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# Estran argileux à blocs glaciels, côte nord du golfe du Saint-Laurent, Québec

Jean-Claude Dionne

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Résumé de l'article

Il existe un estran argileux capitonné de blocs glaciels, localisé dans un rentrant bien protégé, près de Harrington-Harbour, sur la côte nord du golfe du Saint-Laurent. Ce rentrant, d'une superficie d'environ 7 $km^2$, a une pente inférieure à 0,2° et est influencé par des marées de faible amplitude (1,4 à 2,2 m) et par des vagues de faible énergie. L'estran est entièrement couvert de glaces durant 3 à 4 mois par année, mais l'activité glacielle peut s'étendre sur une période de 5 mois. En plus de déplacer des blocs, les glaces affouillent le fond argileux creusant des dépressions superficielles. L'activité glacielle dans ce site protégé est considérée comme modérée.

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# A BOULDER-STREWN TIDAL FLAT, NORTH SHORE OF THE GULF OF ST. LAWRENCE, QUÉBEC

Jean-Claude DIONNE, Département de géographie, université Laval, Sainte-Foy, Québec G1K 7P4.

ABSTRACT A clay flat strewn with ice-drifted boulders occurs in a sheltered embayment near Harrington Harbour, North Shore of the Gulf of St. Lawrence. The embayment, approx. 7 km² in area with a slope gradient less than 0.2°, is under the influence of tides ranging from 1.4 to 2.2 m and of a low wave energy regime. Ice entirely covers the flat during 3 to 4 months per year but may be present up to 5 months. Ice rafting, ice pushing, and ice gauging are moderately important processes in the embayment.

RÉSUMÉ *Estran argileux à blocs glaciels, côte nord du golfe du Saint-Laurent, Québec.* Il existe un estran argileux capitonné de blocs glaciels, localisé dans un rentrant bien protégé, près de Harrington-Harbour, sur la côte nord du golfe du Saint-Laurent. Ce rentrant, d'une superficie d'environ 7 km², a une pente inférieure à 0,2° et est influencé par des marées de faible amplitude (1,4 à 2,2 m) et par des vagues de faible énergie. L'estran est entièrement couvert de glaces durant 3 à 4 mois par année, mais l'activité glacielle peut s'étendre sur une période de 5 mois. En plus de déplacer des blocs, les glaces affouillent le fond argileux creusant des dépressions superficielles. L'activité glacielle dans ce site protégé est considérée comme modérée.

## INTRODUCTION

Boulder-strewn tidal flats are widely distributed in cold regions although they are not exclusive to this environment. In regions dominated by sea ice processes for several months each year, boudler-strewn tidal flats result mainly from ice action (TANNER, 1939; LØKEN, 1962; BIRD, 1967; DIONNE, 1972, 1978, 1981; ROSEN, 1979). However, most boulder-strewn tidal flats in temperate regions that were glaciated during the Quaternary result from erosion of glacial drift, and a wave-cut platform usually occurs in front of the wave eroded unconsolidated deposits. Like in cold regions, boulders are scattered throughout the tidal flat or form various concentrations, such as pavements, ridges or boulder barricades. These features are closely related to boulder lags, a feature resulting from the washing out of the fines. In temperate regions boulders larger than 50 cm in diameter are not commonly displaced over long distances. A good example of a mud flat partly covered with shingles and small boulders is found near Stolford in Bridgwater Bay, North Somerset, England (Fig. 3).

Boulder-strewn tidal flats are poorly documented, and very few papers are entirely devoted to the feature (DIONNE, 1974). It is the purpose of this paper to describe a boulder-strewn clay tidal flat occurring in a low wave energy environment, near Harrington Harbour (59°31′W, 50°32′30″N), on the North Shore of the Gulf of St. Lawrence, between the Nétagamiou and Petit Mécatina Rivers (Fig. 1).

