TECHNICAL COMMUNICATION

Quartz-sand Exploitation from a Dredged Material Disposal Site

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ABSTRACT


The purpose of the report is to investigate a dredged-material disposal site for silica sand exploitation. The deposit, named "D" deposit, is located south of the Madeleine Islands in the Gulf of St Lawrence. The deposit was cored using a vibro-coring device. The cores were analyzed by mineralogical and chemical methods. Three sedimentary units were found in cores at the dredged-material dumpsite: (a) a buff-colored medium sand composing the cover layer, (b) a massive, grey, coarse sand interpreted as the dredged material, and (c) the underlying natural sediment made of reddish, semi-indurated sand. The sands from the "D" deposit have the chemical and physical characteristics of good, natural-bonded moulding sands. The reserves are estimated at 78,000 m³ (proven) and 150,000 m³ (possible) for the cored area, but the total could be considerably increased if other parts of the present-day dumpsite are considered. The report shows that clean dredged sediment may have a resource value. With increasing environmental constraints along coastlines, the utilization of marine dredged-material in shallow water can help to reduce the exploitation of beaches and nearshore sands and provide, at the same time, a good source of silica-sand.

ADDITIONAL INDEX WORDS: Silica, sand, Madeleine Islands, dredge spoils, quartz sand.

INTRODUCTION

Marine sands are abundant in Canada but are rarely exploited commercially. The lack of precedents of marine mining in this country has inhibited the development of inshore mining. Canada, with one of the largest continental shelf areas in the world, has done little to evaluate its unconsolidated mineral resources which include industrial minerals such as silica sand (HALE and McLAREN, 1984). In the mid-1970s, the Department of Energy, Mines and Resources, formed the Departmental Coordinating Committee on Ocean Mining (DCOM) within which a Shelf Working Group developed a method for resource assessment (SHELF WORKING GROUP, 1980). Recently, the Canadian government has stated that more information on the potential impacts of marine mining is required to support a regulation which integrates both environmental and economic concerns (OCEAN MINING DIVISION, 1991).

The study area is located in the center of the Gulf of St Lawrence, south of the northeastern point of the Madeleine Islands (Figure 1). The deposit called "D" deposit is 690 m long and 310 m wide, striking northwest. The sediments discharged at this dumpsite were dredged primarily from the channel between Grande-Entrée and the salt mine. In order to keep waterways accessible to salt shipping, regular dredging of the channel is necessary.

Preliminary studies have evaluated the Madeleine Islands sand at many points along the sand dunes, which are the most striking features of the archipelago topography (WADDINGTON, 1948; MATTHEU, 1982a). Although of good quality for foundry, glassmaking and building-material utiliza-

93117 received 18 November 1993; accepted in revision 15 May 1994.
tions, the exploitation of sand has never been undertaken due to environmental constraints and poor economic return.

This study was conducted on a man-made sediment deposit which had never previously been examined. The purposes of the research are to evaluate the thickness of the deposit and to characterize the sand for future exploitation.

OCEANOGRAPHIC AND GEOLOGIC SETTING

The Madeleine Islands are exposed to winds from all directions with unrestricted fetches. The wave regime is characterized by locally generated waves. The prevailing wind directions of the Madeleine Islands are from the northwest. The
study area is the most protected zone of the Islands with a mean breaker height of 58 cm (Owens, 1977). The wave climate fluctuates and is dominated by the effects of storm waves.

The area is microtidal with semi-diurnal mixed tides (Forrester, 1983). The tidal range varies from 0.7 m (mean tide) to 1 m (spring tide). As opposed to the west coast, the nearshore of Grande-Entrée is an area of modern sediment accumulation (12,000 m³/yr, after Drapeau and Mercier, 1987). The sediments come from the offshore area and from the erosion of outcrops located to the northeast. In the study area, longshore sediment transport is from northeast to southwest. Overall, the Madeleine Islands are a very dynamic system but the net sedimentary budget is essentially balanced.

The shoreline of the Madeleine Islands is composed of sand beaches and red sandstone cliffs. The sands are medium-sized, homogeneous and well-sorted. They are derived from the erosion of carboniferous sandstone cliffs and from Wisconsinan fluvo-glacial material reworked from the shelf by littoral processes.

METHODS

Nine cores, 50 to 100 m apart, were collected from the deposit (Figure 2), using a vibro-coring device with positioning by GPS (Global Positioning System). The water depth was also surveyed.
Table 1. Characteristics of major sedimentary units.

<table>
<thead>
<tr>
<th>Units</th>
<th>Description</th>
<th>Thickness (m)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Buff-colored medium sand</td>
<td>0–1</td>
<td>Cover layer</td>
</tr>
<tr>
<td>B</td>
<td>Grey coarse sand, pebbles shell fragments</td>
<td>1.2–2.6</td>
<td>Dredged-material</td>
</tr>
<tr>
<td>C</td>
<td>Reddish semi-indurated sand</td>
<td>0.2–1.0</td>
<td>Underlying sediment</td>
</tr>
</tbody>
</table>

The cores were logged using standard methods. They were sampled, according to lithologic differences. Mineralogic and chemical analysis was conducted as part of this investigation.

SEDIMENT TYPES

Three major sediment types are described from the cores taken at the dredged-material dumpsite (Table 1). The sediment types were classified according to their color, grain-size and mineralogy.

