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# Exotic Pebbles in Quaternary Deposits from the South Coast of the St. Lawrence Estuary, Quebec*

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## Introduction

Crystalline pebbles from the Canadian Shield occur in the Quaternary deposits within the Appalachian area of Rivière-du-Loup/Trois-Pistoles, on the south shore of the maritime St. Lawrence Estuary.

Counts were made on 34,234 pebbles (2 to 6 cm in diameter), from 175 sites distributed as follows (Table 1): 49 from modern beaches, 23 from post-glacial raised beaches, 14 from delta deposits, 27 from outwash, 20 from the St. Antonin moraine, 32 from ablation till, and 10 from submerged till. Results gave the following proportions of crystalline rocks: 24.3% for modern beaches, 13.5% for old beaches, 1.8% for delta deposits, 1.5% for outwash gravel, 1.3% for the St. Antonin frontal moraine, 0.3% for ablation till, and 5% for submerged till.

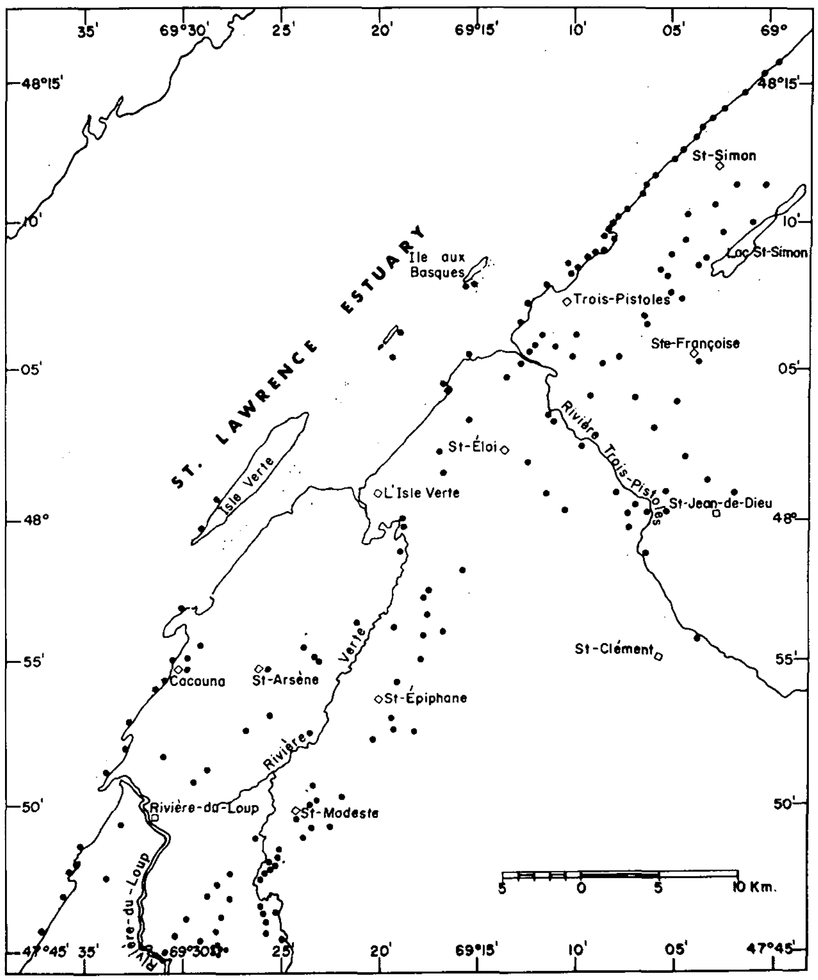


Figure 1. Location map. Black dots indicate sites of pebble counts.

## Source of Exotic Pebbles

A petrographic study of exotic pebbles in the unconsolidated sediments of the south shore shows that they are similar to the crystalline rocks of the Precambrian shield on the north shore of the St. Lawrence, the area studied being located between 25 to 40 km away and separated by the St. Lawrence trough (Shepard, 1931). Other possible sources of crystalline rocks are the small Paleozoic intrusions of the central Gaspé Peninsula, located about 200 km to the northeast, and the Paleozoic conglomerates of the Appalachian formations outcropping in the area studied.

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Table 1 - Proportion of crystalline rocks in Quaternary deposits

| Deposit | Number of sites | Number of pebbles | Mean % | Minimum % | Median % | Maximum % |
|---|---|---|---|---|---|---|
| Modern beaches | 49 | 8389 | 24.3 | 11.8 | 22.6 | 46.2 |
| Raised beaches | 23 | 5965 | 13.5 | 4.9 | 12.1 | 30.9 |
| Deltas | 14 | 2610 | 1.8 | 0 | 1.2 | 5.3 |
| Outwash | 27 | 5043 | 1.5 | 0 | 1.4 | 5.8 |
| Frontal moraine | 20 | 4266 | 1.3 | 0 | 1.0 | 4.1 |
| Ablation till | 32 | 6052 | 0.3 | 0 | 0.2 | 1.1 |
| Submerged till | 10 | 1905 | 5.0 | 2.0 | 4.5 | 14.4 |
| | 175 | 34234 | | | | |

## Facts to Know about the Environment

To understand how the crystalline rocks reached the south shore of the St. Lawrence, it is necessary to know the following facts: 1) that the south shore consists exclusively of Paleozoic sedimentary rocks (shales, sandstone, quartzite, conglomerates, and limestone), is located between 25 to 40 km from the crystalline shield from which it is separated by the deep trough of the St. Lawrence (depths up to 200 m in the vicinity of the Saguenay River); 2) that the main movement of the Laurentide ice-sheet was in a north-south direction with small variations to northwest-southeast and northeast-southwest, and that at a definite period of the Pleistocene, ice was moving parallel to the St. Lawrence in a southwest-northeast direction; 3) that at the post-glacial time the coastal area was submerged up to an altitude of 136 m above present sea level, the transgressive sea retreating progressively with the post-glacial isostatic rebound; 4) that drift ice is carried annually by the St. Lawrence during a period of 3 to 4 months, the drift having a general west-east direction, while the St. Lawrence has a southwest-northeast trend, which results in an accumulation of ice from the north shore to the south shore.

