Current Research (1989) Newfoundland Department of Mines, Geological Survey of Newfoundland, Report 89-1, pages 229-236

PLACER GOLD POTENTIAL OFFSHORE NEWFOUNDLAND: A PRELIMINARY ASSESSMENT

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ABSTRACT

A classification scheme and set of sedimentation models have been developed for high latitude marine-placer deposits and are used to assess the relative placer gold potential of the Newfoundland shelf. Temporal and spatial variations in sea level, marine energy and sediment supply are evaluated within eleven geographical zones on the Newfoundland shelf. A comparison is made with the formation controls identified for each deposit type. An estimate of the likelihood of occurrence for each deposit type is provided for each geographical zone. Since there is no basis on which to assess the absolute marine-placer potential of the zones, they are ranked on the basis of their potential, relative to each other.

Of the eleven geographical zones, five are associated with on-land gold mineralization. A closer examination of these indicates that Zone 9, which extends from Twillingate to Indian Bay, has the highest relative marine-placer gold potential. Zone 9 is characterized by a wide range of potential deposit types, including those considered to hold the strongest economic promise.

INTRODUCTION

This paper presents a regional assessment of relative marine-placer gold potential on the Newfoundland continental shelf. The study is part of a larger project that will assess the placer potential of platinum, chromium, iron, zirconium and titanium. A more detailed and comprehensive examination of those sites having the highest potential is in preparation for later publication.

The success of offshore gold placer-mining on the Alaskan continental shelf has resulted in speculation as to the viability of seabed mining in Canadian waters (e.g., Samson, 1984; Hopkins, 1985). West Gold Incorporated is actively mining the Alaskan deposits at a rate of 30,000 ounces per year and has a cash operating cost of less than US $200 per ounce. The total recoverable reserves for the deposit are estimated at 780,000 ounces (Mining Journal, 1986). Tin placers off the Soviet Union and Malaysia have also been the focus of extensive mining activity (e.g., Maslov, 1975; Ringis, 1976; Kudrass and Schulter, 1976), whereas other notable exploration activities include chromite prospects off Oregon (e.g., Kulm, 1988; Petersen *et al.*, 1986; Petersen *et al.*, 1987) and gold prospects offshore of New Zealand (Boyle, 1979; R. Falconer, personal communication, 1988) and British Columbia (Samson, 1984; J.V. Barrie, personal communication, 1988).

Newfoundland has recently experienced a significant growth in mineral exploration. Clearly, where mineralized bedrock and associated overburden sediment are located in proximity to coastal waters, a potential for marine-placer deposits exists. A classification scheme and set of sedimentation models developed for high latitude marine-placer deposits (Emory-Moore and Solomon, *in preparation)* is used here to aid in the regional delineation of such sites on the Newfoundland shelf.

Deposit Classification

Marine placers are subdivided into modern deposits and relict deposits. Modern placer deposits are defined as those that are in equilibrium with the marine processes by which they are formed. Relict placers deposits form under environmental conditions that differ from the modern marine setting (e.g., submerged fluvial).

Modern marine-placer deposits can be classified on the presence and character of a source unit, the marine sedimentary environment in which they form and the mode of mineral concentration (Emory-Moore and Solomon, *in preparation;* Table 1).

1) source: placer deposits that are derived from post-glacial weathering of bedrock are termed 'primary', whereas those derived from the reworking of overburden sediment (i.e., glacigenic sediment) are termed 'secondary'.

This project is a contribution to the Canada–Newfoundland Mineral Development Agreement, 1984–1989

Table 1. Deposit classification and assessment factors for high latitude marine placer deposits (cross-hatching indicates preferred choice; from Emory-Moore and Solomon, *in preparation*).

DEPOSIT CLASSIFICATION					CONSTRAINING FACTORS IN THE ASSESSMENT OF HIGH LATITUDE MODERN MARINE PLACERS														
					Sea Level					Wave Energy				Sediment Supply					
					Movement			Rate		Exposure		Shelf Gradient		Source Type				Net Accumulation	
					trans.	stable	regress	fast	slow	high	mod.	steep	shallow	bedrock	offshore	Coastal bluffs	fluvial	high	low
MODERN	Primary Source	beach/nearshore	Autochthonous	1	X				X	X		X		X					X
MODERN	Primary Source	offshore	Autochthonous	2	X	X	X		X	X			X	X					X
MODERN	Secondary Source	beach/nearshore	Autochthonous	3	X				X	X		X				X			X
MODERN	Secondary Source	offshore	Autochthonous	4	X				X	X			X		X				X
MODERN	Secondary Source	beach/nearshore	Allochthonous	5	X	X	X *		X		X		X		X	X	X	X	
MODERN	Secondary Source	offshore	Allochthonous	6		X	X		X		X		X				X	X	
					CONSTRAINING FACTORS IN THE PRESERVATION POTENTIAL OF RELICT PLACER DEPOSITS														
RELICT	fluvial			7	X			X			X		X						X
RELICT	glacigenic			8	X			X			X	X							X
RELICT	beach/nearshore			9	X			X			X	X							X