Type A: This facies, occurring on the top of the cores, consists of buff-colored medium sand with a few shell fragments and pebbles. Organic material is also present.

This sedimentary type represents the cover layer used by dredging and mine authorities to confine the deposit, according to environmental specifications for dredged-material disposal in the marine and nearshore environment. This unit is absent on the top of 3 cores (Figure 2). This absence is interpreted as the result of irregularity in the capping operations rather than reworking by modern processes. In the past, post-dumping monitoring programs including bathymetric profiling have demonstrated that the deposit does not undergo changes due to modern hydrodynamic processes.

Type B: This unit lies below facies A. It consists of massive grey coarse sand containing some pebbles and shell fragments. Organic material is also present.

This sedimentary type represents the cover layer used by dredging and mine authorities to confine the deposit, according to environmental specifications for dredged-material disposal in the marine and nearshore environment. This unit is absent on the top of 3 cores (Figure 2). This absence is interpreted as the result of irregularity in the capping operations rather than reworking by modern processes. In the past, post-dumping monitoring programs including bathymetric profiling have demonstrated that the deposit does not undergo changes due to modern hydrodynamic processes.

Type C: This sedimentary unit is the basal facies, composed of semi-indurated reddish sands, appearing in some places as altered red sandstone. This sediment is mainly composed of iron oxide-coated quartz grains. The contact between unit B and unit C is always sharp. Due to its hard nature, this material was only cored on 0.2 m to 1 m.

This unit is interpreted as the underlying natural sediment covered by dredged material.

MINERALOGICAL, CHEMICAL AND GRAIN-SIZE CHARACTERISTICS

The sand is composed mainly of well-rounded grains of quartz and feldspar with minor amounts of calcite, dolomite and mica (Table 2). Limonite appears as thin coatings on the silicate grain surfaces.

Grain-size analysis shows that more than 80% of the sediment is comprised between 200 and 400 μm (fine to medium sand). The mud fraction represents less than 0.5% while unit B contains 1 to 5% of pebbles (2 to 5 mm diameter).

Chemical analysis of representative samples of these marine sands have demonstrated a suitable composition for industrial applications. The SiO₂ content in the raw sand ranges from 91.8 % to 94.1 %. Conventional flotation tests have shown that silica concentrate is satisfactory for iron foundry sand and can meet the requirements for glass production. It contains quartz with few alkali feldspars. The content of Fe₂O₃ in silica concentrates varies from 0.15% to 0.7% and can be reduced below 500 ppb by acid leaching processes.

PERSPECTIVES AND RESERVES

Units A and B represent clean sedimentary material which can be exploited for silica. The characterization work has demonstrated that concentrates obtained by floatation are suitable for iron applications. Based on the thickness of these units, the reserves are estimated at 78,000 m³ (proven reserves) and 150,000 m³ (possible reserves) of silica sand for the restricted, cored zone. For the entire “D” deposit if the thickness of units A and B remains similar as in distal cores (about 1 m), the reserves could be 300,000 m³. In the next part

Table 2. Mineral composition of sand from “D” deposit.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>90</td>
</tr>
<tr>
<td>Calcite</td>
<td>1.2</td>
</tr>
<tr>
<td>Dolomite</td>
<td>1.7</td>
</tr>
<tr>
<td>Alkali feldspar</td>
<td>2.1</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>3.6</td>
</tr>
<tr>
<td>Mica</td>
<td>1.1</td>
</tr>
<tr>
<td>Total</td>
<td>99.7</td>
</tr>
</tbody>
</table>
of the project, suitable techniques such as seismic reflection profiling will be used on the site to obtain a better definition of the extent of the deposit.

The reserves could be considerably enlarged if we consider the present-day deposit and the older ones called “B” and “C” islets, located in the harbour and alongside of Ile-de-la-Grande Entrée (Figure 1). However, more work is needed on these sites because they are nesting areas for seabirds. A strategy for risk assessment should be proposed, based on national environmental standards.

The exploitation of beach and nearshore sand is now restricted along the world’s coastlines. The equilibrium of these zones under the influence of littoral processes has to be protected. Utilization of a marine dredged-deposit constitutes an excellent alternative to natural deposits because it does not destroy natural features. Furthermore, the exploitation of sand directly from dredging barges could reduce the costs of exploitation, provide a good source material for silica industries and minimize the environmental impact of sand disposal in marine environment. The amount of dredged-material is estimated at 900,000 m³ total over the next ten years.

CONCLUSIONS

The survey of the “D” deposit at Madeleine Islands, reported here, provides insight into a new silica-sand source. This study shows that clean dredged sediments may have resource value.

1. The sands from “D” deposit have the chemical and physical characteristics of a good natural-bonded moulding sand.

2. The reserves of sand (proven and possible) are sufficient to justify a fair-sized exploitation.

3. The dredging operations can constitute a new long-term silica-sand resource, with low-cost recovery.

4. Environmental constraints have considerably reduced exploitation of beach and nearshore sands elsewhere. The utilization of artificial deposits located in shallow water provide an excellent solution in the context of increasing demand for quality quartz.

ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of the captain Germain Cyr and the crew of Metaprobe Drilling for sampling. We also thank the personnel of Centre de Recherche Minérale (Québec). We are grateful to J. Kelley and an anonymous reviewer for their constructive comments and suggested improvements to the manuscript and to Dr. Finkl for editorial guidance.

LITERATURE CITED


