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# Preliminary assessment of the marine mineral potential of the Bonavista/Funk Park study area, northeastern Newfoundland

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M. Emory-Moore

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**Mineral and Energy Resource Assessment [MERA]**

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# *Preliminary Assessment of the Marine Mineral Potential of the Bonavista/Funk Park Study Area, Northeastern Newfoundland*

## **INTRODUCTION**

This report provides a preliminary overview of the marine mineral potential of the Bonavista/Funk Island study area (Fig. 1). A compilation of relevant geologic data was used in combination with known controls on marine mineral formation for assessment purposes. The commodities reviewed included placer minerals (gold, platinum, zircon, garnet, monazite, rutile, ilmenite, magnetite, chromite, wolframite and diamonds), industrial minerals and hydrocarbons. The focus of study for non-fuel mineral resources was limited to water depths of less than 100 m, which except for diamonds, is currently deemed the economic limit of most marine mining operations.

This study embodies a Phase I Mineral and Energy Assessment (MERA) and in as much is based solely on literature review and application of relevant mineral deposit models. No new data have been collected or analysed.

## **STUDY AREA**

The study area extends along the northeast coast of Newfoundland from the tip of Cape Bonavista, Bonavista Bay to North Head, Notre Dame Bay (Fig. 1). The rock dominated coastline is highly sculptured and characterized by a low-to-moderate relief. Along the northern coast, the protected and semi-exposed areas are characterized by extensive rock and boulder platforms and locally developed sand and gravel beaches (Shaw et al., in prep.). The more exposed areas are dominated by rock platforms, rock cliffs and limited beach development. A notable exception to this is the highly exposed shoreline from Musgrave Harbour to Cape Freels which is characterized by numerous sandy beaches and extensive areas of coastal dune development (Shaw et al., in prep.). The northern part of Bonavista Bay area is characterized by fiord coast line with limited beach development and island and outer-fiord coast with rock platforms, ock cliffs and limited beach development. The coastal zone south

of Indian Bay has not been mapped.

Notre Dame Bay and Bonavista Bay are characterized by north- to northeast-trending glacially-over deepened coastal basins with water depths exceeding 600 m in places. The inner shelf region in the Hamilton Sound-Cape Freels area is, in contrast, gently sloping.

## **Bedrock Geology and Mineral Occurrences**

The terrestrial geology of the study area records a complex sequence of geologic events related to the evolution and destruction of the Lower Paleozoic Iapetus Ocean. Three major lithotectonic geologic zones are exposed in the coastal sections: from east to west these include rocks of the Avalon Zone, the Gander Zone and the Dunnage Zone (Fig. 2; Hayes, 1987). The Avalon Zone is comprised of Precambrian sedimentary and volcanic rocks overlain by Cambrian to lower Ordovician shales and sandstone. The boundary between the Avalon and Gander zone is marked by major fault systems. The Gander zone is characterized by a thick sequence of pre-Middle Ordovician arenaceous rocks intruded in much of the coastal area by large Ordovician/Devonian granites. Finally, the Dunnage Zone is characterized by lower Paleozoic mafic volcanic rocks, ophiolite suites, melanges and associated greywackes, slates, cherts and minor limestone.

The nearshore coastal rock suites are an extension of the terrestrial rocks. Cambrian-Ordovician rocks underlie the deeper waters of the Notre Dame channel with Carboniferous rocks predominating north of 50 degrees latitude (Fader et al., 1989). The shallow (< 200 m) inner shelf east of Hamilton Sound is floored by Devonian granite. Farther offshore, upper Cretaceous-Tertiary rocks are exposed (Shaw et al., in prep.). A large southwest-northeast tending fault separates these rocks from the Paleozoic sedimentary rocks which underlie the nearshore zone of Bonavista Bay.

