Beach Sediment Trends of Malbaie Bay
Gaspé, Quebec

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Introduction

The beach sediments of Malbaie Bay, on the Gaspé peninsula in Quebec, display longshore changes in composition, size, and shape. These trends reflect the dominant processes acting on the shoreline. Of particularly interest to this study is the evaluation of the roles of selective sorting and abrasional processes on beach sediment characteristics.

Description of Location

The studied beach is located at the southwestern end of Malbaie Bay. Along the south side of the bay, conglomerate cliffs of the Carboniferous Bonaventure Formation rise about 50ft above the beach and are backed by regions of Paleozoic grey limestone. Several small streams cut through these cliffs transporting limestone clasts to the beach. A pebbly and sandy spit extends northward from the cliffs for eight kilometers, separating the water of Malbaie Bay to the east from a tidal estuary to the west. Four kilometers of the Malbaie Bay beach were studied for this project.. They include two kilometers under the eroding cliffs which are characterized by an abundance of land sediment imput and two kilometers just prior to the spit that are characterized by an absence of land sediment imput.

The sediment lithologies on the beach reflect the lithologies of the southern highlands. Pebble lithologies include grey limestone, tan limestone, sandstone, and conglomerate, and minor siltstone and mudstone, while the sand lithologies include quartz, limestone, and siltstone and mudstone fragments.

Methods

Sediments were studied at 21 sites at 200m intervals along the 4km stretch of beach. Coarse sediments were examined on the storm berm of the beach. At each site, an unbiased selection of fifty pebbles were measured for long, intermediate, and short axes and lithologies were recorded. Sand samples were collected from the swash zone and size distributions were determined. These sand samples were impregnated and cut into thin sections, allowing for compositional point counts to be made on different size fractions.

Results

An analysis of the beach sediment revealed an absence of textural and compositional trends on the section of beach below the cliffs due to the constant addition of new material. However, general trends are apparent with increasing distances away from the cliffs.

Textural and compositional analysis of sediment revealed the following trends in the longshore drift direction past the cliff region.

Textural

1) Pebble size decreases down the beach for all rock types (fig.1).
2) The percent of coarse sand generally decreases along the beach.
3) Pebble sphericity values and shapes have no significant relationship with distance, however the river imput of sediment is reflected in the sphericity pattern.
4)Pebble sphericity levels are low and shapes are dominantly bladed or platy

Compositional

1) The percent of tan limestone pebbles increases down-drift while grey limestone decreases (fig.2).
2) Pebble conglomerates disappear past the cliff region.
3) Fine sand fractions steadily lose carbonates and become increasingly quartz rich along the beach (fig.3).
4) Coarse sand fractions show a rise and fall of quartz percentages (fig.4).
5) Finer sand fractions contain higher percentages of quartz than coarser sand fractions.

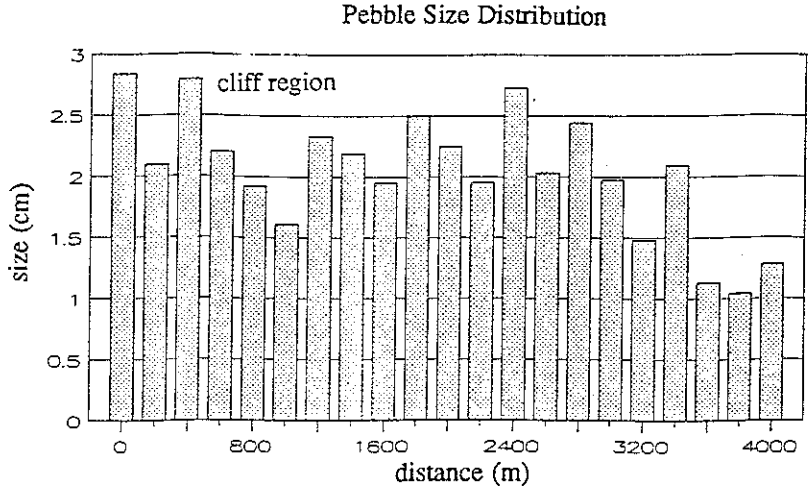


fig.1 Average pebble size distribution along the beach showing a decrease in size past the cliff region (2000m mark).