Along the North Shore of the St. Lawrence Estuary and Gulf numerous boulder-strewn tidal flats are exposed to wave, current, tide and ice action; enclosed embayments like the one reported here are not common. Boulder-strewn flats from the North Shore have been surveyed for many years, and some localities have been briefly described (LAVERDIÈRE, 1970; DIONNE, 1972a, 1975; DREDGE, 1976; DUBOIS, 1980). Observations made from Pentecôte to Blanc-Sablon between 1978 and 1980 will appear in a separate report (DIONNE, in preparation).

## COASTAL SETTING

The coastal area is low and mostly rocky; it is developed in the Precambrian Shield, locally composed of charnokitic gneiss (AVRAMTCHEV and MARCOUX, 1980), highly fissured and irregularly eroded. Structural control largely determines the shoreline configuration which generally trends SW — NE. Several bedrock outcrops occur in the shore and nearshore zones forming a series of low islands, islets and skerries (Fig. 2).

Most bedrock outcrops along the shore exhibit glacially polished and striated surfaces, chattermarks, grooves and dissymetrical rocks. However, there are no glacial deposits outcropping at the coast. Deglaciation of the coastal area occurred approximately 10,500 years ago and was followed by a marine submergence (DUBOIS, 1980). The maximum limit of the marine sub-