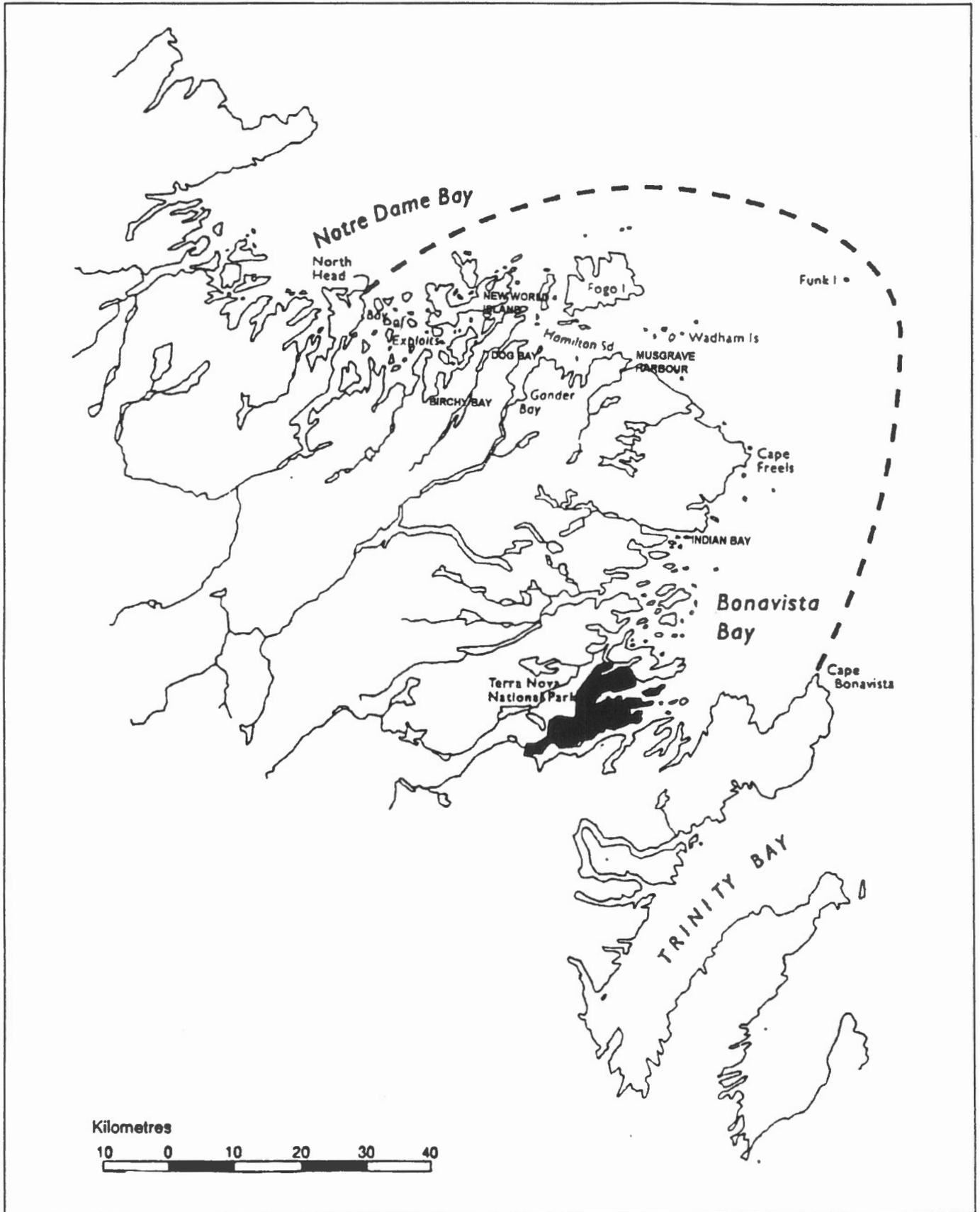


Figure 1. Outline (solid dashed line) of Coastal Zone Study Area.

- INTRUSIVE ROCKS**
- ORDOVICIAN TO DEVONIAN**
- PROTEROZOIC II TO CAMBRIAN**
- DEVONIAN TO CARBONIFEROUS** Subaerial, lacustrine fluvial and deltaic clastic sedimentary rocks; minor limestone
- SILURIAN** Shallow marine and subaerial clastic sedimentary rocks; volcanic and volcanoclastic rocks
- DUNNAGE ZONE**
- CAMBRIAN TO SILURIAN** Marine clastic sedimentary rocks; island-arc volcanic and volcanoclastic rocks
- CAMBRIAN TO ORDOVICIAN** Ophiolitic mafic - ultramafic rocks, pillow lava and related intrusions
- GANDER ZONE**
- CAMBRIAN TO ORDOVICIAN** Clastic metasedimentary rocks and migmatitic equivalents
- HUMBER ZONE**
- PROTEROZOIC III TO ORDOVICIAN** Autochthonous and parautochthonous clastic and metasedimentary rocks
- Platform limestone and dolostone; includes clastic sedimentary rocks
- Allochthonous sedimentary, mafic volcanic and minor metamorphic rocks
- Basal clastic and carbonate sedimentary rocks; includes mafic volcanic rocks
- PROTEROZOIC II and III** Orthogneiss, paragneiss and amphibolite
- AVALON ZONE**
- PROTEROZOIC III TO ORDOVICIAN** Subaerial and marine clastic sedimentary rocks; minor limestone
- PROTEROZOIC III** Marine and deltaic clastic sedimentary rocks
- Mafic and felsic volcanic and volcanoclastic rocks

