Suspended Matter in the Southern Beaufort Sea

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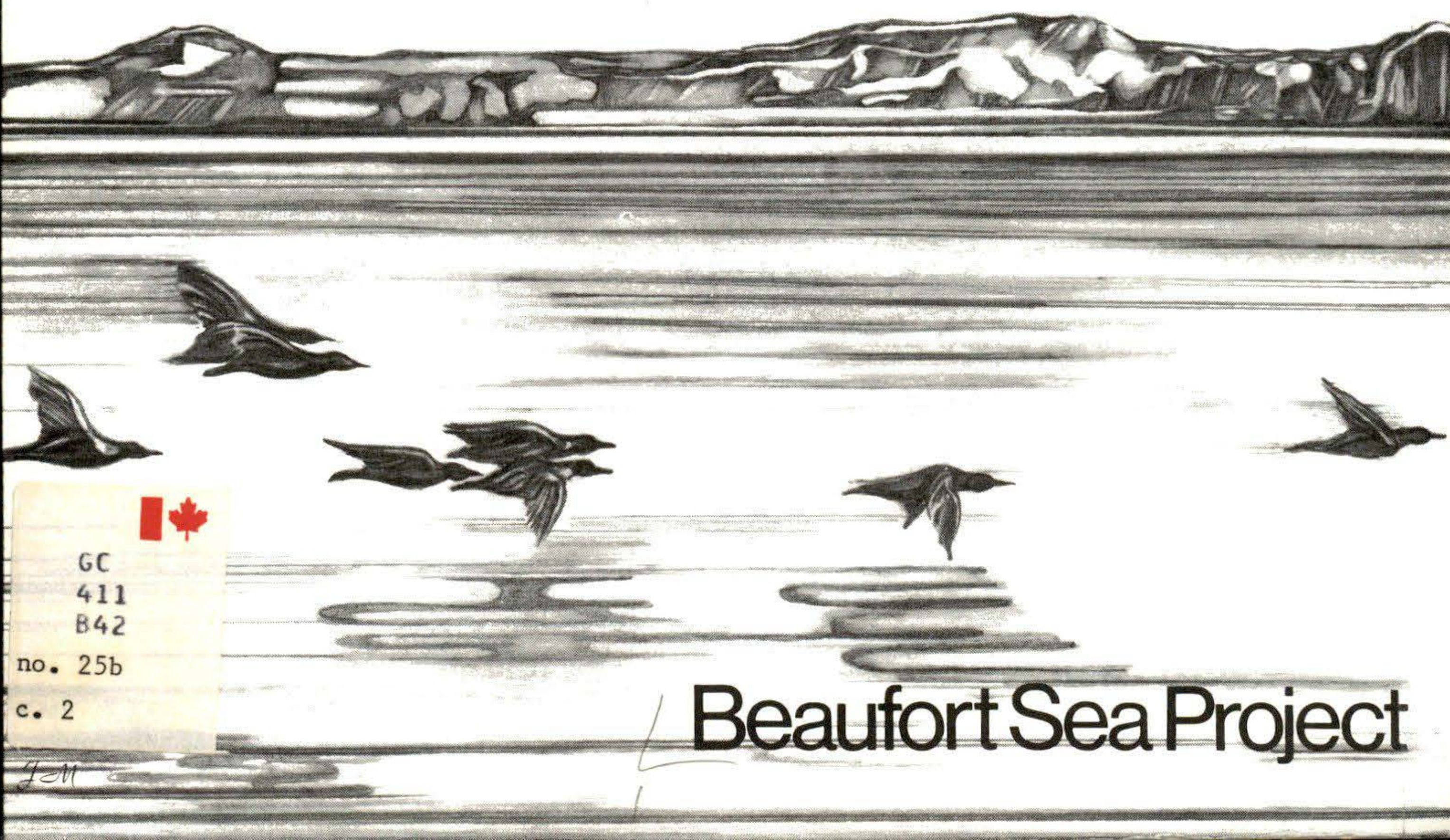

Beaufort Sea Project

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1. SUMMARY.

Concentrations of suspended matter measured in the southern Beaufort Sea in August and September, 1975 ranged from less than 0.1 mg/l to more than 17 mg/l. The highest concentrations were recorded at nearshore stations off Kugmallit Bay. Mid-water and near-bottom zones of turbid water are common, though their exact causes are not clear.

The distributional pattern of suspended matter reflects closely the physical oceanography of the area. As seen from satellite photographs, the sediment plume from the Mackenzie River is carried eastwards along the inner shelf while the plume emanating from Kugmallit Bay remains as a distinct band of turbid water along the southwestern Tuktoyaktuk Peninsula. The small basin southeast of Herschel Island receives considerable suspended sediment from longshore drift produced by a small clockwise eddy and the easterly flow past Herschel Island. The anticlockwise gyre which flows south and southeastward into Mackenzie Bay, brings little suspended matter into the shelf waters west of Herschel Island.

The major components of the suspended matter include fine inorganic particles, organic aggregates of plankton and inorganic particles, and phytoplankton. Throughout the area the clay minerals display distinct differences. The Mackenzie Bay and outer shelf samples contain montmorillonite, kaolinite and little chlorite and inshore samples off Kugmallit Bay contain no kaolinite or montmorillonite and abundant chlorite.

2. INTRODUCTION

In terms of suspended load, the Mackenzie River is the third largest river entering the Arctic Ocean (Lisitzin, 1972). It contributes 15 x 10^6 tons of suspended matter annually and is surpassed only by the Lena (15.4 x 10^6 tons) and the Ob (15.8 x 10^6 tons). Despite its obvious importance in the sedimentary budget of the Arctic Ocean, little is known of the fate or composition of Mackenzie River suspended sediment as it enters the Beaufort Sea.

Between August 20 and September 9, 1975, suspended matter samples were collected from M/V THETA in the southern Beaufort Sea (Figure 1). Three transects across the shelf were completed in order to determine the concentration and composition of suspended matter off the Mackenzie delta, and to attempt to relate them to prevailing oceanographic conditions.

3. METHODS

The methods used in the collection and analysis of suspended matter samples are similar to those described by Manheim *et al.* (1970, 1972). Surface water samples were collected using a polythylene bucket; the remainder were obtained using 5-l Van Dorn bottles placed at specified intervals, usually 8, 25, 48, 75, 98, 125, 138 m and 3 to 4 metres above the sea floor. Niskin and/or Nansen bottles, with reversing thermometers, were placed usually at 10, 20, 30, 50, 75, 100, 125, 150 m and two metres above the bottom for salinity and temperature determination. In addition, subsamples of the large-volume samples were drawn off for salinity determination. Salinities were measured at the Bedford Institute of Oceanography following the cruise.

Suspended matter samples were filtered through pre-weighed Nuclepore[R] filters, Millipore [R] filters and Selas Flotronics [R] silver filters. All filters have a nominal pore diameter of 0.45 μm. The Nuclepore filters were washed thoroughly with distilled water following filtration and were air-dried and reweighed following the cruise in order to obtain the concentration of suspended matter in the sea water. The precision of this method is 0.05 mg (Tucholke, 1975). Weights of total suspended matter collected ranged from 0.10 mg to 16.3 mg, averaging about 1.0 mg. Except for very turbid waters, between 1 and 3 litres were filtered for each sample.

The Millipore filters were washed in distilled water, dried, and small segments mounted in oil (R.I. 1.51) on glass slides. These slides were then examined under a petrographic microscope and the composition of the suspended matter determined. Interesting components were photographed.

The silver filters were used for X-ray diffraction analysis of the mineral composition of the suspended sediment (CuKα, 2°2θ/min). As has been found by other investigators (Manheim *et al.*, 1972; Milliman *et al.*, 1975) organic matter in sea water frequently clogs the filter before sufficient terrigenous material has been collected to yield a good diffractogram. Only those filters which appeared to contain appreciable inorganic material were analysed. Of those, only three samples were chosen for further analysis; these filters were glycolated and heated to 550°C. Peak heights were, in general, too small to permit anything but a qualitative assessment of the clay mineral composition.

4. RESULTS.

4.1 Suspended Matter Concentrations

Profiles of suspended matter concentration, temperature and salinity are shown in Figures 2. through 5. and the results are included with wind and station data in Appendix I.

In general, concentrations were greatest in the nearshore waters off Kugmallit Bay (Stations 101, 179, 180) where values exceeded 1.25 mg/l. Station 180 yielded concentrations of 13.4 and 17.5 mg/l at the surface and at 6 m, respectively, the highest values found. Concentrations were markedly higher in samples collected east of Herschel Island: the average of all eastern samples (excluding stations 101, 179 and 180 which have very high values) is 0.63 mg/l compared to 0.36 mg/l for transect N west of Herschel Island.