## Agents of Transportation

The transportation of crystalline rocks from the Canadian Shield to the Appalachian region can be attributed to many agents: Pleistocene ice-sheet, drift ice, organic agents, currents and waves.

Waves and currents can easily remove pebbles of the class 2 to 6 cm in diameter, and transport them over long distances. Considering the environment of the area studied, it is difficult to believe that the exotic pebbles from the Quaternary deposits were transported across the St. Lawrence by waves and currents. One has to remember the great distance (25 to 40 km) between the crystalline shield and the Appalachian region, the depth of the St. Lawrence (up to 200 m at the head of the central trough), and the main direction of water flow and discharge (southwest to northeast).

Coastal erosion of the Paleozoic conglomerates outcropping in the area may have contributed an indefinite amount of crystalline pebbles, since this formation contains such rocks. But a petrographic study of these conglomerates shows that crystalline rocks amount only for about 1/10, other elements being mainly limestone rocks. Eight pebble counts made along the shore where this conglomerate is outcropping gave proportions of 2.6% of limestone and 22.6% of crystalline rocks. Thus it may be concluded that shore erosion of the conglomerates cannot explain by itself the high proportion of crystalline pebbles in the beaches.

Organic agents can transport pebbles over large distances (Emery, 1963, Dionne, 1965). Even though seaweeds, (particularly *Laminaria* and *Fucus*), do really transport annually a large amount of pebbles on the south shore of the St. Lawrence, it is considered quite improbable that this agent brings rocks from the north shore across the St. Lawrence. Other organic agents (sea mammals and driftwood) can also transport pebbles. However, no evidence of this action has been noted yet in spite of our numerous surveys on both shores of the St. Lawrence since 1960. The proportion of crystalline pebbles brought by organic agents from the north to the south is considered very small, in fact, not much greater than 0.5%.

Pleistocene glaciers flowing from the north could theoretically be considered the main agent of transportation. But the proportion of crystalline rocks in glacial deposits compared with the littoral deposits, is strikingly different. If exotic rocks are considered as glacial erratics, it is necessary to explain the great difference between glacial drift deposits (2%) and shore deposits (13.5% and 24.3%). The low proportion of crystalline rocks in glacial drift is considered normal since glaciers usually do not transport over long distances a great quantity of coarse material. Over a distance of 25 km from a source area, the composition of the drift is usually over 90% local. One has to remember the wideness, the depth, the orientation of the St.

Lawrence and the direction of the flow of basal layers of glaciers at a given period of the Pleistocene, to understand that a small amount of coarse detritus from the Laurentides Shield could have reached the Appalachian region.

The low percentage of crystalline rocks in stratified and non-stratified glacial drift of the south shore of the St. Lawrence estuary is a fact well established today. How can we explain the increase of crystalline pebbles in raised and modern beaches, and also in submerged till? The only logical explanation is that this exotic material was brought by drift ice from the north shore to the south shore across the St. Lawrence estuary. It is difficult to estimate the proportions of crystalline rocks transported both by annual ice and by icebergs. However, it is suggested that the greatest proportion of crystalline pebbles was transported by annual ice, since this process is still in action today and has proved to be very effective (Dionne, 1968b, 1970).

The higher proportion of crystalline pebbles in modern beaches in comparison with raised beaches is apparently the result of a longer action of drift ice at this level. It is well known (Elson, 1969) that successive post-glacial sea levels in the Rivière-du-Loup/Trois Pistoles area were reached rapidly.

The higher proportion of crystalline rocks is submerged till (5%) compared with the ablation till (0.3%) is well explained by the action of drift ice. Otherwise no one can explain adequately why an apparently homogeneous sheet of glacial drift contains more exotic rocks in the areas that were submerged than those that were located over the maximum level reached by the sea.

The low proportion of crystalline pebbles in the Trois-Pistoles and St. Modeste deltas is considered normal, since these deposits were laid down by rivers flowing northwesterly from the Appalachian Uplands.

## Conclusion

Exotic pebbles from the Quaternary deposits of the Appalachian coastal region of Rivière-du-Loup/Trois-Pistoles come from the Canadian Shield located on the north shore of the St. Lawrence estuary, 25 to 40 km away. Pleistocene glaciers contributed only a small proportion of crystalline rocks (less than 2%). A very little proportion (less than 0.5%) can be related to transportation by organic agents, waves and currents, and to the erosion of the Cambro-Ordovician conglomerates which outcrop in the area. The main contribution was made by drift ice, an agent of transportation still in action along the shores of the St. Lawrence estuary.

The data collected do not corroborate the presumptions of (Brochu, 1969), but can be compared with those obtained from Hudson Bay by (Pelletier, 1969).

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