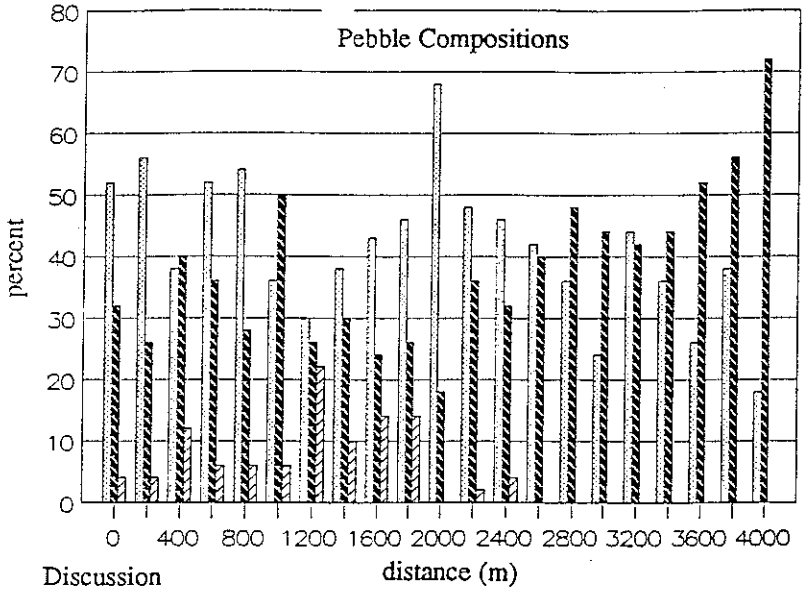


fig.2 Pebble composition percentages along the beach show a disappearance of conglomerates, a decrease in grey limestones, and an increase in tan limestone past the cliff region. (sandstone, sedimentary rock fragments (S.R.F), and other lithologies were omitted in order for clarity, therefore percentages will not total 100).

Discussion

Both abrasion and selective sorting have been found to be significant processes influencing the nature of beach particles (Dobkins and Folk, 1970, and Bluck, 1967). While they are two different processes it is their combination that produces the sediment trends found on this beach. Abrasion rates are a function of lithology, sediment size, and wave energy. Generally, limestone abrades easier than other rock types. Abrasion rates also increase with size since the collision force is generally greater for larger sized sediments. However, the particle size that receives the most abrasion depends on the amount of wave energy. The size that is small enough to be moved by waves and large enough to stay out of suspension will undergo the most abrasion.

Selective sorting processes rely on the specific hydraulic behavior of a grain, based on its size, shape, and density (Carter, 1988). Selective sorting produces size and morphological trends by moving material to positions of equilibrium with prevailing nearshore wave conditions (Derbyshire, 1979). Selective sorting would therefore explain a longshore decrease in grain size as finer grains outdistance coarser grains.

The textural patterns of the pebbles on the Malbaie Bay shoreline show the effects of selective sorting. The decrease in size with distance past the cliffs is significant for all storm berm pebbles regardless of lithology (fig.1). On this beach, size grading comes from selective sorting by longshore drifting. Smaller grains are preferentially moved greater distances both in suspension and traction during swash-backswash events. This process of longshore sediment transport allows for the fining of pebble size in the down drift direction.

The compositional trends of the storm berm pebbles show the influences of both abrasional and selective sorting processes (fig.2). As one would expect, the conglomerate pebbles quickly disappear past the headlands. They lack the durability necessary to keep them intact under the pounding of the surf and are quickly abraded. Alternatively, the percent of sandstone pebbles on the berm stays relatively constant. The main pattern shown by composition is the decrease in grey limestone and the increase in tan limestone. Since there is little difference in the abrasion rates between the two limestones, this pattern is largely the result of selective sorting. The tan limestone characteristically has a smaller average diameter then the grey limestone. Therefore, the abundance of tan limestone at the end of the studied area is more a function of its smaller size then of its durability.

The composition of the fine sand fraction also presents expected trends along the beach (fig.3). The clear increase in quartz and decrease in carbonates and sedimentary rock fragments over distance shows the relative durability of quartz while carbonates and sedimentary rock fragments are abraded away. Selective sorting is not an option for this trend since the sizes and densities of the rock types are similar.