Aside from the extremely turbid shallow-water samples, the highest concentrations (about 1.6 mg/l) were found beyond the shelf edge in mid-water samples (75 and 138 m) at station 107. Mid-water maxima were also found at several stations on the shelf and very turbid near-bottom water, as found by Herlinveaux and de Lange Boom (1976), was a very common feature.

Station 153 (Figure 5.) was located in the large depression south-east of Herschel Island. Concentrations were high (about 1.0 mg/l) and unusually uniform throughout the water column. Station 168 Figure 5.), located adjacent to and east of the Mackenzie Canyon had a surface water concentration of 1.2 mg/l and near-bottom values of less than 0.4 mg/l.

4.2 Suspended Matter Composition.

The most commonly observed components of suspended matter seen on the Millipore filters were: (1) fine (less than 5μm) mineral particles (Figure 6.); (2) organic aggregates of mineral grains and plankton commonly 100 to 400μm in size (Figure 6.); (3) dense, red-brown aggregates of mineral particles, usually 40 to 100 μm in size but occasionally up to 300 μm (Figures 6.and 7.); and (4) plankton, principally silicoflagellates and diatoms (Figure 7.). The red-brown aggregates frequently appeared to have the form of a cross developed on a circular central nucleus (Figure 6.). In addition to the above, other components such as pollen grains and iron-stained quartz (up to 60 μm) were occasionally encountered.

No clearly defined distributional patterns were apparent in the major components. Samples from station 180, which had very high concentrations of suspended matter, consisted entirely of inorganic material, both as individual fine particles and as organic aggregates. Elsewhere however, all types of component were present, with the trend being toward slightly higher organic contribution west of the Mackenzie River mouth (transect N). Within the main sediment plume from the Mackenzie River (Station 168) a high concentration of a diverse diatom flora was present.

4.3 Clay Mineralogy.

Examination of diffractograms from 17 samples yielded a qualitative picture of the clay minerals in the suspended sediment. Illite is the dominant clay mineral throughout the area and displays no apparent trends. Chlorite appears to be abundant in the turbid water emanating from Kugmallit Bay (Station 180; Figure 8a) but is much less common offshore. Kaolinite is practically absent in nearshore waters east of the delta (Station 180, Figure 8a) but is present farther offshore (e.g. Stations 107, 174; Figure 8b). Montmorillonite is absent from nearshore waters northeast of Kugmallit Bay (Station 180; Figure 8a) and only appears to be significant in the offshore stations of transects A and K (Station 174; Figure 8b) and to a lesser extent in the mouth of the western Mackenzie River channel (Station 153; Figure 8c).

4.4 Physical Oceanography

The temperature and salinity data are consistent with previous results and reveal several interesting features of the circulation in this area. The transects were occupied over a period of three weeks under a wide range of wind and ice conditions making correlation between them impossible.

The water along transect K (Figure 2.) was sampled in ice-free waters in mid-August and is characterized by a layer of fresh (<$20^{0}/_{00}$), warm (>5^{0}C) water, 9 to 15 m thick, and extending over the shelf edge, approximately 95 km from shore. Beneath this surface layer, isotherms and isohalines slope southward indicating a flow of shelf waters toward the east. This concept is compatible with models for Beaufort Sea circulation (Cameron, 1953; O'Rourke, 1974; Herlinveaux and de Lange Boom, 1976) and with current meter results (S. Huggett, unpublished data) which show persistent easterly currents on the shelf in this area.

Temperature and salinity values along transect N (Figure 3), west of Herschel Island, show a markedly thinner surface layer of warm, fresh water than along transect K. Surface water temperatures were consistently less than 2^{0}C; the halocline lies at 4-5 m depth. Upwelling is evident from the penetration of cold (< -1.5^{0}C), saline (> $32.4^{0}/_{00}$) water to within 20 m of the surface. The samples were taken during a period of northwesterly winds indicating that upwelling was not actively occurring; the subsurface temperature and salinity distributions were apparently remnants from a few days previous when steady 15-30 km/hr esterly winds had dominated for several days.

The waters along transect A (Figure 4) were sampled with 3/10 to 6/10 ice in early September. The results are characterized by a thick (12 m) surface layer of low salinity water (<17.5%) over 50 km wide. Unlike values from transect K, however, these low salinities do not have correspondingly high temperatures. Except for a 2 to 3 m surface layer of 2 to 3^{0}C water, isotherms rise toward the surface into this layer of fresh water. The low salinities and temperatures in this area are thought to be a combination of river outflow and degradation of sea ice.

5. DISCUSSION AND CONCLUSIONS

The distribution of suspended matter appears to be compatible with the concepts of circulation advanced by previous workers. Currents on the shelf off the Mackenzie delta (Figure 9.) appear to be predominantly anticlockwise, carrying the warm, fresh-water sediment plume from the river mouth eastward along the Tuktoyaktuk Peninsula, as is evident in satellite photos of the area (Figure 10). This anticlockwise pattern draws water southward into Mackenzie Bay from the westward-flowing Pacific gyre located farther offshore and results in markedly higher salinities and lower nutrient values (Grainger, 1974) in the western part of the Bay (station 153; 21^{0}/oo) than exist to the east (station 168, 11^{0}/oo).

This pattern has important implications for the distribution of fine sediment in the southern Beaufort Sea. The southward flow of offshore water past Herschel Island into Mackenzie Bay brings little suspended matter into shelf waters west of the Mackenzie River as indicated by the observed low sediment concentrations (less than 60% of those to the east of the delta), by the absence of fine sediments collecting on the shelf north of Herschel Island (Pelletier, 1976) and by the preferential build-up of stratified sediments on the east side of Mackenzie Canyon (Shearer, 1972). Though this pattern appears to be the most common, it is probable that, during periods of prolonged easterly or northeasterly winds, some Mackenzie River water is carried westward and off-shore. Such conditions are known to occur 10 to 20% of the time during July and August (Wilson 1974) and result in upwelling, such as that observed along transect N, and in the northwestward transport of low salinity water from Mackenzie Bay (O'Rourke, 1974).

The relatively high sediment concentrations (about 1.0 mg/l and salinities throughout the water column at station 153 are interpreted as being the result of local shoreline sediment being mixed in water of a clockwise eddy drawn from the main anticlockwise gyre as it passes Herschel Island (Figure 9). This conclusion is supported by the orientation of shoreline features (e.g. Kay Point). The high salinities indicate that most of the sediment has been derived from the longshore drift of material originating on Kay Point and southeastern Herschel Island, with only a small amount coming from the Babbage and Firth Rivers except in periods following storms or during breakup. This concept is consistent with the results of McDonald and Lewis (1973) and Lewis and Forbes (1974) who document the substantial coastal retreat in this area.

The clay minerals are in general agreement with the average composition of Mackenzie River sediment (Dewis *et al.*, 1972) and with values found in samples from the continental shelf (Naidu and Mowatt, 1974; B.R. Pelletier, personal communication). Marked regional differences do exist, however, in the suspended sediment mineralogy. The plume emanating from the main Mackenzie River distributary is characterized by a clay mineral assemblage which includes small amounts of kaolinite and montmorillonite. The outflow from the eastern distributary, on the other hand, contain appreciable chlorite and no montmorillonite or kaolinite. From these limited mineralogical data and from direct observations from the air (C.P. Lewis, personal communication), it appears that the plume emanating from the eastern branch of the Mackenzie retains its integrity for much of the distance along the Tuktoyaktuk Peninsula rather than mixing with the main Mackenzie plume.

One of the most noteworthy features apparent from the microscopic examination of the suspended matter is the prevalence of organic aggregates. As Manheim *et al.* (1972) pointed out, the literature on particulate organic matter in sea water is large and controversial, particularly with regard to its origin. They feel that in the Gulf of Mexico fecal pelleting by zooplankton is the dominant source of aggregates of organic matter, mineral grains and diatom frustules and is an extremely important process in the rapid removal of suspended matter from the water column. Similar conclusions were drawn by Bornhold *et al.* (1973) for the eastern Gulf of Guinea. In the southern Beaufort Sea, however, this explanation appears less adequate to explain the very high concentrations of aggregates observed; zooplankton productivity is rather low within the area (Grainger, 1974; D. Faber, personal communication) and few of the observed aggregates had shapes resembling typical fecal pellets (Figure 6). It is felt that most of the aggregates probably originate in the river itself, with only a small proportion produced through fecal pelleting.

The red-brown, nearly opaque grains are believed to be aggregates of colloidal iron oxide and hydroxide and organically complexed iron which are formed both within the river system itself and where the river water enters the sea (Krauskopf, 1967; Head, 1971). Suspended matter in the Mackenzie River system contains appreciable iron, ranging from 2.2% to 14% (Reeder, 1973), with most values falling between 3 and 5% The latter are average values for detrital clays (Blatt *et al.*, 1972).

