A PROCESS-RESPONSE MODEL OF SAND SPIT FORMATION IN THE BAIE DE MALBAIE, GASPÉ PENINSULA, QUEBEC

Gary J. Creaser
Department of Geology
Beloit College
Beloit, WI 53511

The purpose of this study was to determine the process of formation of a sand spit named le Cordon littoral de Malbaie in the Baie de Malbaie of the Gaspé peninsula, Quebec. The bay is bounded by sea cliffs up to 640 feet high in the south composed of vertically dipping beds of Carboniferous conglomerates with underlying Ordovician limy shales. In the north, Devonian conglomerates are dominant. The spit itself is nearly 6 miles long and traverses the bay from the south to nearly the north end, where it is truncated by a tidal inlet. A railroad crosses the spit as well as two sea walls. One of these protects the railroad bed from erosion, the other protects the coastal dwellings of the town of Coin du Banc in the south. The southern cliffs have been undercut by wave action, and large landslides of shale have come down onto the beach.

Patterns of wave refraction were computed by a bottom contouring program developed by McIntire and others (1968) and a wave refraction program written by Dobson (1967) and modified by Fox (1969). Bathymetric and map data for the bay and spit were digitized from a bathymetric chart of the Baie de Malbaie. The program proved excellent for predicting wave refraction patterns related to heavy winter storm waves that were not directly observed in the field. The direction of the incoming waves was varied from northeast, due east, and southeast. For each direction, the period of the waves was varied from 6 to 10 seconds, with a constant wave height of 5 feet. The results of waves coming in from N80°E with a period of 10 seconds are shown in figure 1. The northerly rays converge upon the headland, but the more southerly rays diverge quickly, representing a lesser concentration of energy. However, the southerly rays are closely spaced all along the south shore, and represent more concentration of energy. In order to look at the acceleration and deceleration of the longshore current, the breaker height of each incident wave ray (computed by the program) and the acute angle made by the wave crest to the shore were entered into a relation giving relative current velocity (Fox and Davis, 1972). Figure 2 is a plot of longshore current velocities for 21 incoming rays from 1 in the south to 21 in the north. The current accelerates and decelerates along the south shore until it reaches zero near the spit. Minor acceleration is found in the north, but quickly reaches zero. Thus, it is expected that there should be more contribution of sediment from the south side of the bay to the spit than from the north.

Sediment samples were taken from 15 localities at 2000-foot intervals along the length of the spit and labelled A - Q from north to south respectively, as is shown in figure 3. At each locality, three samples of the top 4 inches of sediment were taken at sites corresponding to 1/6, 3/6, and 5/6 the distance covered by a line running from the top of the beach, defined by the edge of the sand, to the low water level. The samples were run through sieve nests with half-ϕ intervals on a Rotap machine for 10 minutes. Mean, standard deviation, skewness, and kurtosis were calculated using the graphic statistical method used by Folk and Ward (1957). Figure 4 shows scatter plot distributions of mean grain size of the upper, middle, and lower beaches along the length of the spit. The data are quite scattered in the lower and middle plots, but show a trend of fining towards the north. The upper beach plot is clustered much better and is believed to be due to a lack of sediment reworking, as only storm waves and the highest tides can reach this area. Figure 5 is a bar graph of graphic standard deviation for each locality. Several large peaks and valleys in these data are not consistent with the wave refraction model, which might be expected to show a general increase in sorting towards the north. At locality M, the first major deviation is noticed. Just north of that locality, a small stream carrying some glacial sediment empties onto the beach, and has built a small raised delta onto the upper part. This would account for the coarse sediment found at O, M, L, and K. This would also account for the poor sorting at these localities, except at L and M, where there is good sorting due to the stream contributing a consistently coarse grain size to the beach surface. A strong coarse trend is noticed at locality I on the grain size plots. This is believed to be due to a gap between two sea walls that allows fill and railroad ballast to migrate onto the beach and become incorporated into the sediment farther to the north as the surface sediment is transported north by longshore current and mixed with finer surface sediment. Deviations in the data around C and D cannot be explained without further field observations, but may be due to a past tidal inlet.

