Resume of Marine Geological Investigations Carried out by the Atlantic Oceanographic Group in the Gulf of St. Lawrence, 1964 - 1966.

D. H. LORING
Fisheries Research Board, Bedford Institute of Oceanography, Dartmouth, N. S.

In 1961, the Atlantic Oceanographic Group initiated a series of geological and geochemical investigations in the Gulf of St. Lawrence. A progress report on those made between 1961 and 1964 appeared in Maritime Sediments, (1-4). Since then, additional studies have been carried out in the southern (Magdalen Shelf) and northeastern parts of the Gulf. Geochemical studies of the sediments in the Gulf have also been continued.

1) Geological Investigations

a) Sediments on the Magdalen Shelf, southern Gulf of St. Lawrence:

After a preliminary survey of the morphology and sediments in the southern Gulf (AOG, Ann. Rept., 1964) had been completed, a more detailed study of the eastern half of the shelf was undertaken. In 1965 and in 1966 detailed sampling and echo sounding were carried out in this area using conventional methods. Additional information on the surface and subsurface features around the Magdalen Islands was obtained from sub-horizontal echo sounding and sparker surveys. This investigation, which synthesized results from acoustical, underwater photographic and bottom sampling data, revealed that sandstone bedrock with an intermittent veneer of sediments occurs on the sea floor between PEI and the Magdalen Islands, as well as to the north of the Magdalens. In contrast, the sea floor west and east of the Magdalens has an almost continuous sediment cover with only small exposures of bedrock. These sediments are considered to be mainly the erosional products of the bedrock locally intermixed with material foreign to the shelf area. It was also found that the major geomorphological features of the shelf are not related to present environmental conditions. Instead, the shelf shows the effects of extensive Pleistocene glaciation in the configuration of its submarine troughs, the occurrence of tunnel valleys, and in the composition of its sands and gravels.

b) Recent depositional conditions in the northeastern Gulf of St. Lawrence:

An investigation of recent depositional conditions in the northeast corner of the Gulf of St. Lawrence was initiated in 1965. Some 90 bottom sampling stations were occupied between the west coast of Newfoundland and the coast of Labrador as far north as the Strait of Belle Isle. Continuous echo sounding of the sampling lines was also carried out to provide detailed information on the submarine topography of the area. Preliminary analyses of the echograms and information derived from available hydrographic charts show that the sea floor in the central part of the Gulf between Cape Whittle, P.Q. and Bay of Islands, Newfoundland, is divided obliquely into two parts by a broad, semi-continuous, topographic 'high' on the bank (minimum water depth 20 fathoms) which extends northeastward to the Strait of Belle Isle. The topography north of the bank is rugged. Several semi-isolated basins, with water depths greater than 100 fathoms, occur between the central bank and the Quebec-Labrador coast. South of the central bank, a deep (water depths greater than 100 fathoms), funnel-shaped, submarine trough, known as the Esquiman Channel, extends southwestward from a point off Riche Pt., Newfoundland to join the Laurentian trough.

Preliminary analysis of the bottom samples shows that sand and gravel are the dominant sediment types on the banks, while greenish grey calcareous muds are

*Manuscript received 21 April, 1967

found in the isolated basins north of the central bank, and in the Esquiman trough. Sub-bottom reflections recorded in the Esquiman trough indicate that the thickness of the soft sediment layer, which probably forms the post-glacial sediment addition, varies regionally and has a maximum thickness of 60 feet in the central part of the trough. Near the coasts of Quebec and Newfoundland, in water depths less than 20 fathoms, sand and coralline encrusted gravel are the dominant sediment types. Further analysis of the data obtained in this area is being undertaken to provide more information on the interrelationships of submarine topography, sediment composition, sediment sources, present processes of sedimentation, and depositional history of the area.

2) Geochemical Investigations

Since 1964 it has been possible to extend the type and number of geochemical investigations by the use of atomic absorption techniques. During this period a study of the distribution and significance of calcium carbonate ($CaCO_3$) in the Gulf sediments has been completed, investigations have been made of the contribution of the different particle size-fractions to the major element content of sediments from the estuary, the geochemistry of sands from all over the Gulf, and the distribution and significance of "free" iron in sediments from selected areas. The results of these investigations, which will be published in detail elsewhere, are summarized in the following paragraphs.

a) Calcium carbonate in marine sediments of the Gulf of St. Lawrence:

Completion of carbonate analyses of over 400 samples provided a good picture of the distribution and significance of $CaCO_3$ in the marine sediments from the river and Gulf of St. Lawrence. It was found that sediments in the river, estuary and southern Gulf contain less than 5% by weight $CaCO_3$ while sediments in the Laurentian Channel, Jacques Cartier Passage and northeastern part of the Gulf contain between 5% and 30% carbonate. Sediments in the near-shore environs of Anticosti Island and at the southern end of the Strait of Belle Isle were found to have carbonate contents in excess of 30%. A study of these regional distribution patterns and the carbonate mineralogy shows that shell detritus is the main source of carbonate in sediments containing less than 5% $CaCO_3$, while those containing higher concentrations contain limestone detritus in addition to shell fragments and calcareous foraminifera. Limestone debris and detritus in the Gulf have been and are being derived from limestone bedrock on Anticosti Island, the Mingan Islands and the submerged reefs around these islands, as well as from the calcareous rocks on the sea floor between Labrador and Newfoundland. Since the calcareous material decreases in concentration away from these sources in a definite pattern, it has been possible to relate the patterns to the effects of present depositional conditions such as ice-rafting and past environmental conditions such as glaciation in the Gulf. In addition, it has been possible to map the distribution of limestone bedrock on the sea floor around Anticosti Island and in the northeastern part of the Gulf from the results of carbonate content studies of the samples. This study has also shown that carbonate in the sediments is not related to the shell content (fragments greater than 2 mm) of the sediment and that only two areas of the Gulf are prolific in calcareous foraminifera. Further study of these features of the carbonate distribution is contemplated.

b) Major element distribution in size fractions:

The study of the distribution of major elements (Si, Al, Ca, Mg, Na, K, Mn, Fe and P) in various size fractions of sediments from the estuary of the St. Lawrence provided definite confirmation of the constancy of the chemical-mineralogical composition of each size fraction, the chemical immaturity, and crystalline source

of these sediments. These results had been suggested from our previous study of the gross chemical-mineralogical composition of sediments from this area.

c) Geochemistry of sands in the Gulf:

Initial investigations of the chemical composition of sands from all over the Gulf shows that the distribution of the major elements can be used as a sensitive indicator of mineralogical variation within the Gulf sediments. At least four distinct chemical-mineralogical associations and their interrelationships have been identified so far in the Gulf sands with each association being diagnostic of its provenance and its past and present depositional history.

d) "Free" iron in Gulf Sediments:

Investigations of "free" iron, that is, amorphous iron compounds and secondary and primary iron oxides, in sediments from the Gulf were initiated as a basis for understanding the nature of physical-chemical exchanges at the sediment-water interface. Of immediate interest are the occurrence and formation of amorphous iron compounds and crystalline iron oxides associated with sediments at the sediment-water interface and the dissolution of iron oxide grain coatings in recently deposited sands.

So far it appears that selective chemical treatment results in the dissolution of amorphous and crystalline iron compounds and their associated trace elements to the extent of 5-10% of the sediment by weight, and that 20-70% of the total Fe and Mn in the sediments is contained in this fraction. The results also suggest an affinity with the extractable iron compounds of other metallic cations such as Cu, Co, Ni, Cr and V. It seems from our preliminary work that the retention and mobilization of many of the metallic cations at the sediment-water interface is directly related to the formation and dissolution of these iron compounds under the present physical-chemical conditions. Further work is being done to evaluate these processes.

PREVIOUS REPORTS*

NOTA, D.J.G. and LORING, D.H., 1964, Recent depositional conditions in the St. Lawrence river and Gulf, Marine Geology, 2, p. 198-235.

LORING, D.H. and LAHEY, R.J., 1965, Rapid silicate analysis of marine sediments. Fish. Res. Bd. Canada, MS Rept. Series (Oceanogr. and Limnol.), No. 189, 53 pp.

_____ and NOTA, D.J.G., 1966, Sea floor conditions around the Magdalen Islands in the southern Gulf of St. Lawrence. J. Fish. Res. Bd. Canada, 23(2): 1197-1207.

_____, 1966, Geomorphology of the sea around the Magdalen Islands in the southern Gulf of St. Lawrence (Abstract), Geological Association of Canada Annual Meeting, 1966.

GILBERT, R.L.G., MELANSON, R.C., EATON, R.M., LORING, D.H., and KING, L.H., 1966, An experimental evaluation of the Kelvin-Hughes horizontal echo sounder off the east Canadian coast. Bedford Institute of Oceanography Internal Note, 66-4-1. Unpublished manuscript.

* Not including reports appearing in Annual Reports (1964-1966) of the Atlantic Oceanographic Group, Fisheries Research Board of Canada, Dartmouth, N.S.