Very high near-bottom sediment concentrations in the Beaufort Sea were apparent both in light transmission measurements (Herlinveaux and de Lange Boom, 1976) and in the suspended matter samples, and are common features elsewhere on continental shelves (e.g. Kulm *et al.*, 1975; Lyall *et al.*,1970). Herlinveaux and de Lange Boom (1976) suggest that these zones were the result of the tremendous sediment loads in nearshore waters creating turbidity currents which flowed seaward along the bottom. A similar explanation is put forward by Moore (1969) to explain the offshore transport of fine sediment off California.

In the light of data collected during the summer of 1975, this explanation appears untenable. Suspended matter concentrations of at least several thousand mg/l would be required to permit nearshore water (σ_t<10-15) to flow offshore and displace near-bottom waters (σ_t>25). Such concentrations are at least two orders of magnitude greater than the highest measured values (15-20 mg/l). Such underflows also would be expected to produce distinct high temperature and low salinity anomalies in the near-bottom waters of high turbidity; these were not observed in the present study. These two arguments are presented by Drake (1971) to discount the role of turbidity currents off southern California as proposed by Moore (1969).

Low density turbidity currents are believed to be of importance only where canyons indent the shelf and bring colder, more saline water directly beneath the sediment plumes from the Mackenzie distributaries. Sediment fallout from the overlying waters may raise bottom-water densities sufficiently high to permit the generation of turbidity currents.

Several possible meachanisms appear to exist to account for near-bottom turbidity: (1) unidirectional bottom currents; (2) surface waves associated with storms; (3) tidal currents; and, (4) breaking internal waves. Kulm *et al.*,(1975) favour unidirectional bottom currents and storm waves to account for turbid water at depths to 125 m off Oregon. Current velocities on the Beaufort shelf related to tides are as high as 15 to 18 cm/sec (S. Huggett, unpublished data) and, thus, are capable of at least keeping silt and clay in suspension near the bottom and possibly of resuspending them. Lyall *et al.*, (1970) stress the importance of short-term, sporadic variations in water masses (principally internal waves) in the resuspension of sediments along the shelf edge off Delaware. During periods of ice cover, unidirectional and tidal currents may become accentuated on the shallow Beaufort Sea shelf. This accentation may explain the high turbidity observed in near-bottom waters from a submersible in the summer of 1974 (Shearer and Blasco, 1975).

Although all of the above mechanisms may play a role in the creation of near-bottom turbid layers in the southern Beaufort Sea, their relative contributions will not be known until detailed observations are undertaken.

Mid-water turbidity maxima are common in the southern Beaufort Sea andelsewhere in continental shelf water (e.g. Kulm *et al.*, 1975; Drake, 1971) and are generally attributed to the slower settling of particles as they sink below the thermocline. No clear relationship exists between concentrations of mid-water suspended matter and the position of the halocline or thermocline in the southern Beaufort Sea, however. More closely spaced samples combined with transmissometer and STD profiles will be required to explain the origin of these features.

6. ACKNOWLEDGEMENTS

The suspended matter sampling program was undertaken during the course of other marine geological investigations under the direction of Dr. C.F.M. Lewis. I should like to express my thanks to Dr. Lewis, Dr. B.R. Pelletier, Glen Tite, Roland Wahlgren and Steve Blasco for collecting and filtering the samples. Drs. Lewis and Pelletier critically reviewed the manuscript and provided many helpful suggestions during it preparation.

Salinity measurements were made by C. Cunningham of the Atlantic Oceanographic Laboratory at the Bedford Institute of Oceanography.

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FIGURE TITLES

Figure 1.- Location map of the southern Beaufort Sea showing the suspended matter stations occupied during August and September, 1975.

Figure 2.- Profiles of suspended matter, temperature (T^oC) and salinity ($S^o/_{oo}$) along transect K.

Figure 3.- Profiles of suspended matter, temperature and salinity along transect N.

Figure 4.- Profiles of suspended matter, temperature and salinity along transect A.

Figure 5.- Profiles of suspended matter, temperature and salinity at Stations 153 and 168.

Figure 6.- Photomicrographs of suspended matter components

(a) red-brown aggregate of particulate iron;
(b) organic aggregate of mainly inorganic grains; large opaque grains are aggregates of particulate iron;
(c) and (d) organic aggregates consisting mainly of inorganic particles.

Figure 7.- Photomicrographs of suspended matter components. Scale bar is 100μm.

(a) a 'chain' of diatoms, a small organic aggregate, and a dark, red-brown aggregate of particulate iron in the form of a cross around a circular nucleus;
(b) a fragment of a large marine diatom (*Coscinodiscus* sp.);
(c) marine diatoms (*Chaetoceros* sp.);
(d) silicoflagellates.

Figure 8.- X-ray diffractograms of suspended matter with samples untreated (u), glycolated (g), and heated to 550°C (h). Q-quartz, I-illite, C-chlorite, K-kaolinite, M-montmorillonite, Ag-silver (filter). Degrees 2θ are indicated on the diffractograms.

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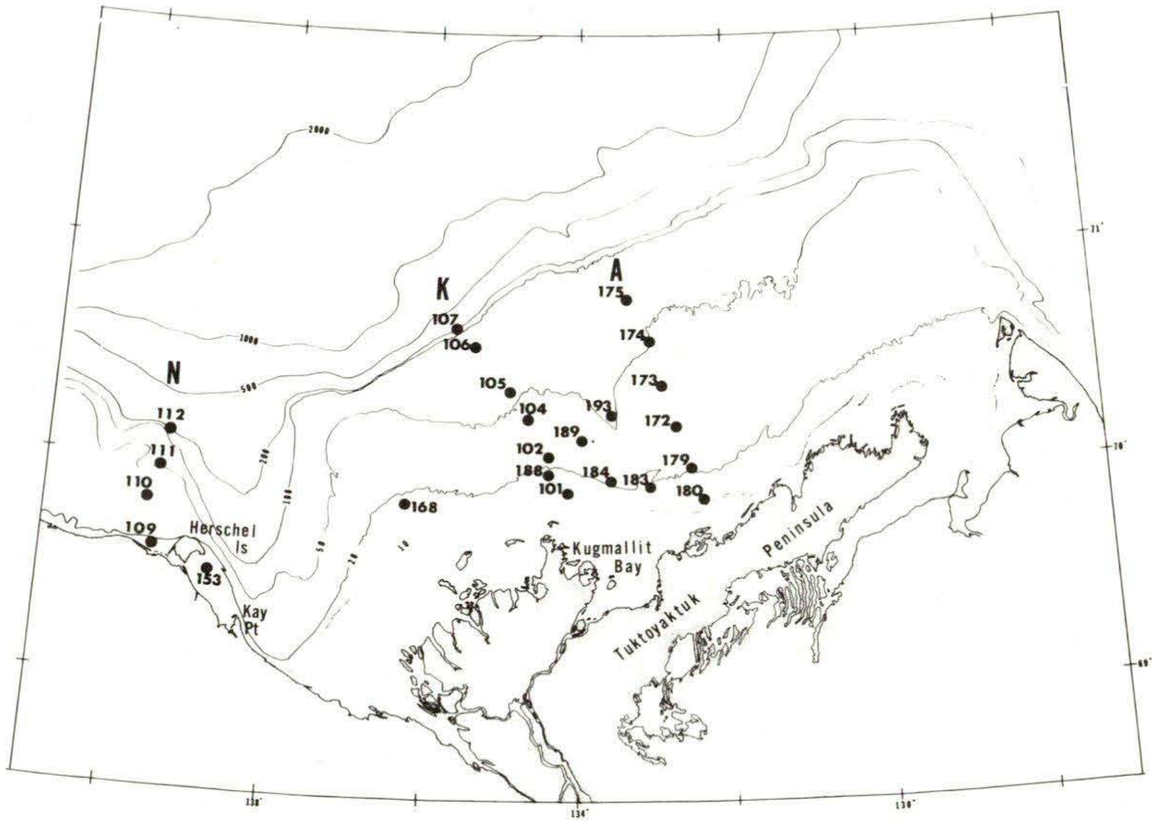
Figure 10.- Satellite photograph (7 September 1973) of the Mackenzie delta showing the eastward flow of sediment-laden water from the main river channel.