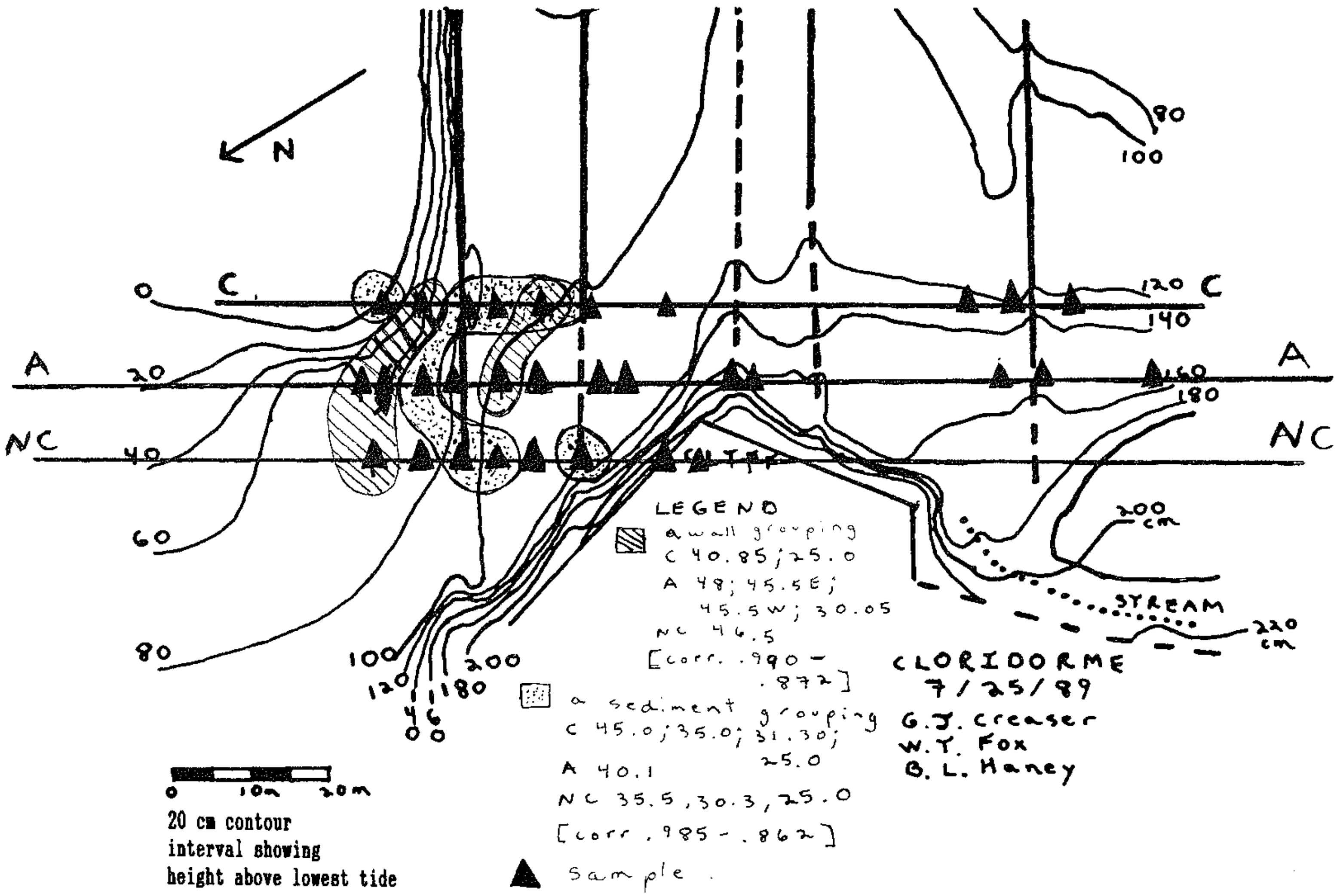


Figure 2. Sampling locations on transects and examples of cluster analysis grouping.

