study of the crust and mantle beneath the Appalachian System and continental margin of Eastern Canada, and of deep reflections from the Mohorovicic discontinuity. Development of instruments for remote seismic recording is also being carried out. Geophysical studies in detail are being carried out over the Mid-Atlantic Ridge, and eastern Canada. Particular attention is being paid to precise measurement of gravity at sea, and to automatic data processing at sea, using ship-borne computers. Another geophysical study is currently in process in the Bay of Fundy off western Nova Scotia where tides range up to 50 feet. The tilting of the earth caused by this periodic loading of the crust is being studied with tiltmeters in a mine, in order to determine the elastic and plastic properties of the earth's crust in this vicinity.

R. D. Hyndman is initiating work on geomagnetic depth sounding and magnetotelluric measurements over the continental margin of eastern Canada. These measurements should provide a valuable comparison with similar measurements made on other coasts, notably California and Australia. These measurements should also outline the electrical conductivity structure to depths of several hundred kilometres. A low power (4 watts) battery-operated magnetic recording system is being developed using a fluxgate magnetometer and a digital magnetic tape recorder. Earth potential measurements are to be made at a number of stations using battery-operated chart recorders. Some of the measurements will be obtained in cooperation with S. Srivastava of the Bedford Institute, who is obtaining instruments for measuring magnetic field variations on the sea floor. Some measurements in Labrador are also tentatively planned. Some heat flow measurements at sea may be attempted, particularly near the coast, again in cooperation with the Bedford Institute.

Research associate B. D. Loncarevic selected a small area near the crest of the mid-Atlantic Ridge near 45°N and is carrying out detailed studies while engaged on three expeditions in the past and a fourth which is planned for 1968. Newly compiled bathymetric charts have revealed a pronounced change in the roughness of topography at approximately 50 kilometres distance from the Median Valley, and a surface current pattern appears to be associated with this boundary. The magnetic anomaly map shows a strong lineation associated with the Median Valley. The pattern is more confused away from the valley and open subjective interpretations. Physical properties of a number of samples dredged from the walls of the valley have been investigated. Since it may be possible to correlate the basalt type with depth of intrusion, an indirect correlation between intensity of magnetization and depth is indicated.

Research associate J. E. Blanchard and A. Lambert (a graduate student) are involved in a study dealing with the response of the crust to the weight of tidal water of the Bay of Fundy. Tilt meters and a continuously recording gravimeter are being used. Two Verbaandert-Melchior horizontal pendulums are now recording tilts in the tunnel of an abandoned gold mine near Rawdon, Nova Scotia, on the south-east side of the Minas Basin. Gravity measurements, using the La-Coste Romberg gravimeter on loan from the Dominion Observatory, were used to determine the vertical movement of the crust at two locations. These measurements were made on Ile Haute, an island in the Bay of Fundy, and at Victoria Harbour, on the Nova Scotia side of the bay.

Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth, Nova Scotia

The Marine Geology division at the Bedford Institute carried out field programs in the

Arctic Archipelago, northern Hudson Bay, the Labrador Shelf, the Grand Banks in co-operation with the Hydrographic Service, estuaries in the Atlantic Provinces, the Northumberland Strait, Scotian Shelf and the Atlantic Continental Slope. Sediment distribution maps were prepared for these areas, which are based on mechanical analysis of the sediments carried out in the laboratory. Approximately 2,000 miles of seismic reflection profiling were recorded for the Labrador and Scotian Shelf in an attempt to interpret geological features beneath the sea floor. Long cores and dredge hauls were taken off the continental slope and reconstruction of stratigraphic columns of the continental margin is taking shape.

In Micropaleontology interpretations of ancient environmental conditions are being made from a study of the sedimentary cores and in conjunction with a comparison of modern conditions. Past climates, geology and oceanic circulation are being interpreted. Also new evidence on evolutionary lines of microfauna is emerging and this also includes elucidations on temporal relationships between species.

In Organic Geochemistry a new technique has been developed for the separation of organic matter from marine sediments and new relationships on fulvic and humic acids in these marine soils are being established. This latter program is in conjunction with a long range environmental study of the sedimentary conditions on the Scotian Shelf from which has also evolved new surficial geological maps which are aiding mining and petroleum exploration companies as well as the fisheries industry.

In marine geophysics shipborne gravimeter and magnetometer measurements were made in conjunction with a continuing hydrographic survey of the Grand Banks of Newfoundland. The survey area lies approximately between longitudes 53° to 44° and latitude 45° to 48° . Full use was made of the PDP-8 computer on board ship to process the observed data. This enabled results to be plotted within 24 hours of the data acquisition making it possible to recommend changes in program to ensure detailed study of anomalous features, check instrument repeatability and correct processing and/or navigational errors. Fixed magnetometer stations were installed adjacent to the survey area, to connect the shipboard magnetic records for diurnal and magnetic storm effects.

No new geophysical data was collected in the Arctic in 1967. However, the sea magnetometer data collected in previous years was compiled and reduced to a standard form and presented at the Canadian Committee on Oceanography's 1967 annual meeting in Halifax as a paper by D. L. Barrett and K. S. Manchester. The compilation of the data has pointed out the need for detailed comprehensive geophysical surveys in the Arctic rather than more reconnaissance surveys.