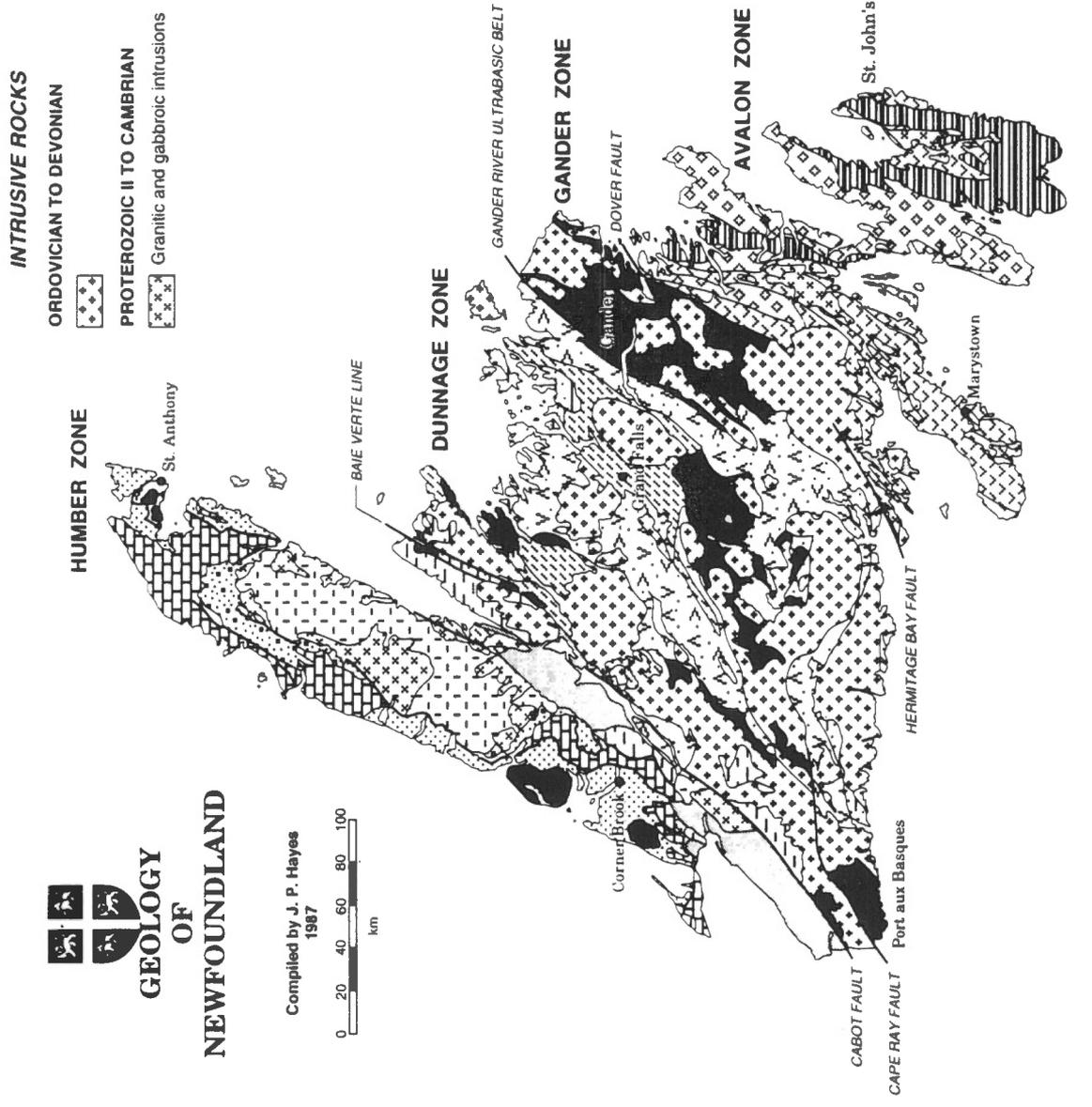


Figure 2. Generalized geology map of Newfoundland (Hayes, 1987)

Cretaceous-Tertiary rocks are exposed in deeper waters (> 200 m) of Bonavista Bay.

Of the many mineral occurrences documented in the Newfoundland and Labrador Geological Survey's Mineral Occurrence Data System (MODS) files, only the Dunnage Zone was found to host mineral occurrences which may provide a suitable bedrock source of placer minerals. Chromite mineralization has been documented in the ultramafic rocks immediately south of Gander Bay. Epigenetic gold occurrences have been reported in the Gander Bay area, at the head of Dog Bay and on New World Island. Anomalous gold values have also been reported on the small islands immediately south of Fogo Island.