The compositional patterns of the coarse sand fraction are less obvious (fig.4). Quartz percentages increase past the headlands and then steadily decrease after the 2800 meter mark. Conversely, carbonate and sedimentary rock fragment percentages decrease past the headlands and then slightly increase. The reason for the deviation from an expected trend of increasing quartz is unknown.

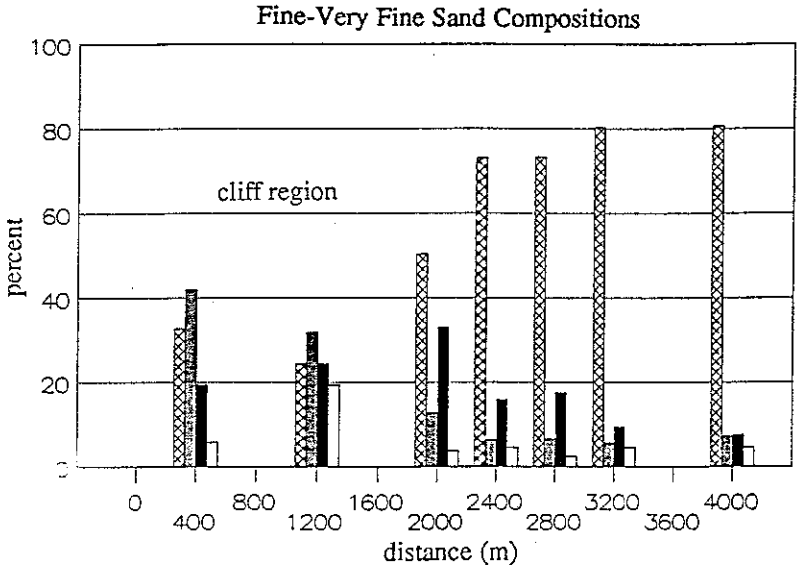
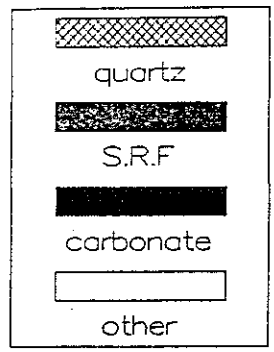


fig.3 Compositional trends in the fine-very fine sand fraction showing a steady increase in quartz percentages and a decrease in carbonates and sedimentary rock fragments (SRF).



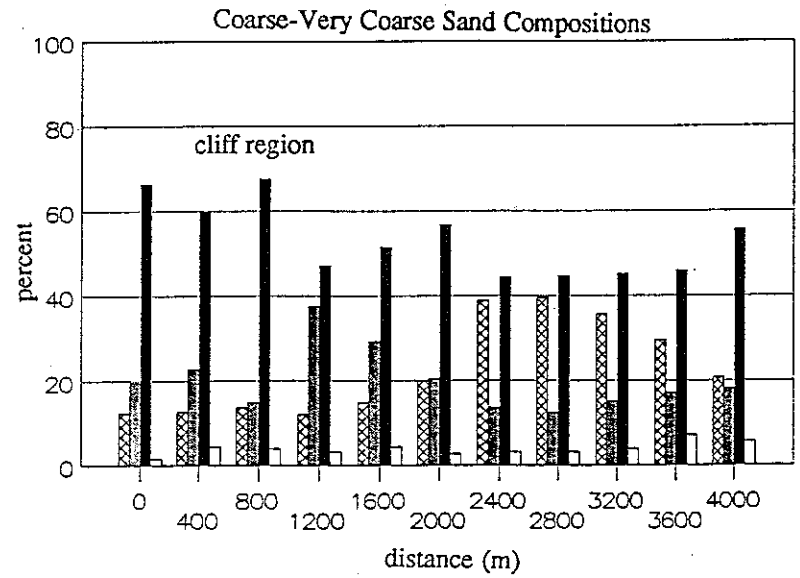


fig.4 Compositional trends in the coarse-very coarse sand fraction showing an unexplained increase and decrease in quartz percentages.

Overall, the composition and size of the durable storm berm pebbles along the Malbaie Bay shoreline are controlled by selective sorting processes. The process of abrasion is found to control the percent of less durable pebbles and the composition of the different sand fractions of Malbaie Bay. The combination of these two beach processes accounts for the textural and compositional sediment trends found in the down-drift direction along the beach.

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