A trench was dug at sample locality G to assess past depositional processes. The trench was dug perpendicular to the shore and measured 35 feet long by 4 1/2 feet wide by 2 1/2 to 3 feet deep. Since the layers of beach sediment are not truncated, an accretionary depositional process can be inferred.

Profiles were taken at each locality along the length of the spit using the stake and profile method and 20 feet intervals between the stakes. The gradient of the profiles decreases from south to north, and represents a decrease in grain size towards the north.

The scanning electron microscope was used to observe textural features of grains along the length of the spit. Preliminary results show that there is a general increase in maturity towards the north. Further work is in progress on the textural investigation, and possibly Energy Dispersive analysis to look at grain composition.

In conclusion, this spit appears to have formed from the south side of the bay to the north via longshore currents. There remains much more work to be done in the future by others. This may include provenance studies and perhaps the taking of samples beneath the top 4 inches of the beach to get a better representation of grain size.

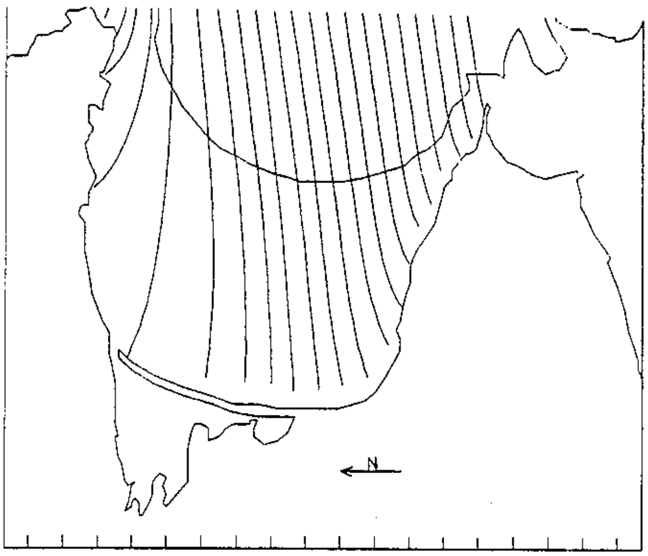


Figure 2

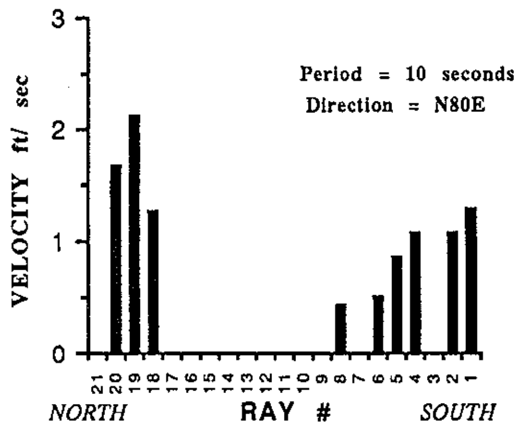


figure 3

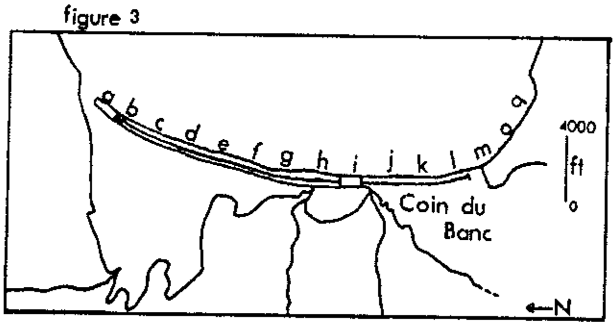


Figure 4-A

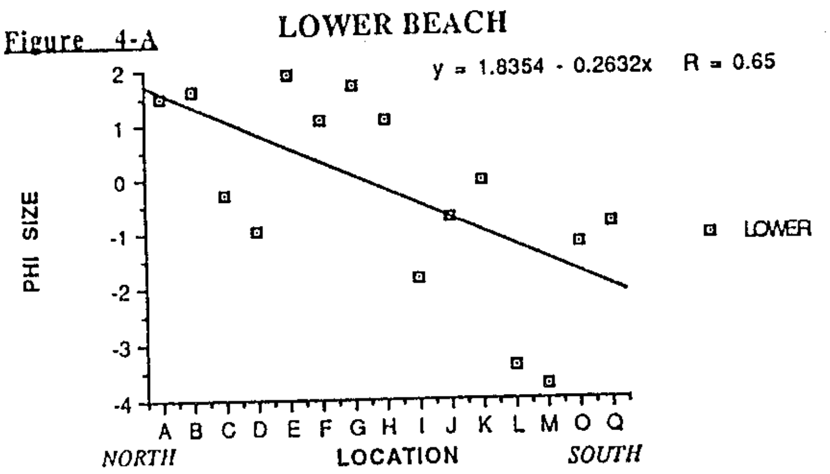


Figure 4-B

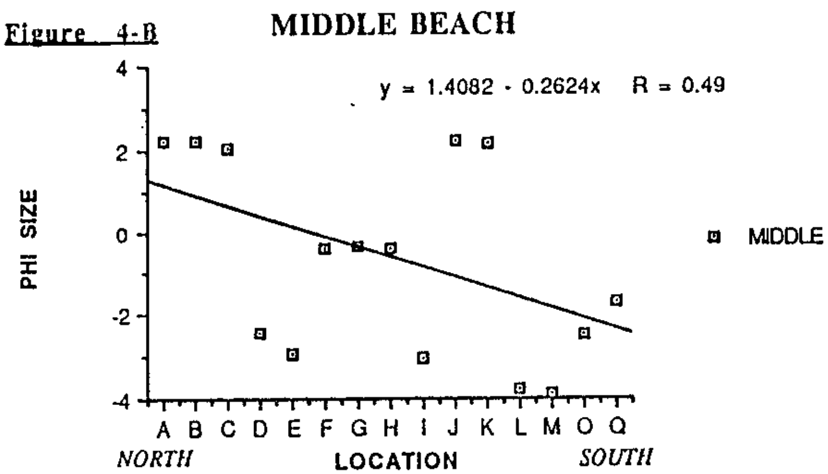


Figure 4-C

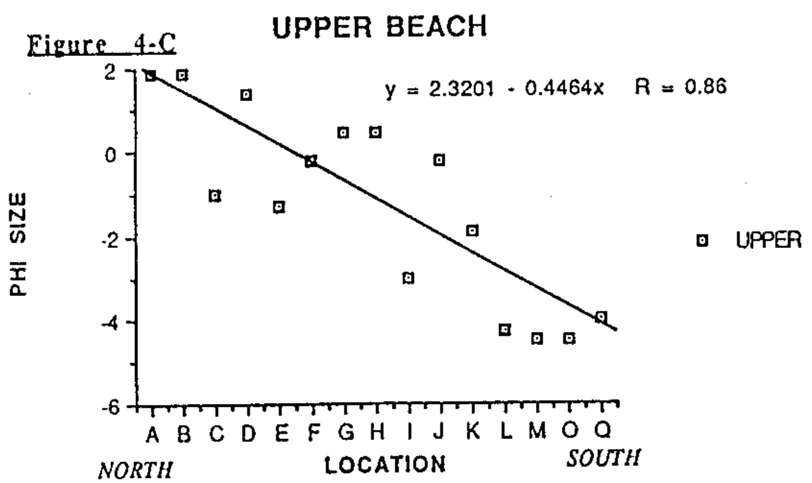
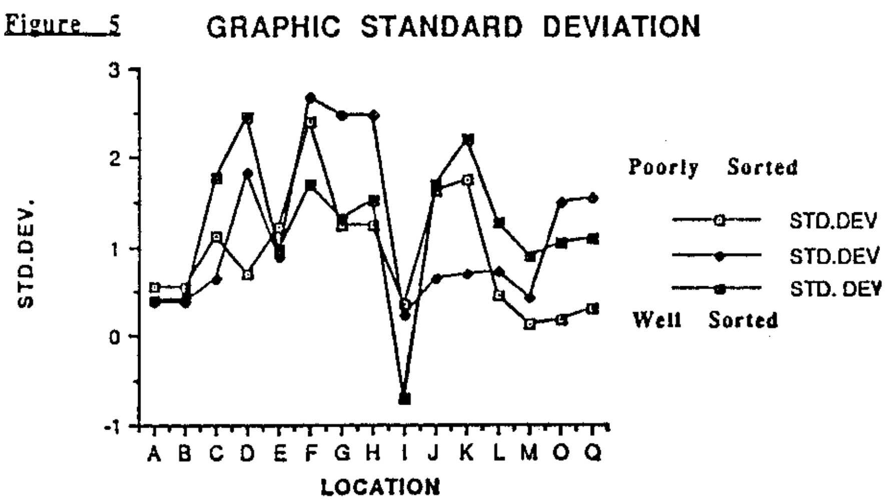