### *Quaternary Geology*

Late Wisconsin ice spread beyond the present coast from an ice cap centred in central Newfoundland (St. Croix and Taylor, 1991). Discontinuous till with extensive areas of exposed bedrock characterize much of the coastal region. Unconsolidated sediments in back shore cliffs are largely restricted to the inner fiord heads where glaciofluvial sediments occur (e.g., Bay of Exploits, Gander Bay, Freshwater Bay and Newman Sound). Raised marine sediments occur in the coastal sediment suites at the head of Gander Bay, between Musgrave Harbour and Cape Freels and in the Eastport area.

Dale and Haworth (1979) identified the occurrence of five seismic facies on the continental shelf just north of the present study area: bedrock, till, a semi-stratified unit, a stratified unit, and an acoustically transparent unit.

Under the 1990-1994 Canada-Newfoundland Cooperation Agreement on Mineral Development, the Geological Survey of Canada completed a comprehensive three year study of the northeast Newfoundland coastal and nearshore zone (Shaw et al., in prep.); much of the following discussion is drawn from this work. Geophysical and sample data were collected from Cape Freels to White Bay. Five seismostratigraphic units were identified and mapped, including: bedrock (unit 1), till and other ice-contact deposits (unit 2), stratified glacial-marine

deposits (unit 3), postglacial muds (unit 4) and postglacial sand and gravel (unit 5). In the Bay of Exploits thick sequences of postglacial mud (70-200 m thick) abut steep rocky side walls. In the New World Island region, the dominant seabed type was found to be postglacial gravel and muddy gravel with basins of ponded sand and mud. Dog Bay and Gander Bay, both relatively shallow, do not contain thick deposits of glacial-marine deposits. In Dog Bay postglacial sediments are up to 11 m thick and range from a sandy silt near the head of the Bay to a silty sand in shallower water. Drumlins occur near the head of Gander Bay and are surrounded by units of silty mud (up to 8 m thick) with scattered gravels. A hard gravelly bottom was detected in some of the shallower water areas.

In the Hamilton Sound area, the Quaternary sediment package is thin with bedrock outcropping in several areas. Till (unit 2) is found throughout the Sound and is thickest where it infills bedrock depressions and near the mouth of Gander Bay where it is moulded into drumlins (15 m thick). Glacial marine mud (unit 3) occurs in small basins in eastern Hamilton Sound. Postglacial gravel, sand, and muddy sand (unit 4) occurs throughout the Sound as thin veneers over bedrock, mobile sheets of rippled gravel several metres thick and basin-fill type deposits. Shaw and Edwardson (1994) identify the presence of wave-cut terraces in water depths of 17-20 m within Hamilton Sound.

The inner shelf (< 75 m water depth) from Cape Freels to Fogo Island is covered by a discontinuous veneer of sand and gravel which averages several metres in thickness. The sediment overlies granitic bedrock which is exposed on approximately 5% of the sea bed. Sediment texture ranges from well sorted fine-medium sands to well sorted gravels. Gravel ripples are very prevalent in water depths of 29-73 m.

Emory-Moore and Davis (1992), Scott (1993) and Shaw et al (in prep.) report the presence of particulate placer gold in beach samples from the Dog Bay area, glaciofluvial samples from the Birchy Bay area, nearshore sediments off New World Island and Indian Island, and within select beach and nearshore samples along west side of Gander Bay (Fig. 3).

High resolution seismic profiles and three cores were collected in the deep waters of Bonavista Bay by Cumming et al. (1992). They report four glacial units: a 15-75 m thick basal till, a localized unstratified sequence of glacial-marine sediments, a more pervasive layer of stratified glacial-marine sediments and finally, postglacial marine sediments which are thickest in marine basins. Unfortunately, the nearshore and coastal sediment package has not been sampled or mapped in the Bonavista Bay area. Based on hydrographic field sheets, Shaw and Forbes (1995) note the presence of submerged terraces (8-9 m water depth) at the head of Newman Sound and Glovertown.

### Sea Level History

Marine limit in the present study area varies from 25 m in the Cape Bonavista area to approximately 60 m above present day sea level in the area of North Head (Grant, 1989). Postglacial sea level lowstand varied from 10 to 20 m below present

and is thought to have occurred before 8.6 ka (Shaw et al., in prep.). In the Hamilton Sound area, relative sea level is considered to have risen close to its present level by 3.5ka and is presently relatively stable (Shaw and Forbes, 1990).