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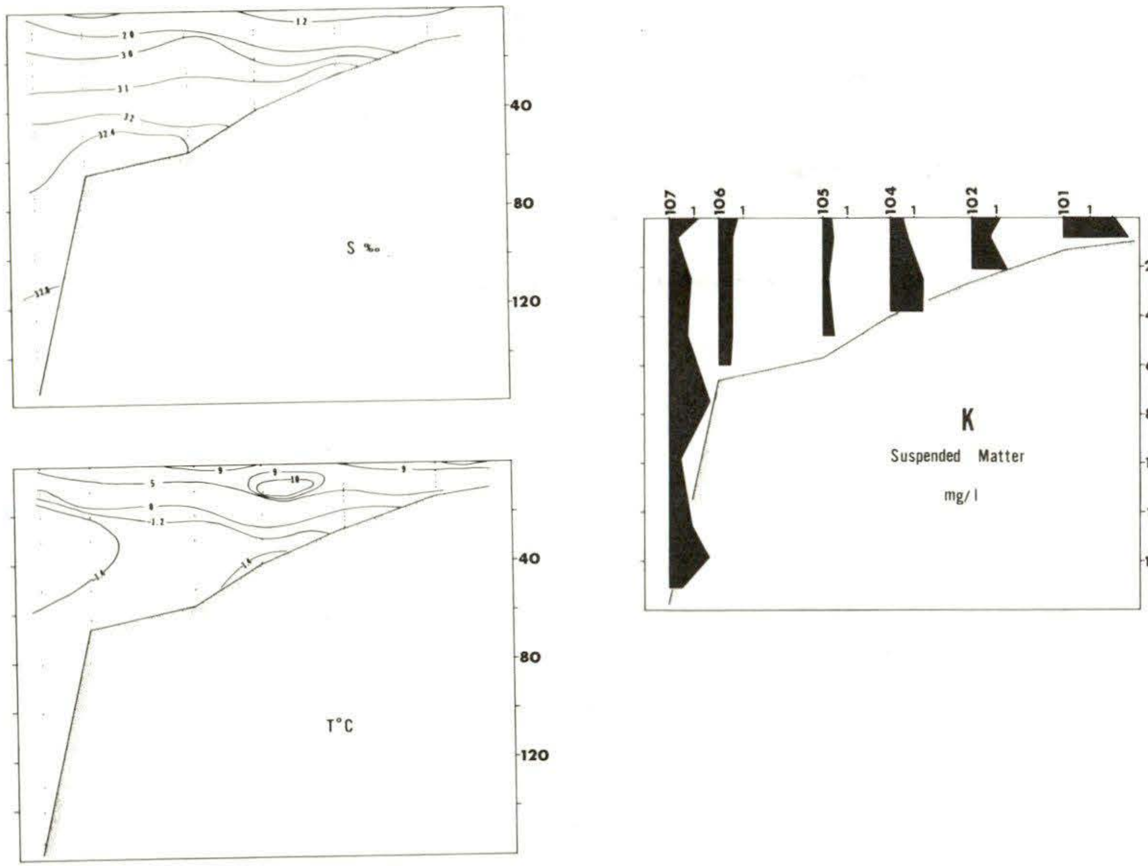

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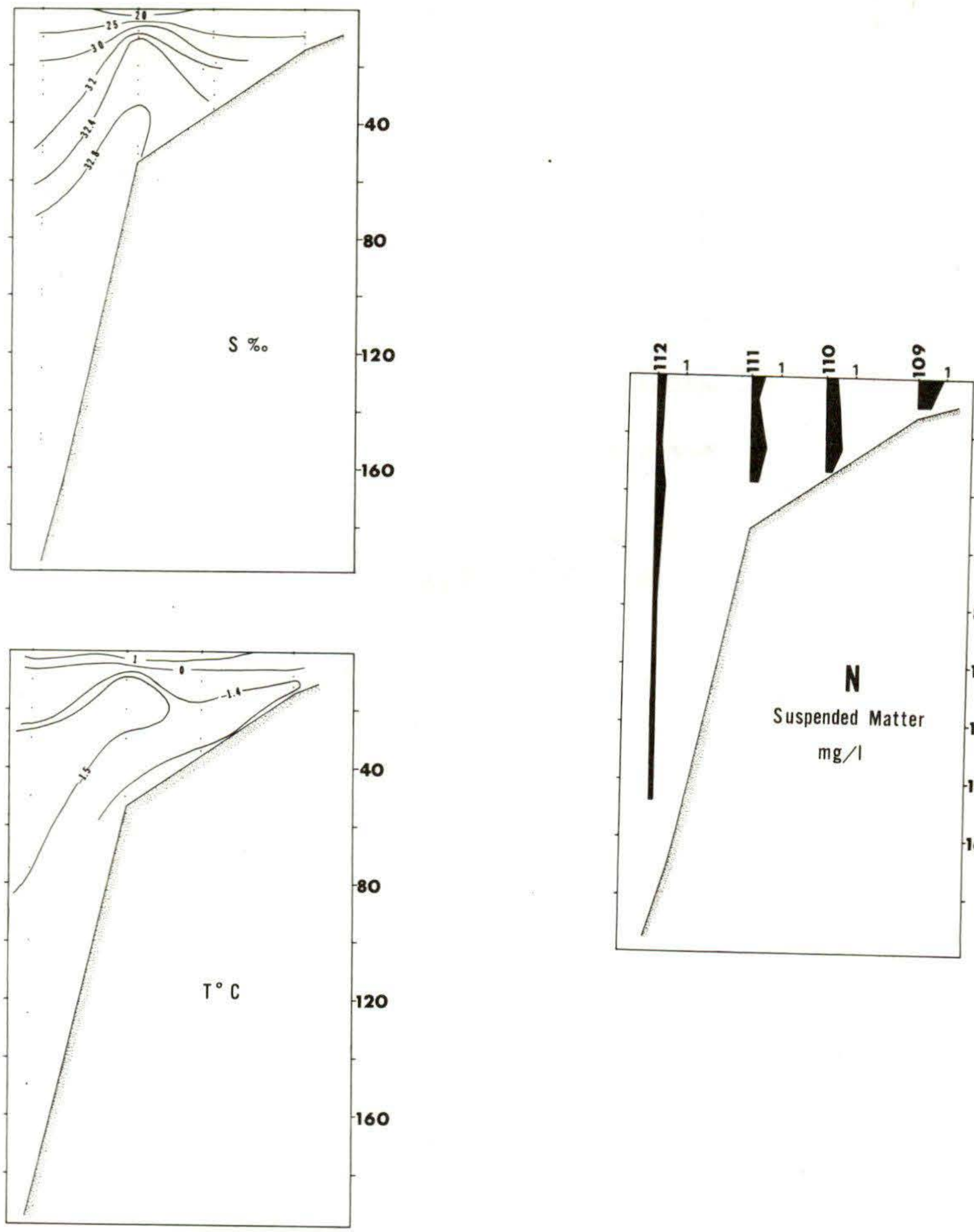

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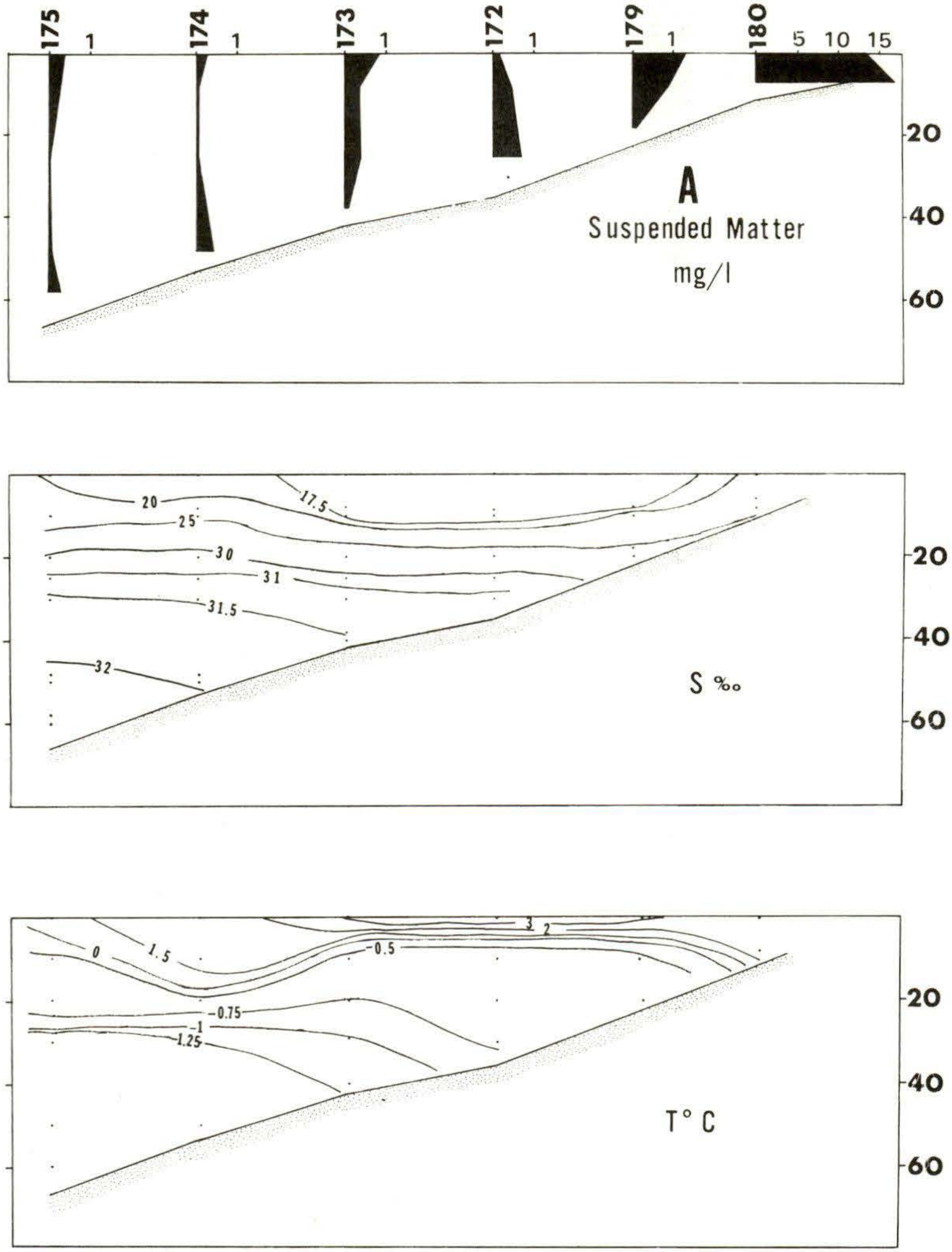

