

What's the St. Lawrence Estuary Shallow Subsurface and Seafloor Made of?

A Regional Appraisal based on an Integrated Geophysical and Geological Study

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Summary

The new geological map of the St. Lawrence Estuary seafloor provides an example of sediment distribution and variability in a relatively confined environment. This map is based on recently collected geophysical and geological data that provide the link between submarine landforms and sedimentary units. Sediments forming the seafloor are Holocene in age except in the southern part of the study area where older Quaternary units are outcropping. Homogeneous fine silts form the relatively deep (250-350 m) Laurentian Channel seafloor. This contrasts with recent sediments on the margins of the Laurentian Channel that are characterized by variable grain sizes and geomorphological signatures. The large amount of mass transport deposits and the dichotomy between the areas to the south and to the north of the Saguenay River are major characteristics of the St. Lawrence Estuary basin.

Introduction

Estuarine and/or incised-valley basins are more protected against erosion compared to open sea basins and are effective sediment traps that make them attractive for hydrocarbon exploration. They are also characterized by an intrinsic complexity that may be difficult to study in exhumed succession. The new geological map of the St. Lawrence Estuary surficial sediments (Pinet et al., 2010) provides the opportunity to document, at the regional-scale, the main characteristics of recent deposits in one of the world's largest estuarine basins.

Regional setting and data

The St. Lawrence Estuary is a funnel-shaped body of tide-influenced salt water that increases significantly in width toward the northeast. The Laurentian Channel is the main geomorphologic feature of the estuary. It is a long, glacially excavated, continuous trough over 300 meters deep that extends 1500 km from the continental shelf in the Atlantic ocean to where it ends abruptly, at the mouth of the Saguenay River.

The study area covers the Lower St. Lawrence Estuary (north of the Saguenay River) and part of the Middle Estuary (south of the Saguenay River), for a total length of ~ 360 km. The northern boundary of the Laurentian Channel is marked by several NE- to ENE-trending escarpments, up to 160 m in height, that are the morphological expression of fault segments in the bedrock. Several disconnected bedrock ridges are found on the southern margin of the Laurentian channel and are associated with erosion-resistant units of the Appalachians.

In the study area, recent sedimentation rates ranges from 0.7 cm/yr in the south to 0.2 cm/yr in the north (Smith and Schafer, 1999).

In the Lower and Middle Estuary recently acquired datasets include multibeam bathymetry and acoustic backscatter for water depth greater than 30 m, high- and very high-resolution seismic lines, bottom sediment samples and seafloor photographs. Integration of the datasets results in a surficial sediment geological map that takes into account seafloor morphologic textures, acoustic characteristics of surficial units and grain-size analyses.

Morpho-sedimentology of the Middle St. Lawrence Estuary seafloor

South of the Saguenay River, the floor of the St Lawrence Estuary is made of: 1) Holocene sands; 2) early Holocene to latest Pleistocene faintly laminated to homogenous silty clay facies (ice-distal deposits), and sandy mud facies including ice-rafted debris (ice-proximal deposits) and 3) pre-Holocene sediments that have not yet been sampled.

Dunes fields up to 10 km in length and 2 km in width develop through coarse-grained, geological units. These migrating landforms attest of strong bottom current in the southern, and relatively shallow, part of the study area.

Morpho-sedimentology of the Lower St. Lawrence Estuary seafloor

Sediments forming the St. Lawrence Estuary seafloor north of the Saguenay River are Holocene in age.

The floor of the Laurentian Channel is composed of fine silts. Grain size analysis of these sediments indicate an homogeneous lithology, with a cumulative sand and gravel content consistently less than 10% (usually less than 3%) and a silt content varying between 49 and 60%.