The magnetotelluric data collected from simultaneous measurement at Fredericton, N. B., Halifax, N. S. and Sable Island in 1966 has been digitised and analyzed using power spectral techniques to obtain a conductivity profile across the eastern coast of Canada and to study the effect of the coast on the magnetic and electric variations. The results indicate an anomalous behaviour in the intensity of the vertical component of the magnetic field at Halifax for periods between 30-50 minutes and a gradual increase in its intensity for larger periods from Sable Island to Fredericton. There is no marked direction of polarisation of the electric and magnetic fields at the stations.

The model which best fits the observed data indicates a gradual decrease in the depth of the high conductivity mantle from land towards the deep ocean. This interpretation agrees well with the seismic and gravity data for this area (Keen and Loncarevic, Can. J. Earth Sc., 3, 1966).

A system has been developed to file diazo copies of underwater photographs on IBM aperture cards along with identifying data, including geological and biological interpretation. This simplifies retrieval of data and its statistical comparison.

With the assistance of Professor D. M. Heaps an information retrieval system has been developed for the chart material gathered by the geophysics group. The system is now operational and a manual has been prepared to instruct personnel in its use.

A data storage and retrieval system has been developed for geophysical data collected at sea. Standard procedures have been developed to sort the data from different cruises and to edit and merge all data from a cruise on a single 'edited data' magnetic tape. An important standard

output from the retrieval system is a completely computer written data report. The first of these reports has been published (BIO Data Report 1967-1-D).

York University, Toronto, Ontario

Ian Brookes, Department of Geography, York University, Toronto, has worked on upland surfaces in western Newfoundland, as an M. Sc. thesis for McGill University. The thesis is in Redpath Library at McGill. He is currently engaged in a study of the Pleistocene sequence and landforms of the St. George's Bay - Port-au-Port area of western Newfoundland for the Ph. D. from the same university, and will be in the Stephenville area between mid-June and mid-August 1968. Future plans are for an extension of the study of late Pleistocene sea-level changes along the west coast of the island and for a palynological study of bogs in the island.

McMaster University, Hamilton, Ontario

The following account does not give specific research projects but outlines some of the major equipment and laboratories provided for the study of sedimentary rocks in the geology department at McMaster University. Chief items of equipment include the following: Furnaces for synthesizing minerals, DC-arc spectrograph, X-ray diffraction, X-ray fluorescence, spectrophotometer and atomic absorption spectrophotometer. Some of the major laboratories are: (1) Paleontology Research Laboratory which includes facilities for storage and preparation of fossils; (2) Sedimentology Research Laboratory which provides equipment for size analysis of sands and clays, and equipment for taking small diamond-drill cores from oriented specimens for thin-sectioning and subsequently fabric investigations; (3) Experimental Sedimentology Laboratory which contains two flumes designed for the study of experimental turbidity currents and their associated structures; (4) Sedimentary Geochemistry Laboratory which contains equipment for specific ion electrodes for sensitive determination of F, Cl, Br, Ca and dissolved oxygen, and for determination of pH; (5) Radiochemistry Counting Laboratory which contains equipment for counting sample radioactivity. It is used mainly in the analytical technique known as neutron activation analysis, which is a very sensitive analytical method capable of detecting abundances of only a few parts per billion.

Exploration Notes:

The Arctic Islands - Pan Arctic Oils Ltd.

The government of Canada has joined a 20-company consortium to explore 44 million acres of potential oil land in the Arctic. The program will cost 20 million dollars - 11 million from the company and 9 from the government. However the government in return will hold 45 per cent of the common shares of the consortium and 45 per cent of the preference shares. Approximately 17 deep holes will be drilled under the exploration program commencing in March. Most of the drilling will be carried out in the Sverdrup Basin, supported by drilling on the peripheral areas to the east.

Sable Island, Nova Scotia - Mobil Oil Canada Ltd.

Sable Island situated 180 miles east of Halifax near the edge of the continental shelf was recently the site of drilling activity carried out by Mobil Oil Canada Ltd. The company announced that it had abandoned the hole after drilling to a depth of 15,106 feet. Only gas was reported and was evaluated as uneconomical. Considerable geological information was obtained and according to reports released by the company the estimates of the thickness of the sedimentary column was confirmed.

Glance Bay, Nova Scotia - Four-company combine

A four-company combine including Murphy Oil Company Ltd., Terrabonne Petroleum Ltd., Aquitaine Company of Canada, and Canada Homestead Oils Ltd., are presently drilling in the Glance Bay area where a thick sedimentary column is predicted. The drilling is being under-

taken by Petrolia Oilwell Drilling Company Ltd. and will take a minimum of 70 days at a cost ranging between \$200,000 and \$300,000. Dr. Shaw of St. Francis Xavier university holds the oil and gas rights on the drilling site, and feels the possibilities of success are fair although the risk is high.

Hudson Bay - Richfield Atlantic Company and Aquitaine Co. of Canada

At a recent symposium in Ottawa possibilities of oil and gas were assessed from the geological and geophysical data presented to the meeting. This included information gathered at sea, from the air and on land. The sedimentary column is several thousands of feet thick with a minimum thickness of Paleozoic estimated to be 3,000 feet and a maximum of 6,000 feet or even slightly more. It is expected that exploration by the companies will continue and drilling offshore is anticipated.

Hudson Bay and James Bay Lowlands - Geological Survey of Canada

A helicopter-supported geological exploration of the lowlands of Hudson and James Bay was completed by the Geological Survey of Canada in the fall of 1967. Besides the stratigraphic column established that will assist oil and gas exploration, numerous areas of mineral wealth were outlined. Among the economic possibilities mentioned were indications of gypsum, and columbium. Preliminary geological maps of the area are available from the Geological Survey offices in Ottawa.