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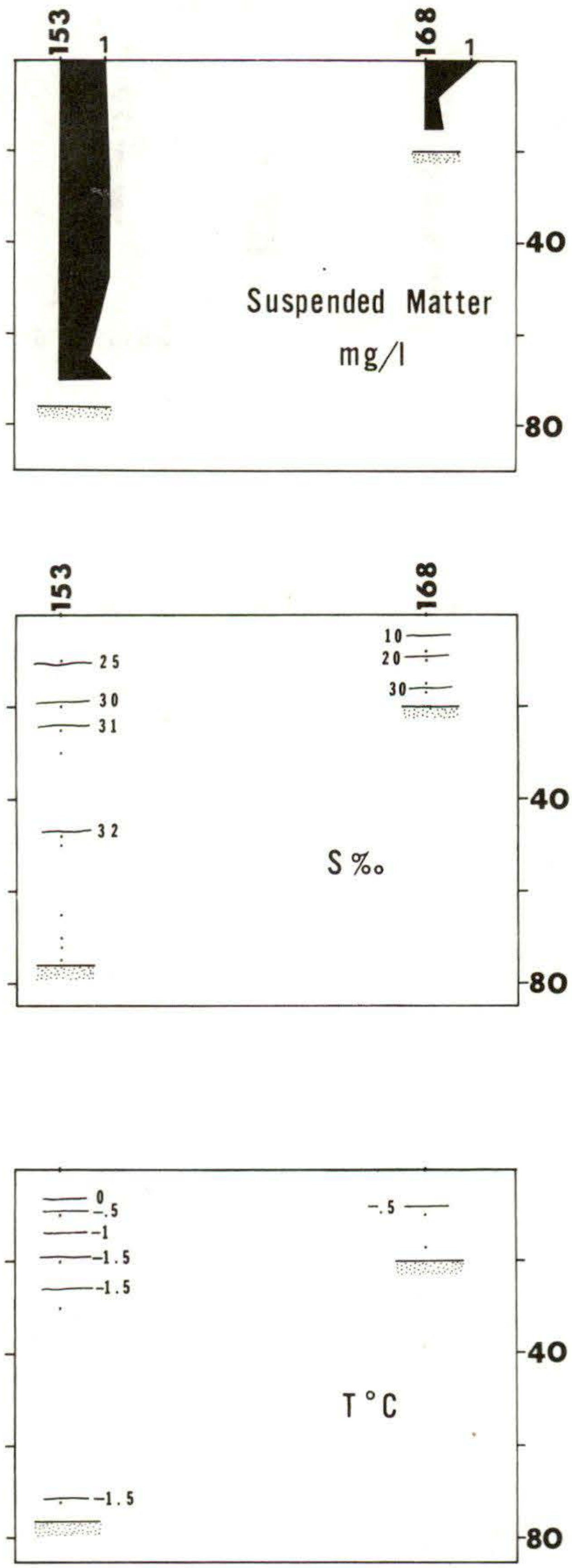

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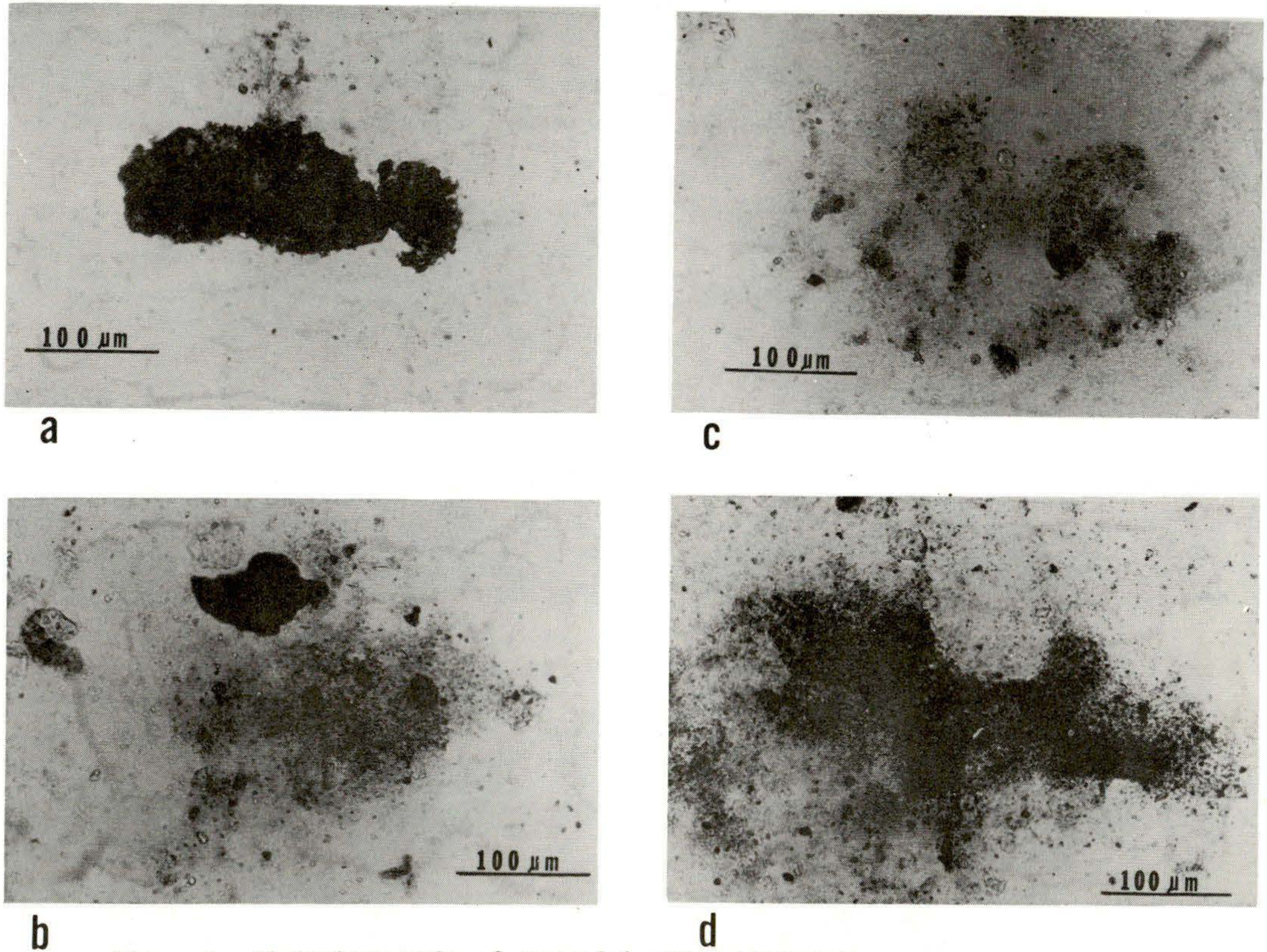