### Marine Setting

Wave exposure ranges from very protected inner-bay settings to large sections of coast fully open to the Labrador Sea and North Atlantic Ocean. The exposed coastline is affected by intense wave activity during the ice-free season with an annual significant wave height of 9 m; fifty percent of the time wave heights exceed 1.9 m (Walker, 1984). Wave energies are highest in fall with a dominant south to southeasterly approach. The mean tidal range for the area is 0.8 to 1.0 m. Ice bergs scouring and ice-keel ridges rework bottom sediments in water depths of 200-400 m off the east coast of Newfoundland.

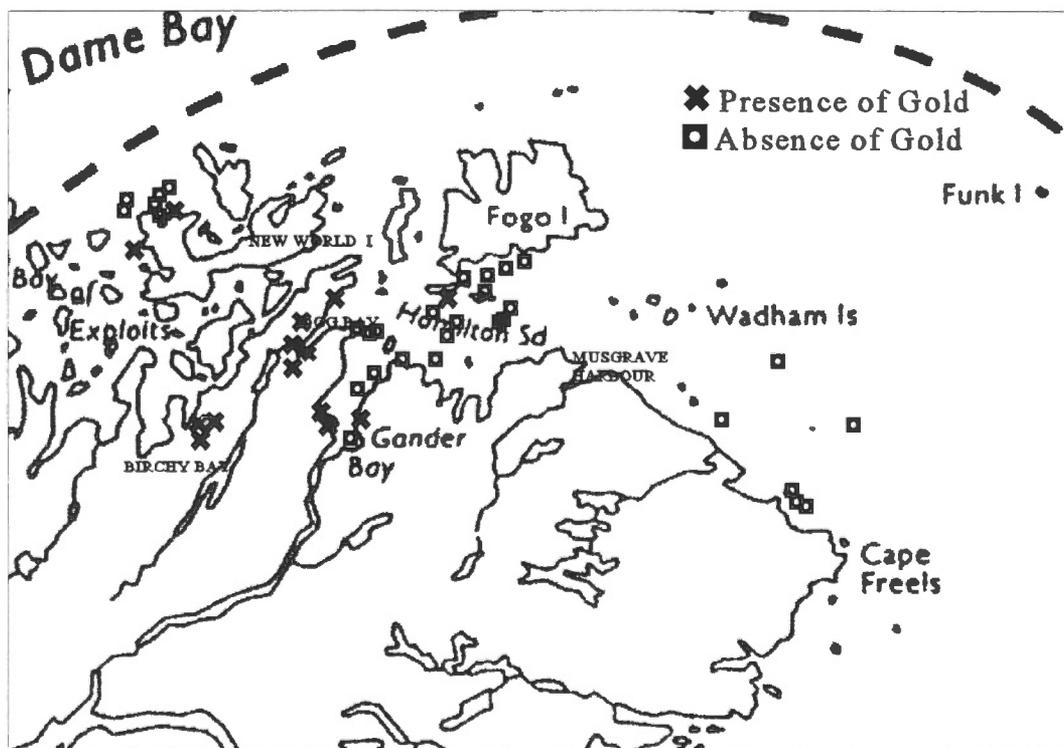


Figure 3. Distribution of particulate gold.

