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Preliminary Observations on Suspended Matter in the Gulf of St. Lawrence*

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Introduction

In the exchange of solid matter between the St. Lawrence basin and the deep-sea, the Gulf of St. Lawrence acts as a temporary reservoir for the suspended matter. Recent studies by Griffin et al (1968) have indicated the importance of the contribution of the St. Lawrence drainage to pelagic sedimentation in the Atlantic Ocean. It is therefore of some geochemical interest to try to assess the total budget of matter for the Gulf of St. Lawrence by determining gains and losses to this system. In this preliminary survey, the purpose was to gather simple observations of the concentration, distribution and composition of the suspended matter in the Gulf and to determine if significant differences exist between early spring and middle summer. On the basis of information already published on current velocities, an attempt was also made to obtain general figures on the net flux of suspended matter at two critical points of the Gulf: Cabot Strait and the Gaspé Passage.

Method

The data were collected during two cruises: one in August 1967 aboard CSS HUDSON, another in the spring of 1968 aboard CSS BAFFIN (Fig. 1). The two sections mentioned above were surveyed in both seasons. Maximum volumes of one-gallon per sample were filtered during the first cruise. To minimize the error, two-gallon samples were processed in the second cruise. Filtration was done immediately through preweighed, 0.8μ - Millipore filters. These filters were washed thoroughly with distilled water before storage. In the laboratory, gravimetric determinations of filter residues on a Cahn electrobalance were made before and after ashing at 800°C in a muffle furnace. The weighing accuracy, based on control filters, was 10μg. Grain counting and sizing of inorganic particles on the filters were done under the microscope, and X-ray diffraction analysis of the suspended matter was made directly on material collected on metallic membrane filters. Standard oceanographic observations allowed the interpretation of the distribution of particulate matter in terms of water masses and σ_t.

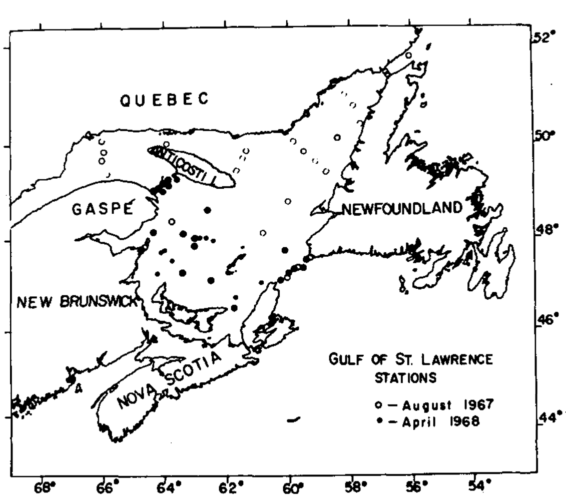

Fig. 1 Survey area and sampling stations in the Gulf of St. Lawrence.

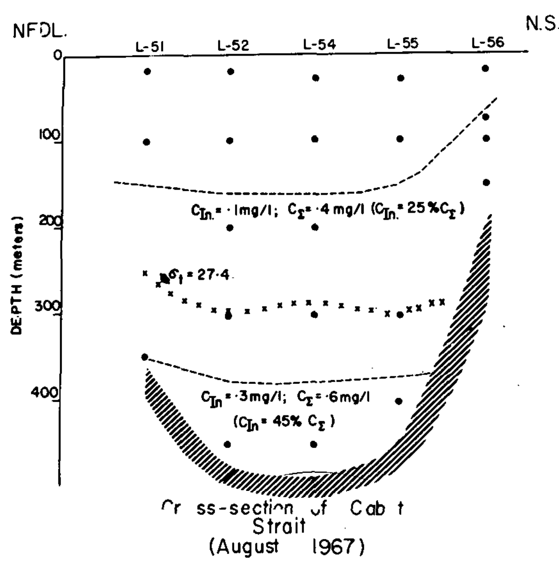

Fig. 2 Cross-section of Cabot Strait showing concentrations of total (Σ) and inorganic (In) suspended matter in April 1968.

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Observations

Concentrations of total particulate matter in the Gulf of St. Lawrence were lower than expected for inshore waters influenced by the estuary of a major river, with most values between 0.3 mg and 1.0 mg per litre, and only a few values nearing 2 mg/l. No significant seasonal differences were observed between spring and summer, possibly because only very few summer observations were carried out in deep waters where the larger concentrations occur.