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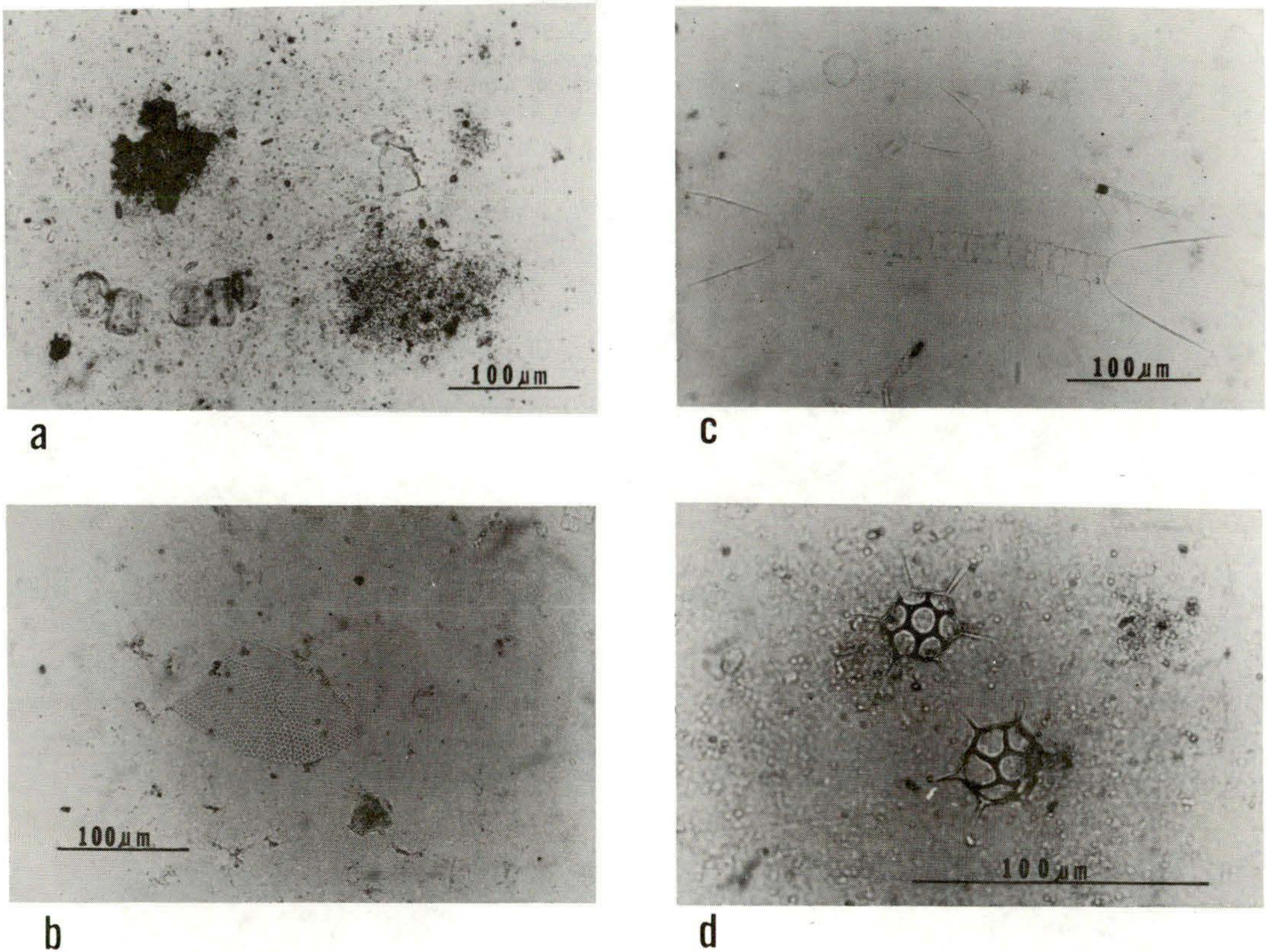

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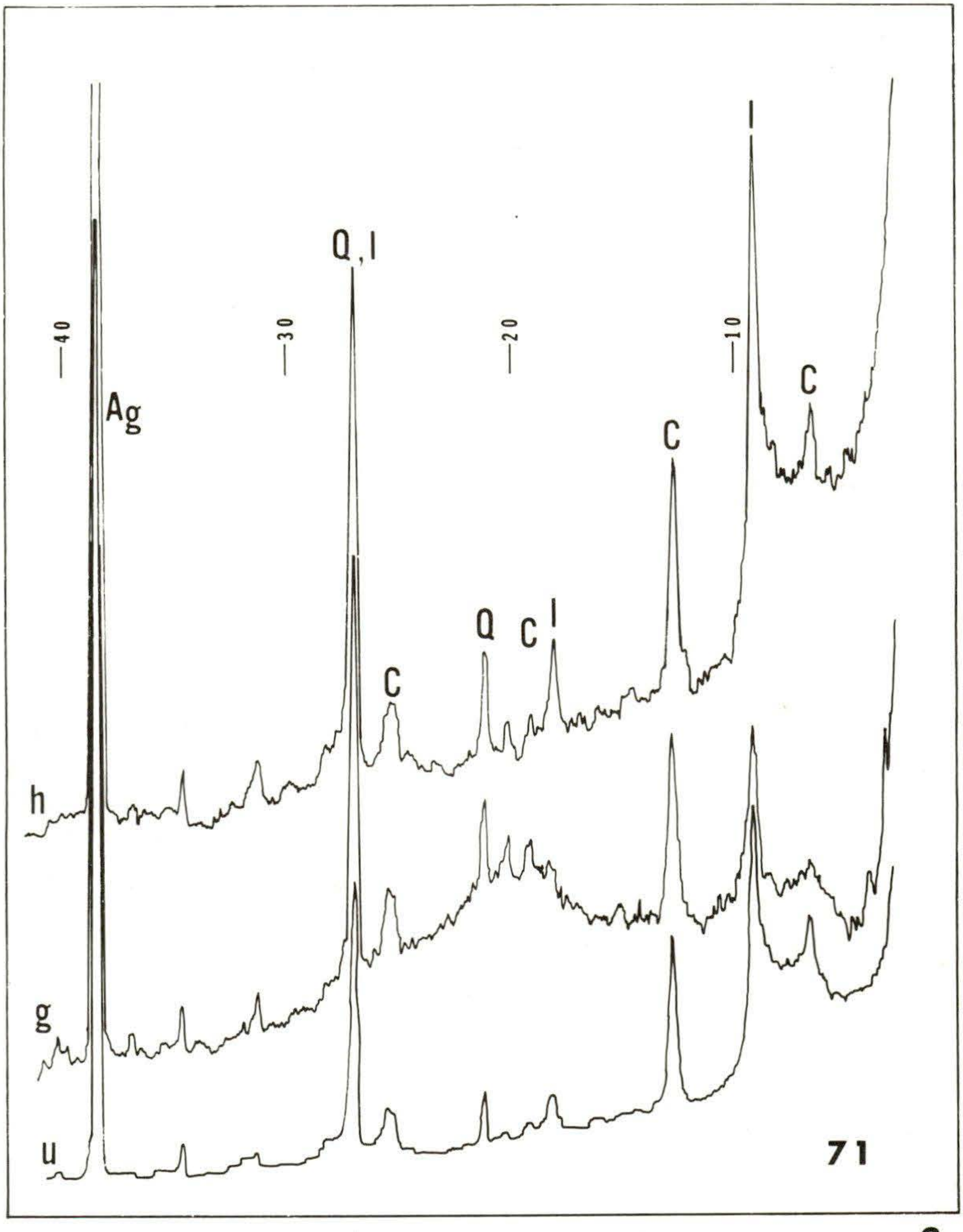

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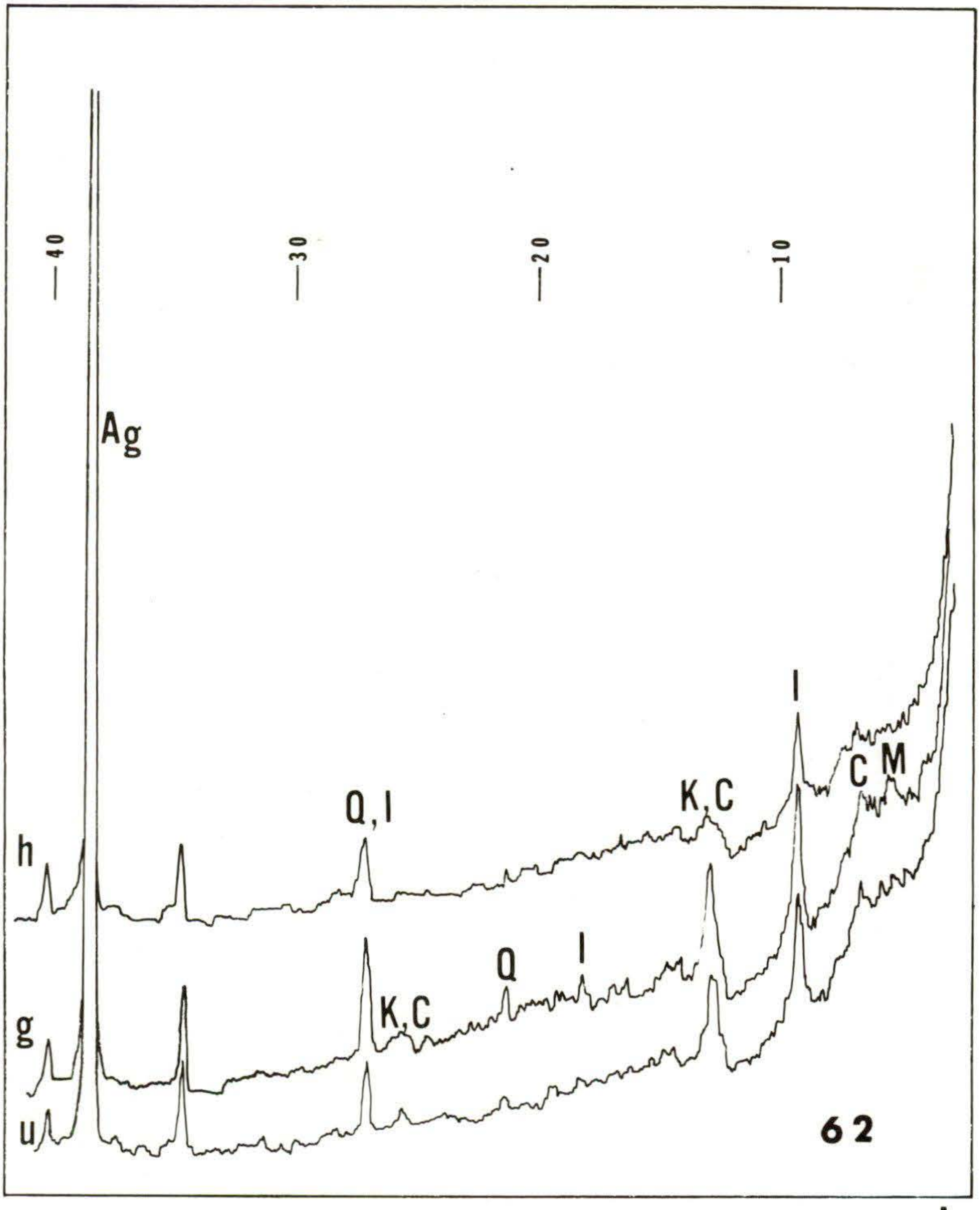