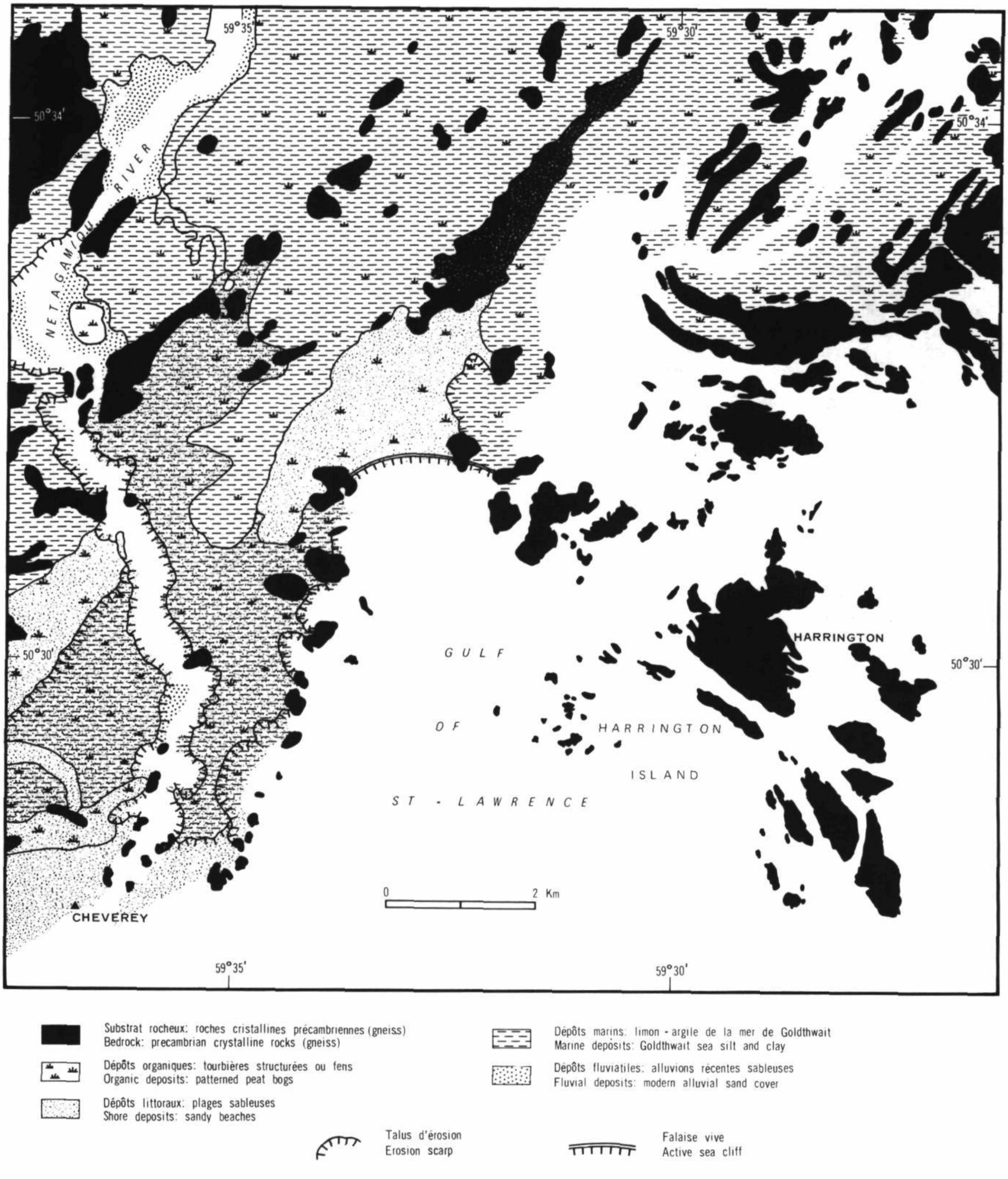


**FIGURE 1. Location map and geomorphological sketch.**

*Carte de localisation et croquis géomorphologique.*

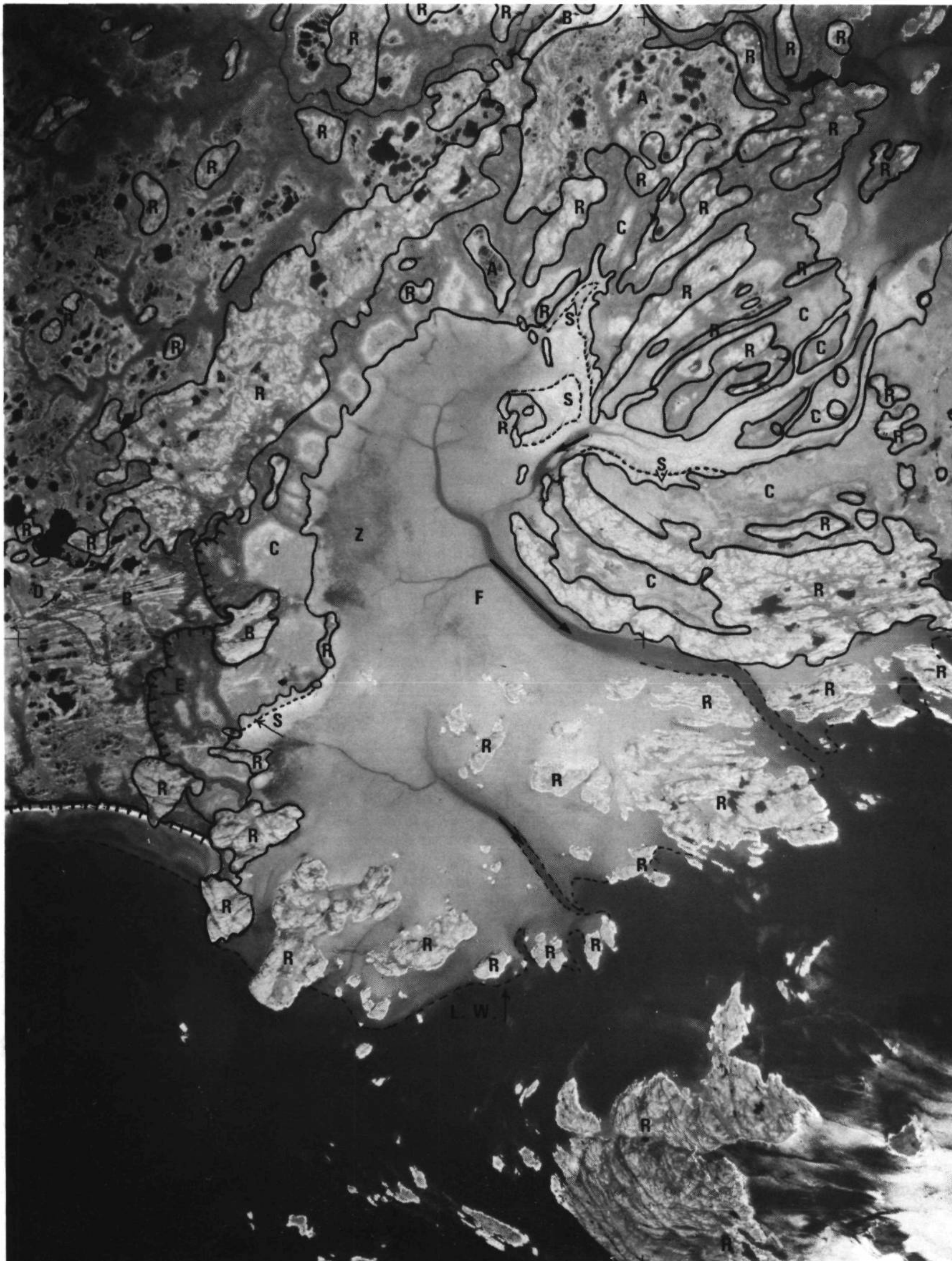


FIGURE 2. Aerial vertical photo of the embayment facing Harrington Islands, and main landform components. Photo No. A11702-374, NAPL, Ottawa, Canada Dept. Energy, Mines & Resources, approx. scale: 1: 40,000. Legend of symbols: A) patterned peat bog over marine clay; B) sandy beaches; C) peat over marine clay; D) dunes; E) erosion scarp; F) tidal flat; H) Harrington Harbour; L.W.) low water level; R) bedrock (crystalline rocks); S) tidal marsh; Z) Zostera (eel grass).

*Vue aérienne verticale de la baie près de Harrington-Harbour et principales composantes du relief. Photo n° A11702-374, Photothèque nationale, Ottawa, Min. Énergie, Mines et Ressources; échelle approx.: 1/40 000. Légende des symboles: A) tourbière structurée sur argile marine; B) plage sableuse; C) tourbe sur argile marine; D) dunes; E) escarpement d'érosion; F) bas estran argileux; H) Harrington-Harbour; L.W.) limite des basses mers; R) substrat rocheux (roches cristallines); S) schorre; Z) zostères.*

FIGURE 3. Small boulders and large cobbles at the surface of a mud flat near Stolford, Bridgwater Bay, North Somerset, SW England. These well rounded stones were moved there by waves and tide currents (8-15-77).

*Petits blocs et gros galets concentrés en tas à la surface d'une slikke vaseuse près de Stolford, baie de Bridgwater, nord du Somerset, SO de l'Angleterre; cailloux déplacés par les vagues et les courants de marée (15-8-77).*

mergence, the Goldthwait Sea, is approximately 140 m. Following isostatic rebound, the Goldthwait Sea regressed rapidly and reached the present sea level several hundreds years ago. The 4-6 m level is about 2000 years old (DIONNE, 1977; DUBOIS, 1980, p. 445). Three types of deposits were left in the coastal area. Deep water sediments (silt and clay), several metres thick, occur at the base of the marine sequence; these are overlain by deltaic sands or shallow marine deposits, a few metres thick; locally, sand beaches occur along the present shoreline and at several levels inland. These beach deposits are only a few metres thick and they are anchored on bedrock spurs (Fig. 2). The area of Harrington Harbour is an emerging lowland shoreline, very irregular in shape and developed partly in bedrock and partly in unconsolidated marine deposits.