In a spring section across Cabot Strait, a concentration gradient was found to exist with a consistent three-layer distribution of values (Fig. 2). From the surface to 150 metres, the total suspensoid concentration was 300 to 400 μg/litre, the inorganic fraction being only 10 to 15% by weight (less than 100 μg/litre). From about 150 metres to approximately 350 metres, the total concentration values do not change appreciably but the inorganic fraction represents 25% to 30% of the total weight. Below approximately 350 metres, total concentrations rise to 600 to 700 μg/litre, with the inorganic fraction making 45% of the total. The nepheloid layer was entirely within the bottom waters as defined by the position of the isopycnal $\sigma_t = 27.64^{\circ}C$ (Forrester, 1964).

A mean net flow across Cabot Strait of .52 x 10^6 m^3/sec was computed by McGregor (1956) for levels above the 400-metre isobath which was taken as the level of no motion. Water budget considerations for the entire Gulf require, however, mean inward velocities of approximately 2 cm/sec or so below this depth. Suspensoid concentrations across the Strait are uniform enough to attempt, as a first approximation, an estimate of the in and out suspended transport based on these low values.

For total and inorganic suspended matter, mean deep-water inward transports of 2 x 10^3 tons/day and 1.1 x 10^3 tons/day respectively are indicated. The outward inorganic transport above the 400-metre level is approximately 4.5 x 10^3 tons/day, thus roughly four times the inward flux. The material carried into the Gulf in the deep layer could be supplied either by settling from the St. Lawrence effluent outside the Strait, or from nearby outside sources, either the Grand Banks or the Scotian Shelf. The August 1967 section across Cabot Strait was not deep enough to outline the presence of a deep water turbidity layer for this season, but surface and intermediate water concentrations were consistent with those observed in the spring.

For the spring also, several stations along the Laurentian Channel between Cabot Strait and the Gaspé Passage indicate the persistence of the vertical gradient observed at the entrance of the Gulf and the continuity of the nepheloid layer over the bottom.

In the Gaspé Passage the nepheloid layer is observed under the Gaspé Current in both spring and summer while it is not as evident along Anticosti Island (Fig. 3). The summer deep-water concentrations along the channel adjacent to Gaspé were significantly higher than for the spring, but more work is needed to ascertain if these values are representative of summer conditions along the whole Laurentian Channel, or if they are only the results of local effects. The low surface salinities in the summer months reflect a large spreading of St. Lawrence waters in the Gulf at this time and one would expect an increase in the supply of suspended load from the river, which toward the end of August could show up in higher turbidity levels in deep waters.

Making an estimate of the net suspended flux across the Gaspé Passage is difficult because of variations both in flow conditions and suspended load concentrations in this section. Farquharson (1966) gives velocities for upstream residual currents in the order of 5 cm/sec below 80 metres along Gaspé, against 25 cm/sec in the Gaspé Current.

East and west velocities are considerably lower along Anticosti Island. Computations based on these data and the spring concentrations suggest an upstream suspensoid flux of 4,000 to 5,000 tons/day of inorganic matter for the region under the Gaspé Current alone, thus at least four times the upstream flux in Cabot Strait.

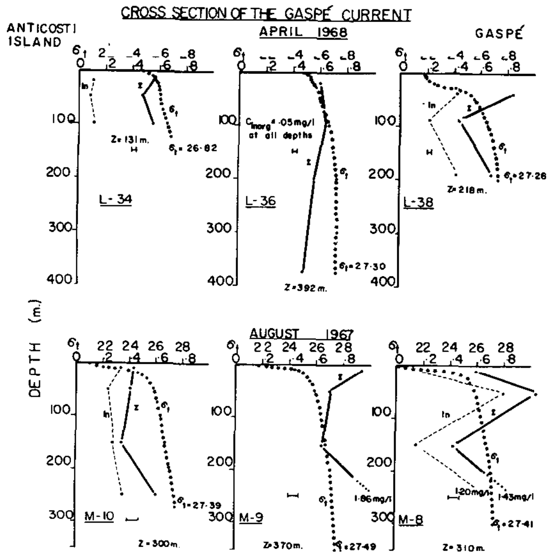

Fig. 3 Total and inorganic suspended matter (in mg/l), and σ_t in the Gaspe Passage, August 67, April 68.