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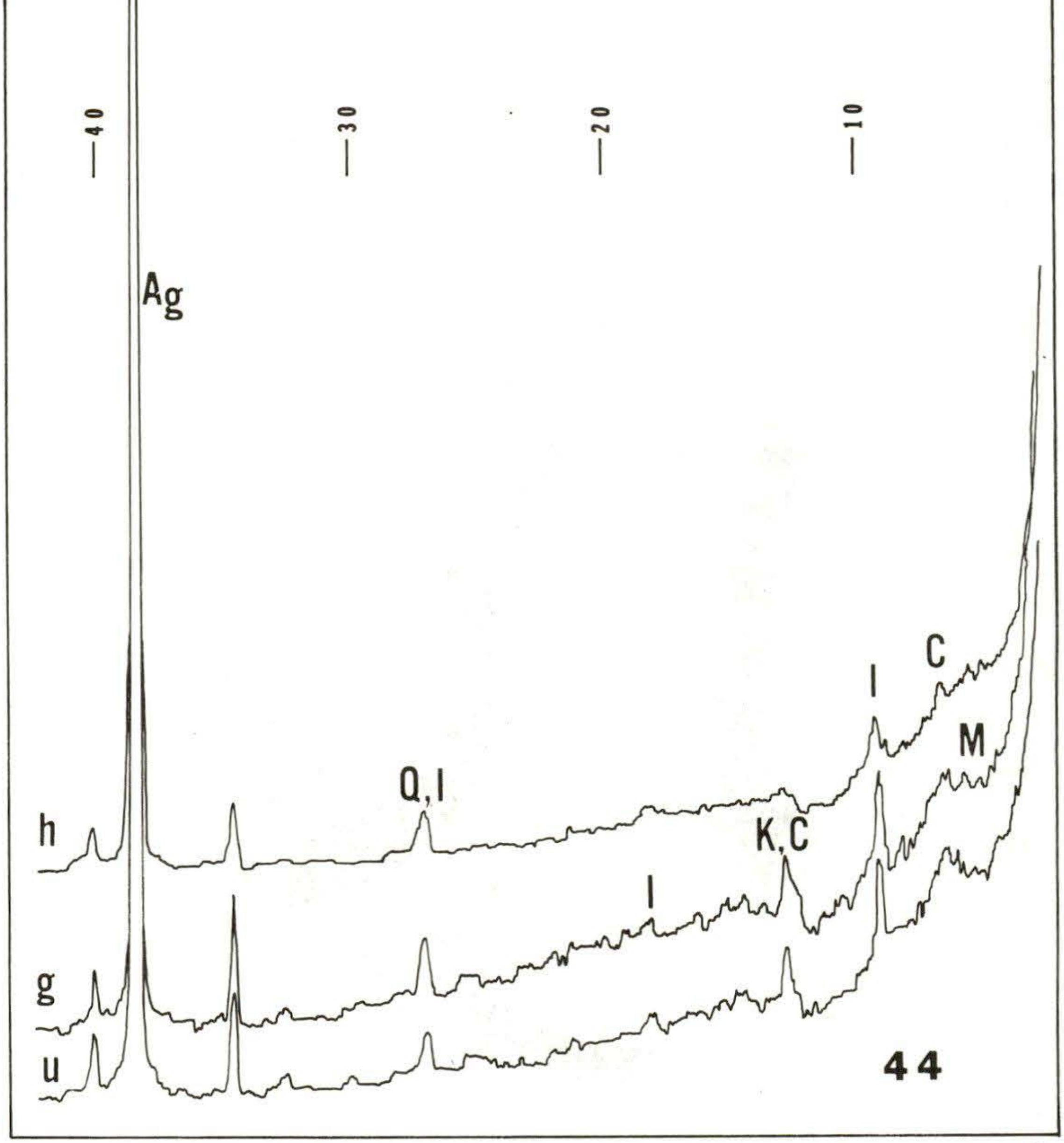

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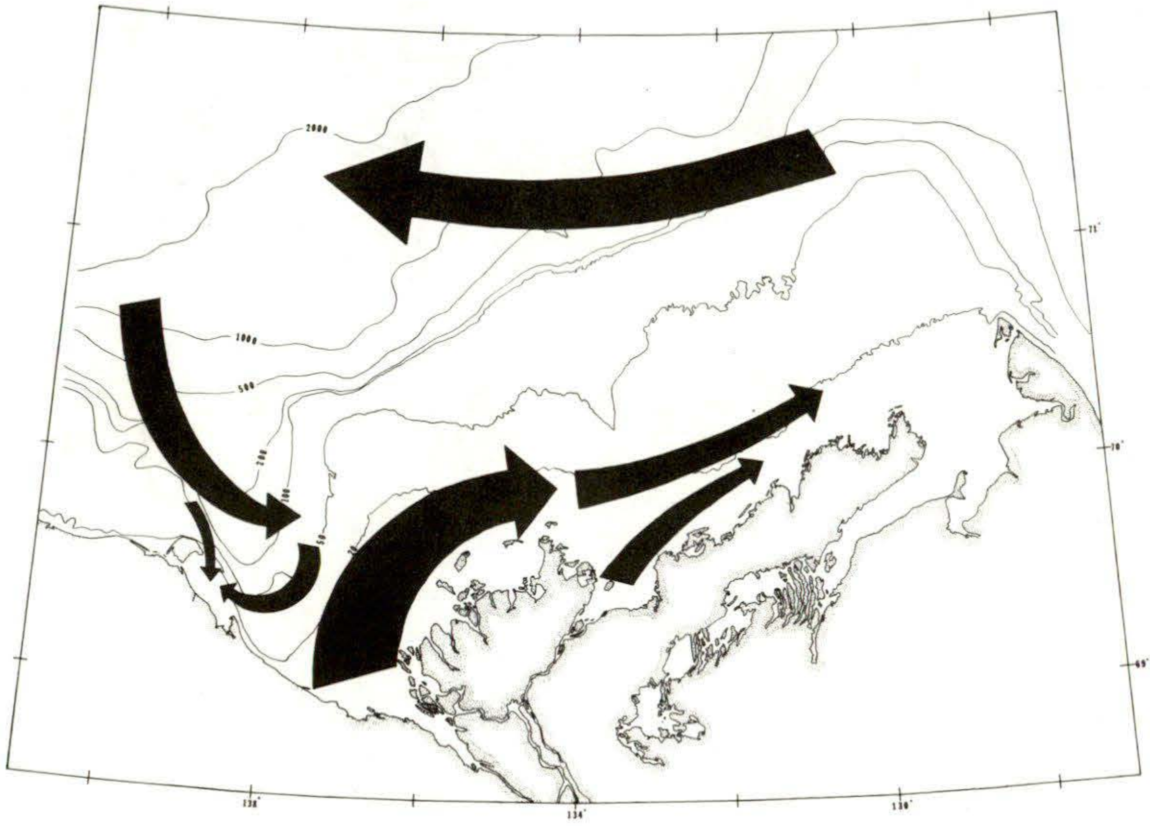

Figure 9. Circulation in the southern Beaufort Sea based on previous observations and on inferences from distribution of suspended matter.