The mean annual air temperature is 1.3°C with monthly means of −11.1° and 13.1° in January and August respectively. Maximum and minimum temperatures recorded are 28.3° and −38.3°. Total mean annual precipitation is 1214 mm including a mean annual snow fall of 505 cm (VILLENEUVE, 1967). Prevailing wind directions are from the SE, NE and W. Maximum fetches are from the S and SW. However, within the embayment, only small waves can form at high tide and their action on the flat is of little importance. The embayment is generally entirely ice-covered during most of the winter. Freezup begins along the shores in December and may extend to January; breakup usually occurs between the end of March and mid-April.

The U-shape embayment is 4 km long and up to 2.5 km wide, the total area being approximately 7 km$^2$. It is surrounded by numerous rock ledges and spurs forming low emerging islands, rock mounds or hills partly buried by marine Quaternary deposits. The presence of several islands, islets and skerries at the entry made this embayment a well protected intertidal zone.

The tidal flat is composed essentially of marine grey clay, deposited during the Goldthwait Sea episode; the clay is overlain by an intermittent thin (2-3 cm) veneer of mud or fine sand. The intertidal surface slopes gently seaward (*i.e.* to the SE), at one metre per kilometre or less than 0.2°. There is no evidence that this surface has been cut by waves.

Tidal range is small, neap tide being 1.4 m and spring tide 2.2 m, with highest high tide reaching 2.9 m above *datum* and the lowest low tide −0.5 m; the mean water level is 1.1 m. At low tide, two small channels drain the flat to the SE (Fig. 2). Marine water is also introduced during the flood period through a narrow and shallow passage located to the NE; this passage serves also during the ebb period for draining the embayment. The water circulation pattern within the embayment is complicated by the topographic setting.

## ICE MADE FEATURES

Hundreds of boulders up to 250 cm in diameter, averaging 75 to 125 cm, are scattered throughout the clay tidal flat (Fig. 4). The number of boulders varies slightly from place to place, but no boulder concentration is observed at one particular level as observed for some other localities along the Lower St. Lawrence Estuary (DIONNE, 1972a, 1979; GUILCHER, 1981). Most commonly, boulders are several metres apart and they rest directly on the surface, being rarely embedded more than a few centimetres in the underlying clay (Fig. 5). Mobility of boulders is thus relatively great. Some boulders rest in a shallow depressions, 5 to 15 cm deep (Fig. 6) created when boulders are pushed by ice floes either by wind-driven floes or by floes drifted seaward by ebb currents. Small clay ridges develop around several boulders (Fig. 7). These features are produced by the bulldozing effect of the boulders. Like the depressions, they are usually located seaward of the boulders, indicating the direction of displacement. The boulders are all crystalline rocks (mostly gneiss) from the nearby shield. They are usually subrounded to rounded, but some are angular (Fig. 8). The angular blocks originated from shore outcrops shattered by frost action.

The clay flat surface is not only boulder-strewn, it is also ice-eroded and gouged. The rising up and down of floes by waves and tide motion allows the keel of floes to dig out shallow circular depressions, a few centimetres deep and a few metres in diameter (Fig. 9). The micro-relief resulting from that action is particularly

FIGURE 4. A general view of the boulder-strewn clay tidal flat in the vicinity of Harrington Harbour, North Shore of the Gulf of St. Lawrence; boulders are scattered throughout the embayment (7-20-79).

*Vue générale de l'estran argileux dans une baie près de Harrington-Harbour, côte nord du golfe du Saint-Laurent; les blocs cristallins sont dispersés dans l'ensemble du rentrant (20-7-79).*

FIGURE 5. Gneiss boulders from shore outcrops, 100 to 125 cm in diameter, scattered at the surface of a clay tidal flat near Harrington Harbour.
*Blocs de gneiss de source locale, mesurant entre 100 et 125 cm de diamètre, reposant directement à la surface de l'estran argileux, près d'Harrington-Harbour.*

FIGURE 6. A gneiss boulder lying in the shallow depression scoured into the underlying marine clay under ice floe pressures; embayment near Harrington Harbour.