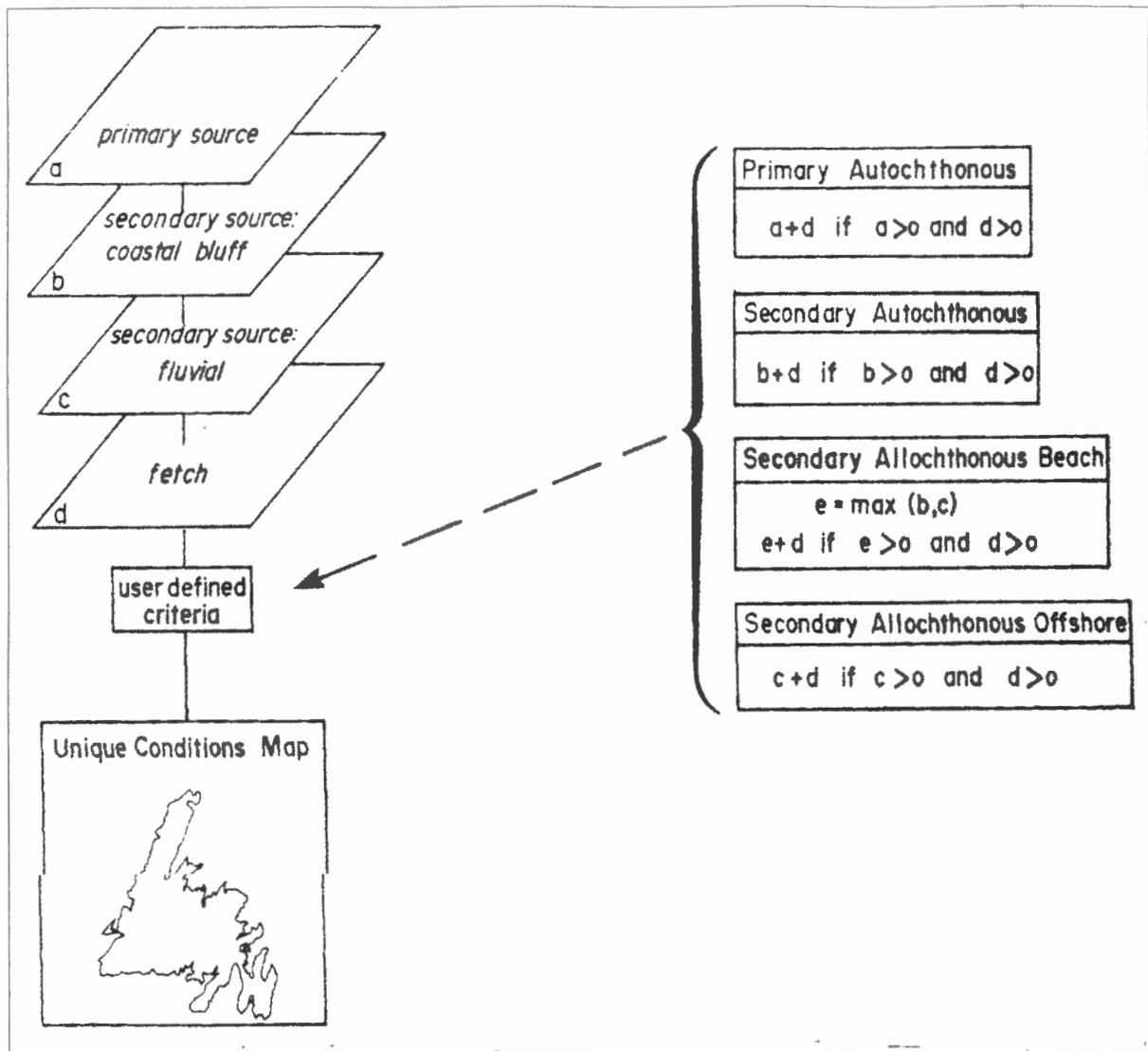


Figure 4. GIS-based method for generation of unique conditions maps.

## ***MARINE MINERAL POTENTIAL***

### ***Marine Placer Deposits***

Marine placer deposits can be divided into allochthonous and autochthonous deposit types. Autochthonous placers are defined as residual deposits which form very close to their source through grain entrapment in bedrock crevices (primary autochthonous) or within coarse sediment sequences (secondary autochthonous). Autochthonous placer minerals include gold and platinum. Allochthonous deposits form through processes of selective grain sorting and can occur a significant distance from their source. Allochthonous placer minerals include monazite, zircon, rutile, ilmenite, garnet, magnetite, chromite and diamonds.

Emory-Moore (1993) discusses a number of geological controls on the formation of allochthonous and autochthonous placer deposits in a glaciated marine environment. Using a Geographic Information System [GIS], known controls were used to generate a series of thematic layers for the province of Newfoundland and Labrador (Fig. 4). In order to determine which coastal areas may contain good secondary (unconsolidated) sources of placer minerals, spatial variations in sediment cover, mineral occurrences, the distribution of bedrock lithologies containing > 50% of all known occurrences and bedrock lithologies known to be associated with specific placer minerals, ice flow direction and transport distances, and the location of drainage basins were mapped and 'overlayed'. Other

thematic layers included primary source and wave fetch. These thematic layers were then combined to create 'unique conditions' maps using the criteria illustrated in Figure 4. The 'unique conditions' map identifies and ranks areas based on their suitability to host marine different types of placer deposits. The success of this approach has been demonstrated through regional sampling and detailed site studies in key target areas (e.g., Port au Port Bay and Deer Cove, Newfoundland and the Porcupine Strand, Labrador; see Emory-Moore, 1993).

Those areas found to have some potential for marine placer formation in the present study area are listed in Table 1.

**Table 1.** Results of unique conditions mapping (Emory-Moore, 1993).

DEPOSIT TYPE	GENERAL LOCATION
Secondary Autochthonous Epigenetic Gold	- Dog Bay - Birchy Bay
Allochthonous Scheelite +/- Wolframite	- Hamilton Sound - south of Cape Freels - Birchy Bay area
Allochthonous Garnet	- Hamilton Sound - Loon Bay area - Cape Freels area
Allochthonous Zircon	- Birchy Bay area - Hamilton Sound - Musgrave Harbour to south of Cape Freels

The results of the above study suggest that the Bonavista Bay area holds little potential for marine placer deposits. This is largely due to the absence of suitable mineralization within the Avalon and Dunnage lithotectonic rock suites. Given the inherent limitations of any assessment model, and the data upon which it rests, it is nevertheless important that some level of regional mapping and sampling of the coastal sediments be undertaken before such a large area be eliminated as a potential site of marine placer formation.