Present-day sedimentation on the Laurentian channel margins corresponds to sediments with grain size characteristics far more scattered than in the Laurentian Channel and varying from sands to fine silts. On significant portions of both the north and south margins, these sediments are reworked by mass-wasting. Mass transport deposits exhibit various geomorphological signatures, including: 1) a blocky signature testifying of significant internal disruption; 2) a smooth morphology with less internal disruption, except close to the headwall scar and in the frontal, often folded, area; 3) a series of sub-parallel ridges attesting a pervasive deformation by folding of the entire mass-wasted volume. Mass transport deposits result from several catastrophic events, several of them most likely triggered by earthquakes.

On the Laurentian channel margins, relatively flat to gently sloping subtle geomorphological features define cone-shaped units interpreted as submarine fans. In some cases, fan sediments bypass the margins through submarine valleys and canyons and settle on the Laurentian channel seafloor. Locally, fans and channels show multiple crosscutting relationships indicating a polyphased sedimentary history.

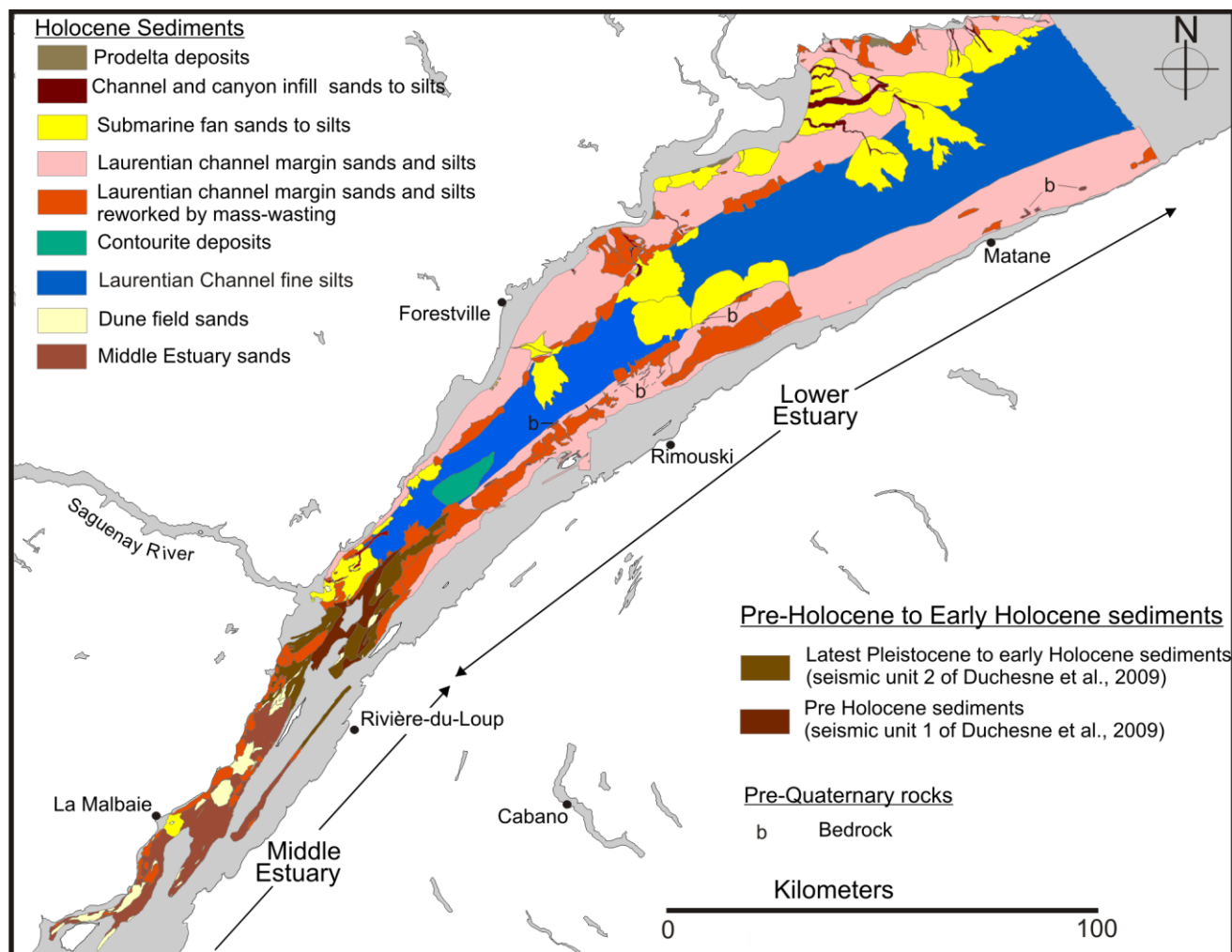


Figure 1: Geology of surficial sediments in the St. Lawrence Estuary. For a detailed version of this map, see Pinet et al. (2010).