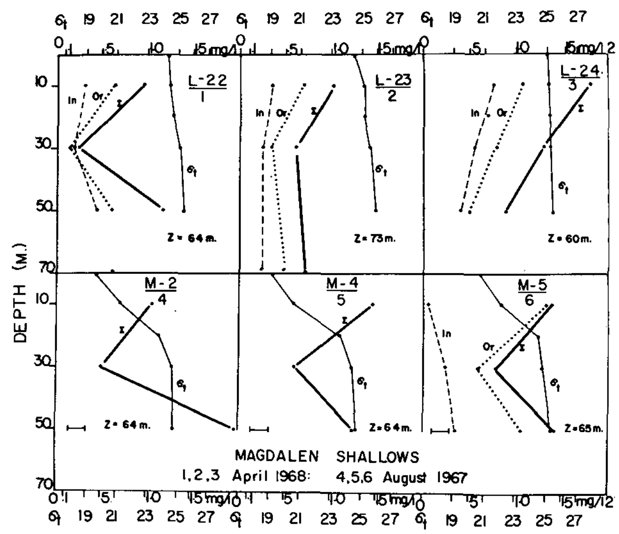

Fig. 4 Concentrations of inorganic (In), organic (Or) and total (Σ) suspended matter over the Magdalen Shallows August 67, April 68.

An upstream increase in the suspended load of the deep layer is realistic if, with respect to suspended sediments, the Gulf acts as a partially closed reservoir with the suspended load from the surface waters being supplied by settling to the bottom waters and refluxed toward the western end of the Gulf; also, if added contributions come from regions north and south of the Laurentian Channel. In particular one can expect that the Magdalen Shallows, which have high levels of suspended matter and very little fine bottom sediments, may be a source of fine sediments for the deep waters.

In poorly stratified estuaries, it has been noted (Postma, 1967) that a turbidity maximum exists toward the furthest reach of the tidal incursion and that silting very often takes place at this point with material coming mostly from downstream. There are indications that this estuarine feature exists to some extent in the Laurentian Channel and is fully developed under the Gaspé Current and westward. Acoustic sections described by Nota and Loring (1964) have indicated that the thickness of post-glacial muds in the Laurentian Channel increases significantly to the west of Anticosti Island. It is suggested that bottom reflux of suspended load and the observed turbidity maximum may have something to do with the deep cover of recent sediments over the western part of the Gulf.

Over the Magdalen Shallows large relative concentrations of suspended matter were observed during both cruises (Fig. 4). Values are several times as high as those at the same depths over the nearby Laurentian Channel, suggesting dynamic isolation. Because of the presence of the main amphidromic point for the Gulf near the Magdalen Islands, strong circulatory motions over the shallows may set up cells that will temporarily trap suspended matter. A marked increase in suspended load over the bottom may here be attributed to resuspension, with values of the concentration in midwater commonly lower than those from above and below. This pattern of distribution is more frequent in summer than in spring suggesting that the summer pycnocline may reinforce this distribution.

Nature of the Suspended Material

The suspended matter collected on metal membrane filters was examined directly by means of X-ray diffraction. The first-order illite and second-order chlorite reflections are broad and diffuse compared with similar reflections for the fine-fraction of bottom sediments, and the illite/chlorite ratio appears significantly reduced. Amphibolite, quartz and plagioclase are also present. Quartz in sediments is observed in material as small as .5 micron, carefully isolated by centrifugation, and it is therefore not surprising to find it abundant in the suspended load. A mixed-layer clay having a basal reflection of approximately 12Å is found in both suspended and bottom clays. Biscaye (1965) has shown a systematic decrease in ML basal spacing from low to high latitudes in Atlantic pelagic sediments, with values between 12 Å and 13Å around 45°N latitude. The present observations indicate that the Gulf could be a source for this material.

Size determination of inorganic suspended particles under the microscope after impregnation of the filters in Permount indicate that there is hardly any suspended material larger than 16 microns in diameter.

Conclusion

Much work remains to be done before one arrives at a quantitative understanding of the suspended flux through the Gulf of St. Lawrence. These preliminary observations indicate, however, the existing ranges of concentrations and underline the role played by the estuarine-type circulation in regulating the exchange between the Gulf and the open ocean. Although the values observed are low, the abundance of both fine muds in recent Gulf sediments and chlorite-rich clays in areas of the Atlantic Basin south-east of Newfoundland indicate the possible importance of the suspended transport from the St. Lawrence drainage system, and invite further studies. The significance of the upstream transport in the deep water also requires a closer examination.

Acknowledgements

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