Figure 10. Satellite photograph (7 September 1973) of the Mackenzie Delta showing the eastward flow of sediment-laden water from the main river channel.

A P P E N D I X I

Station Data

Station	Lat. °N Long. °W	Date	Time (GMT)	Station Depth m	Wind Speed (knots) & direction	Sample Depth m	Temperature °C	Salinity °/oo	Sample No.	Suspended matter concentration (mg/l)
101	69°54'.0	20 Aug.	1800	13	4	0	11.6	2.618	1	2.004
	134°09.0'				180	3	9.0	11.25		
						5	7.0	12.55		
						8	5.5	12.674	2	2.603
						10	5.5	13.526		
102	70°05.5'									
	134°26.0'	20 Aug.	2320	26	10	0	9.0	11.55	3	1.095
					130	8	8.2	12.688	5	0.750
						10	7.15	13.955		
						11	4.3	21.05		
						13	1.9	27.45		
						15	1.7	27.45		
						20	-0.2	30.373		
						21	-0.6	30.817	6	1.410
						23	-1.05	31.198		
104	70°15.5'	21 Aug.	0210	40	11	0	8.50	11.904	7	0.524
	134°41.6'				130	8		13.042	4	0.737
						10	10.50	13.090		
						20	1.10	29.912		
						25		30.220	8	1.365
						30	-1.20	31.134		
						38		31.670	9	1.295
						40	-1.40	31.595		

Station	Lat. °N Long. °W	Date	Time (GMT)	Station Depth m	Wind Speed (knots) & direction	Sample Depth m	Temperature °C	Salinity °/oo	Sample No.	Suspended matter concentration (mg/l)
105	70°22.5'	21 Aug.	0515	57	11	0	9.5	12.328	10	0.327
	134°58.3'				130	8		16.426	11	0.407
						10	3.80	30.275		
						20	-1.08			
						25		30.961	12	0.229
						30	-1.38	31.368		
						48		32.058	13	0.464
						50	-1.38	32.366		
106	70°34.0'	21 Aug.	0754	66	10	0	8.50	11.963	14	0.760
	135°26.0'				200	8		12.375	15	0.573
						10	4.40	21.018		
						20	-1.40	30.246		
						25		30.572	16	0.576
						30	-1.50	30.943		
						48		32.348	17	0.527
						50	-1.30	32.389		
						60		32.524	18	0.430
						62	-.38	32.515		
107	70°39.0'	21 Aug.	1045	155	10	0	6.50		19	1.169
	135°39.0'				230	8		26.193	20	0.316
						10	-0.80	26.676		
						20	-1.50	30.362		
						25		30.719	21	0.889
						30	-1.45	30.972		
						48		32.190	22	0.711
						50	-1.40	32.123		
						75		32.461	23	1.601
						80	-1.30	32.625		
						98		32.596	24	0.426
						100	-1.45	32.754		

Station	Lat. °N Long. °W	Date	Time (GMT)	Station Depth m	Wind Speed (knots) & direction	Sample Depth m	Temperature °C	Salinity °/oo	Sample No.	Suspended matter concentration (mg/l)
107						125		32.880	25	0.893
contd.						130	-1.35			
						138		32.659	26	1.562
						140	-1.30	33.033		
						151		33.291	27	0.500
						153	-1.35	33.073		
109	69°36.8'	23 Aug.	2035	14	8	0	0.50		28	0.865
	139°32.8'				340	8	-0.13	24.142		
						10		27.398	29	0.448
						12	-1.47	28.663		
110	69°48.5'	23 Aug.	2300	36	8	0	1.50	15.864	30	0.377
	139°39.3'				300	8		22.282	31	0.449
						10	-0.39	25.301		
						20	-1.48	32.061		
						25		32.050	32	0.562
						30	-1.45	32.135		
						32		32.419	33	0.241
						34	-1.39	32.510		
111	69°57.6'	24 Aug.	0115	53	8	0	1.80	16.662	34	0.414
	139°31.2'				320	8		31.849	35	0.269
						10	-1.5	32.420		
						20	-1.5	32.747		
						25		32.735	36	0.543
						30	-1.45	32.790		
						48		32.842	37	0.250
						50	-1.40	32.792		

Station	Lat. °N Long. °W	Date	Time (GMT)	Station Depth m	Wind Speed (knots) & direction	Sample Depth m	Temperature °C	Salinity °/oo	Sample No.	Suspended matter concentration (mg/1)
112	70°08.2'									
	139°25.4'	24 Aug.	0345	187	8	0	1.50	15.032	38	0.294
					340	10	-0.68	25.904		
						20	-1.29	30.336		
						25		30.899	39	0.195
						30	-1.54	32.201		
						48		32.097	40	0.332
						50	-1.50	32.198		
						73		32.831	41	0.131
						75	-1.51	32.843		
						98		32.890	42	0.179
						100	-1.49	32.886		
						125	-1.49	32.898		
						148		33.037	43	0.194
						150	-1.45	33.068		
153	69°29.9'	2 Sept.	2100	76	3	0	1.40	20.889	44	0.990
	138°47.8'				310	10	-0.52	24.029		
						20	-1.52	30.316		
						25		31.536	45	1.084
						30	-1.31	31.617		
						48		32.088	46	1.074
						50		32.106		
						65		32.077	47	0.648
						70			48	1.141
						72	-1.50	32.107		

Station	Lat. °N Long. °W	Date	Time (GMT)	Station Depth m	Wind Speed (knots) & direction	Sample Depth m	Temperature °C	Salinity °/oo	Sample No.	Suspended matter concentration (mg/l)
168	69°50.5'	5 Sept.	1845	19	12	0	0.0	10.672	49	1.162
	136°18.9'				30	8		19.179	50	0.235
						10	-0.55	20.349		
						15		23.243	51	0.348
						17	-0.52	26.831		
172	70°13.0'	7 SEpt.	0110	35	28	0	3.20	15.931	52	0.154
	132°43,6'				50	8		15.982	53	0.413
						10	-1.29	16.042		
						20	-0.52	25.821		
						25		30.428	54	0.688
						30	-0.76	31.355		
173	70°24.3'	7 Sept.	0213	42	24	0	3.20	16.328	55	0.814
	132°55.0'				40	8		16.344	56	0.374
						10	-0.54	16.452		
						20	-0.75	28.566		
						25		30.916	57	0.392
						30	-1.02	31.293		
						38		31.479	58	0.093
						40	-1.25	31.583		
174	70°08.2'	7 Sept.	0522	53	30	0	1.20	19.228	59	0.259
	133°01.0'				60	8		23.657	60	0.067
						10	1.56	24.507		
						20	-0.53	30.576		
						25		31.085	61	0.044
						30	-1.29	31.481		
						48		31.820	62	0.401
						50	-1.25	31.974		

Station	Lat. °N Long. °W	Date	Time (GMT)	Station Depth m	Wind Speed (knots) & direction	Sample Depth m	Temperature °C	Salinity °/oo	Sample No.	Suspended matter concentration (mg/l)
175	70°47.5' 133°23.0'	7 Sept	1600	65	20 50	0	0.90	19.399	63	0.393
						10	-0.53	22.697		
						20	-0.54	30.480		
						25		31.073	64	0.023
						30	-1.41	31.610		
						48		32.153	65	0.051
						50	-1.47	32.212		
						58		32.290	66	0.275
						60	-0.54	32.378		
179	70°02.8' 132°30.8'	8 Sept.	1525	21	10 10	0	3.00		67	1.282
						8		16.517	68	1.013
						10	-0.53	21.514		
						18		25.027	69	0.082
						20	+1.73	27.605		
180	69°53.1' 132°21.3'	8 Sept.	1712	11	11 10	0	2.50	21.499	70	13.405
						6		21.719	71	17.452
						8	2.31	24.965		
183	69°56.7' 133°03.0'	8 Sept.	1945	17	10 10	0	2.60	17.275	72	0.835
184	69°58.3' 133°50.0'	8 Sept.	2124	21	2-3 (Bfrt) NW	0	1.70	16.093	73	0.500
188	69°59.5' 134°24.5'	8 Sept.	2345	17	2 (Bfrt) NW	0	1.90	15.93	74	0.908
189	70°09.3' 133°58.0'	9 Sept.	0155	36	2 (Bfrt) WNW	0	1.90	15.012	75	0.832

Station	Lat. $^{\circ}$N Long. $^{\circ}$W	Date	Time (GMT)	Station Depth m	Wind Speed (knots) & direction	Sample Depth m	Temperature $^{\circ}$C	Salinity $^{o}/_{oo}$	Sample No.	Suspended matter concentration (mg/l)
193	70°16.4' 133°34.8'	9 Sept.	1740	53	2(Bfrt) SW	0	1.90	15.101	76	0.602