Conclusions

The main characteristics of the St. Lawrence Estuary seafloor sediments are as follows:

- 1- A strong dichotomy exists between the Lower and Middle St. Lawrence Estuary. North of the Saguenay River, surficial sediments are Holocene and the grain size distribution is mainly a function of depth and proximity of river inputs. South of the Saguenay River, the St. Lawrence Estuary is shallower, strong tidal currents preclude the deposition of Holocene mud in some areas, pre-Holocene sediments form part of the seafloor, and Holocene sediments are coarser with erosional processes playing a significant role.

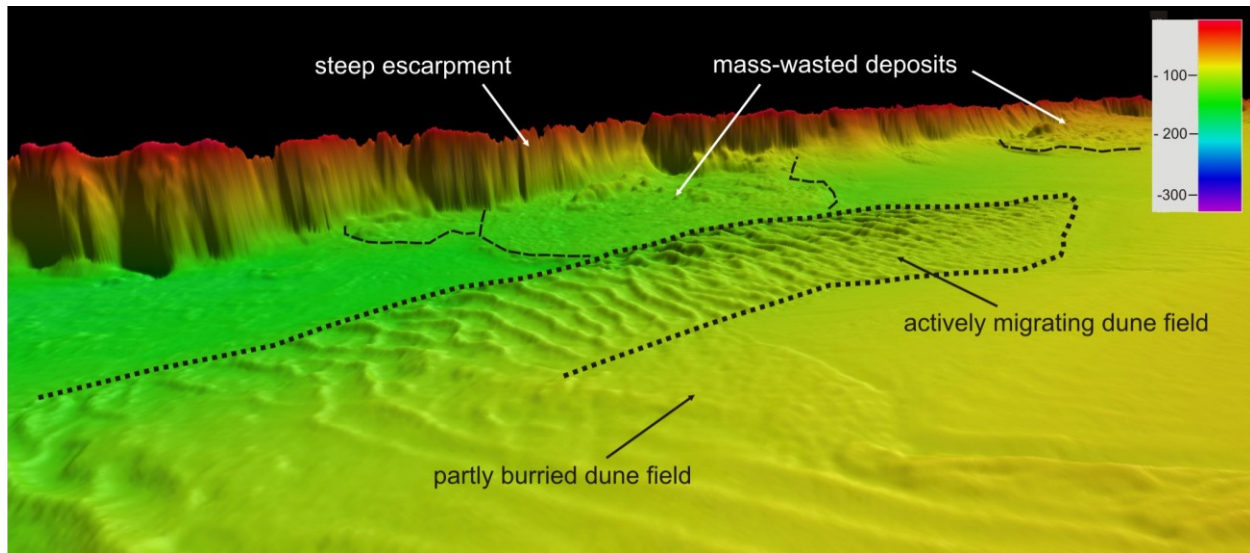


Figure 2: Typical morphology of the Middle St. Lawrence Estuary (southern part of the study area). View looking toward the north.

- 2- Significant portions of the Laurentian Channel margin sediments have been reworked by mass-wasting (~13% of the whole map area). Steep slopes of some segments of both the north and south Laurentian Channel margins and seismicity likely contribute to the formation of instability features.
- 3- Submarine fan sediments either settle on the Laurentian Channel margins or bypass them and rest on the channel seafloor.

References

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