Emory-Moore (1993) identifies a potential for allochthonous placer formation along the coastal and nearshore zone extending from Hamilton Sound

to Cape Freels. The granitic rock suite exposed in the area is targeted as a potential source, albeit likely low grade, of garnet, zircon and scheelite/wolframite.

The large extent of sandy beaches and dune complexes found along this coast is unique in Newfoundland and is in itself a favourable site for allochthonous placer formation. Shaw and Forbes (1990) suggest that sand has accumulated in this area as a result of onshore transport from an unknown glaciogenic source on the inner shelf. Regrettably, no geochemical or mineralogical data are available for the beach sediments, and these data should be acquired before a meaningful analysis of placer potential can be made.

Emory-Moore (1993) suggests that there might be some potential for secondary autochthonous placers in the Dog Bay and Birchy Cove areas. The formation of secondary autochthonous placer requires high energy reworking of coarse grained mineralized glaciogenic sediment. As sediment is eroded, an armour of coarse sediment is formed, and it is within the interstices of this armour that gold concentrates. Although such a sediment armour exists in parts of Hamilton Sound and offshore from the Musgrave Harbour-Cape Freels coastline, only one sample from this area was found to contain particulate gold (see Fig. 3). While the apparent absence of gold may be due to the small sample density and size, and the inherently erratic distribution of gold in placer deposits, it may also be a factor of proximity to a mineralized source rock. These marine gravel sequences are located well over 15 km from the main zone of gold mineralization in the area (i.e., a mineralized lineament extending southeast from Dog Bay), and this factor alone may preclude economic gold placer formation. In contrast, coastal sediments located in close proximity to primary mineralization were found to contain particulate gold, albeit low grade (e.g., the samples from Birchy Cove, Dog Bay and Gander Bay). The sediment suites in these areas do not contain extensive surficial deposits of highly reworked gravel and hence while particulate gold is present, it is not likely to reach economic levels of concentration. Primary autochthonous gold deposits may be found very near to the source but would likely be very small and localized.

## ***Industrial Minerals***

Although much of the coastal source rock in the study area is of a high aggregate quality (Bragg, 1995), the petrographic and textural characteristics of the nearshore sediment suite are not known. However, given that aggregate is a low value commodity, and that there does not currently exist a local demand, the shipping costs alone would likely prohibit economic extraction.

The potential for other industrial minerals such as carbonate and silica sands is low by virtue of the unfavourable source rock.

## ***Hydrocarbons***

Of the four lithotectonic zones in Newfoundland, only the Humber zone is thought to hold any potential for hydrocarbons. While the Humber Zone is not exposed in the terrestrial rock suite of the present study area, a fault bounded Carboniferous basin (the St. Anthony Basin) is located north of 50 degrees latitude and extends from North Head to

Fogo Island (McIntyre, per. comm., 1996). This basin holds modest potential for hydrocarbons; two wells have been drilled in the central portions of the basin with discouraging results. Although this basin lies very close to the northern limit of the present study area, it does not transect it, which renders the hydrocarbon potential of the study area as low.

## **SUMMARY**

The marine mineral potential of the study area is summarized using a procedure developed by Scoates et al. (1986) for northern Canadian resource assessments. For this purpose, the study area is divided into four domains, each delineated on the basis of bedrock geology and coastal geomorphology (see Fig. 5). The suitability of the geologic environment, a key determinant, is drawn from the results of the unique conditions mapping discussed above and each zone ranked using the criteria developed by Scoates et al. (1986), and provided in Table 2. The results of the mineral potential ratings of the various domains are provided in Table 3.