Figure 5



REFERENCES

Cunningham, R.W., and Fox, W.T., 1974, Coastal processes and depositional patterns on Cape Ann, Massachusetts: Jour. Sedimentary Petrology, v. 44, no. 2, p.522-531.

Folk, R.L., and Ward, W.C., 1957, Brazos River bar: A study in the significance of grain size parameters: Jour. Sedimentary Petrology, v. 27, p. 3-26.

Fox, W.T., 1969, Wave refraction program (Wave 87).

Fox, W.T., and Davis, R.A., 1972, Coastal processes and beach dynamics at Sheboygan, Wisconsin, July, 1972: Technical report, Office of Naval Research Contract NR 388-092.

McGerrigle, H.W., 1968, The geologic history of the Percé area: Quebec Department of Natural Resources, Geological Services.

Fossilization Potential of Soft-Bodied Algal (Fucus) Holdfast Traces

Laura S. Dalton

Williams College
Department of Geology
Williamstown, Massachusetts
01267

The history of fossil algae has been studied with varying degrees of success. While the calcareous algae are reasonably well documented (Wray, 1977), little paleontological evidence exists for soft-bodied algae such as kelps and fucoids. The few findings are of the inferred presence of soft-bodied algae through associated invertebrates, and these are relatively recent (Baluk and Randwanski, 1977, and McRoberts and Stanley, 1988).

For this study, argillite substrates carrying several species of the algae genus Fucus collected from wave cut platforms along the north shore of the Gaspe Peninsula, Quebec, Canada. These argillite samples were examined for unusual surface traces produced by the holdfasts of Fucus that could potentially be preserved in the rock record. Algae species were differentiated by the distinctive receptacles found on fertile individuals. The three identifiable species of Fucus studied were: F. vesiculosus, F. edentatus, and F. spiralis. Those individuals that had no fertile receptacles were lumped under the heading of Fucus sp. (Fig. 1).

The substrate samples collected for this study were from turbidite shales of mid-Ordovician age in the Cloridorme Formation. The best exposures of this formation occur along the north shore of the Gaspe Peninsula as sea-cliffs and wave cut platforms (Enos, 1969). On the platforms, the less resistant argillites form the spectacular tide pools interbedded among the more resistant sandstones. Two platforms; one at Grande Vallee and another at Point Mimi 30 kilometers to the east, were chosen as study sites.

Data collected consisted of biological counts taken along transects running from the landward end of the platforms to the sea. Half-meter square grids divided into 25 ten-by ten centimeter squares were laid down at predetermined intervals along these transects in oreder to map the spatial distribution of the various species of algae. "Plant-like" algae were counted by the number of holdfasts, and encrusting algae were counted by estimating their total area in square centimeters.

After the biological data had been recorded, samples of argillite with attached holdfasts were collected from the tide pools at Grande Vallee and Point Mimi. Each sample was sketched, numbered, and the algae species were identified to the degree possible.

In the lab, the holdfast sites of Fucus were marked, and the samples were then soaked for several days in hydrogen peroxide, then rinsed, in order to remove the algae from the argillite substrate. The samples were then dried, mounted, and gold coated. The argillite samples were examined using the Cambridge Stereoscan 100 Scanning Electron Microscope.