*Bloc glaciel (gneiss) reposant dans la cuvette qu'il a lui-même creusée dans l'argile marine sous-jacente sous l'effet des pressions glacielles; havre de Harrington.*

FIGURE 7. An ice-drifted boulder with its characteristic push ridge located seaward; clay flat near Harrington Harbour.

*Bloc glaciel avec son bourrelet de poussée du côté des basses mers; estran argileux près d'Harrington-Harbour.*

well developed and preserved in another embayment to the NE. Furrows (DIONNE, 1971) are not common probably because of the low tidal range. Ice action is also evident in the narrow tidal marsh fringing the embayment on the western and northern sides. As elsewhere in Québec (DIONNE, 1972b, 1978), ice-made pans and a few ice-drifted boulders (Fig. 10-11) characterize this high water level zone. Only a few peat rafts have been found at the surface of the clay flat indicating that ice action is not presently modifying the marsh surface, and that tidal marshes are poorly developed in the embayment.

According to their lithology most boulders are from local source. Displacements range from a few metres to a few kilometres. Angular blocks for example, are first picked up by ice on the modern rocky shores and they are drifted over various distances before being released. Although some boulders could be rafted again, when released in the intertidal zone, most boulders are probably only pushed or rolled at the surface of the clay flat as observed elsewhere (McCANN *et al.*, 1981). Repeated addition of boulders during the last 1500 years has led to the present situation, *i.e.* to a boulder-strewn tidal flat. Due to the particular setting, it is unlikely that boulders from far sources are introduced into the embayment by ice rafting or other processes. However, rounded boulders are possibly erratics removed from higher levels of the emerging coastal area and brought

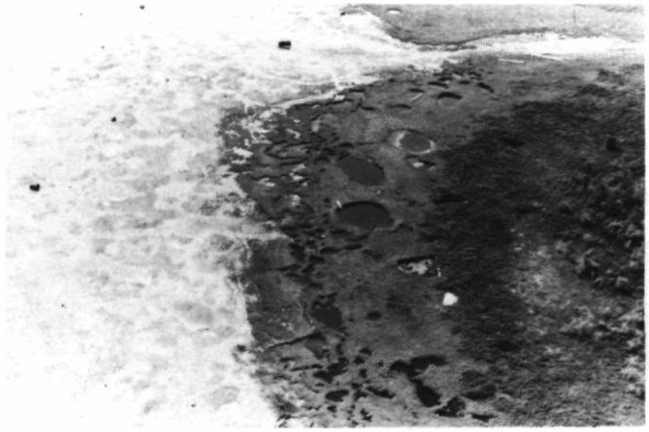

FIGURE 8. An angular block recently removed by ice from a shore bedrock outcrop and transported over the clay tidal flat in the vicinity of Harrington Harbour; note the shallow furrow made by the boulder.

*Bloc anguleux récemment arraché à un affleurement avoisinant et déplacé par les glaces à la surface de l'estran argileux du rentrant près d'Harrington-Harbour; à remarquer la rainure faite par le bloc.*

FIGURE 9. Ice-made micro-relief in a clay flat near Harrington Harbour; shallow depressions and ridges made by ice floes rising up and down under wave and tide motion.

*Micro-relief glaciel sur estran argileux près d'Harrington-Harbour; dépressions peu profondes et bourrelets résultant de l'affouillement par les glaces soulevées par les vagues et la marée.*

FIGURES 10-11. A small tidal marsh fringing the clay flat near Harrington Harbour; pans of various forms and sizes mainly made by ice processes.

*Petit schorre à marelles en bordure de l'estran argileux près d'Harrington-Harbour, basse côte nord du Saint-Laurent; mares de dimensions et de formes variées résultant principalement d'arrachements glaciels.*

down progressively to the present sea level as at Baie aux Feuilles, subarctic Québec (LAURIOL and GRAY, 1980).

Although the clay tidal flat in the vicinity of Harrington Harbour is not intensively boulder-strewn, this enclosed embayment is of a great interest because it provides evidence of ice action in a well protected environment characterized by a low tidal range and a low wave-energy.

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