**Table 2.** Explanation of rating categories for mineral, hydrocarbon potential (after Scoates et al., 1986).

<b>Numeric Rating</b>	<b>Potential</b>	<b>Criteria</b>
1	Very High	<ul style="list-style-type: none"> <li>- Geologic environment is favourable</li> <li>- Significant deposits/accumulations are known</li> <li>- Presence of undiscovered deposits/accumulations is very likely</li> </ul>
2	High	<ul style="list-style-type: none"> <li>- Geological environment is very favourable</li> <li>- Occurrences are present but significant deposits/accumulations may not be known.</li> <li>- Presence of undiscovered deposits/accumulations is likely.</li> </ul>
3	Moderate to High	<ul style="list-style-type: none"> <li>- Intermediate between moderate and high potential.</li> <li>- Reflects greater uncertainty.</li> </ul>
4	Moderate	<ul style="list-style-type: none"> <li>- Geological environment is favourable, occurrences may or may not be known.</li> <li>- Presence of undiscovered deposits/accumulations is possible.</li> </ul>
5	Low to Moderate	<ul style="list-style-type: none"> <li>- Intermediate between low and moderate potential.</li> <li>- Reflects greater uncertainty</li> </ul>
6	Low	<ul style="list-style-type: none"> <li>- Some aspects of the geological environment may be favourable but are limited in extent.</li> <li>- Few, if any occurrences are known.</li> <li>- Low probability that undiscovered deposits/ accumulations are present.</li> </ul>
7	Very Low	<ul style="list-style-type: none"> <li>- Geological environment is unfavourable.</li> <li>- No occurrences are known.</li> <li>- Very low probability that undiscovered deposits/ accumulations are present</li> </ul>
n	Not Assessed	<ul style="list-style-type: none"> <li>- Deposit type unknown, overlooked, beyond the scope of the assessment, or not worth mentioning at the time the assessment was done (could be a high rating in the future).</li> </ul>

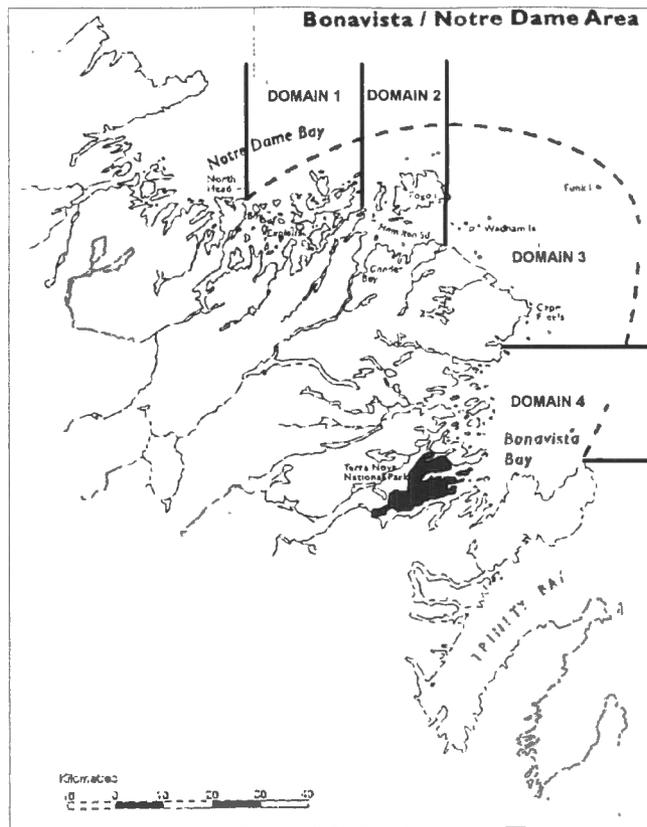


Figure 5. Mineral assessment domains

Table 3. Summary of mineral potential ratings (see Table 2) of mineral assessment domains (see Fig. 5).

DOMAIN	ALLOCHTHONOUS PLACER	AUTOCHTHONOUS PLACER	AGGREGATE	OTHER INDUSTRIAL MINERALS	HYDRO CARBONS
Domain 1 - North Head to Port Albert	6	6	6	7	6
Domain 2 - Port Albert To Musgrave Harbour	5	5	5	7	6
Domain 3 - Musgrave Harbour to Indian Bay	4	5	5	7	7
Domain 4 - Indian Bay to Cape Bonavista	6 (?)	6 (?)	6 (?)	7	7

The results suggest that with the exception of allochthonous placer formation in Domain 3, most areas have a low potential for marine mineral deposits. The specific area of interest in Domain 3 is the beach and dune complexes extending from Musgrave Harbour to Cape Freels. While the geologic environment of this area is favourable for allochthonous placer formation, no sample data are available. Mapping and sampling of the beach and dune complexes is hence required. In addition, Domain 4, while ranked as having a low potential, is

done so with a high level of uncertainty as no sample data are available. Regional sampling and mapping of the costal sediment suite should be undertaken to provide a reasonable measure of confidence to the assessment.

#### ***RECOMMENDATIONS FOR FURTHER WORK***

It is suggested that a small field program be undertaken, the objectives of which would be to collect and analyse a series of beach samples from

the Bonavista Bay area and a series of samples from the beach and dune complexes of the Musgrave Harbour-Cape Freels coastal zone. On the basis of these data, a more meaningful and conclusive assessment of the marine placer potential of these areas can be made.

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