*where the source type is fluvial

2) sedimentary environment: the modern marine environment is divided into the beach–nearshore zone and the offshore zone. The beach–nearshore zone is defined as that area shoreward of the breaker zone and extending to the backshore beach complex. The offshore zone extends seaward of the breaker zone to a water depth of 100 m.

3) mode of concentration: offshore-placer deposits can be divided into allochthonous and autochthonous varieties depending on the mode of mineral concentration. Allochthonous deposits can occur hundreds of kilometres from source and generally form discrete lenticular laminae interbedded with well sorted quartzose sands. They form under conditions of net sediment aggradation through a process of hydraulic sorting. Allochthonous placer minerals include zircon, monazite, ilmenite, rutile, magnetite, chromite, and fine grained gold and platinum (i.e., generally < 50 microns). Autochthonous deposits form close to source through grain entrapment within porous gravel sequences or bedrock crevices. They are residual in nature, and occur in areas where the rate of marine erosion exceeds the rate of net sediment accumulation. Autochthonous placer minerals include cassiterite and coarse grained gold and platinum.

Relict deposits are classified on their primary depositional environment only, and include submerged fluvial, glacigenic and beach–nearshore deposits.

Shelf Sedimentation and Marine-Placer Formation

Three primary factors control the processes of shelf sedimentation and, consequently, the formation of marine-placer deposits and the preservation potential of relict deposits. These factors are sea-level fluctuations, sediment supply and the energy of the marine environment (Davis and Clifton, 1987). An examination of the role that each of these factors play in placer formation, and a brief summary of the relevant data for the Newfoundland shelf, is provided below.

Sea Level. As the hydraulic conditions required for offshore-placer formation fall within a critical water depth zone, the net results of eustatic and isostatic variations (e.g., local regressions and trangressions) control the location and extent of a deposit. Relative sea-level movement also influences both the type and volume of sediment supplied to the shelf region. For example, a regressive sea level results in base-level lowering and fluvial incision of sediment; where a river drains into the ocean, large volumes of sediment are supplied. In addition, the rate of sea-level change governs the degree to which sediment is reworked and, thus the likelihood of modern placer formation and relict placer preservation. Where sea-level change is slow, sediment is extensively reworked and the probability of allochthonous and authochthonous placer formation is greatly increased. A rapid sea-level rise favours the preservation of relict placers as sediment reworking and re-distribution is minimal.

The postglacial sea-level history of the Newfoundland shelf is, in most areas, poorly defined (Figure 1). Sea-level curves have been reported for the Great Northern Peninsula (Grant, 1972), western Newfoundland (Grant, *in press*) and southwestern Newfoundland (Brookes *et al.*, 1985). Postglacial sea level along western Newfoundland varies from a major regressive phase in the north to a regressive–transgressive phase in the south. Work on the Grand Banks indicates sea-level submergence of about 120 m (Fader and Miller, 1986) whereas recent work in northeastern Newfoundland indicates a slow regressive–transgressive phase (Shaw and Forbes, 1988).

Sediment Supply. There are four primary sources of sediment and associated particulate gold to the nearshore shelf regions. These are: 1) modern fluvial discharge, 2) erosion of unconsolidated coastal bluffs, 3) erosion of coastal and submarine bedrock faces, and 4) submarine erosion and shoreward transport of unconsolidated sediment. Autochthonous placer deposits form under erosive conditions, where the sediment supply is low, whereas allochthonous placers require a moderate to high sediment supply (see Deposit Classification Section). Relict placers are less prospective where overburden sediment is thick; a low sediment supply is thus favoured.

A significant part of coastal Newfoundland is characterized by steep bedrock faces (Figure 2) and the coastline is generally sediment starved (Forbes, 1984), except in areas where there are large unconsolidated bluffs (e.g., St. George's Bay) (Forbes, 1984) or where fluvial discharge is locally significant. The extent of unconsolidated submarine deposits is poorly known on the Newfoundland shelf and for the purposes of this report, assumed to be ubiquitous. Net accumulation is not considered in this regional study as it is highly localized and not easily measured; it is, however, an important factor in detailed studies.

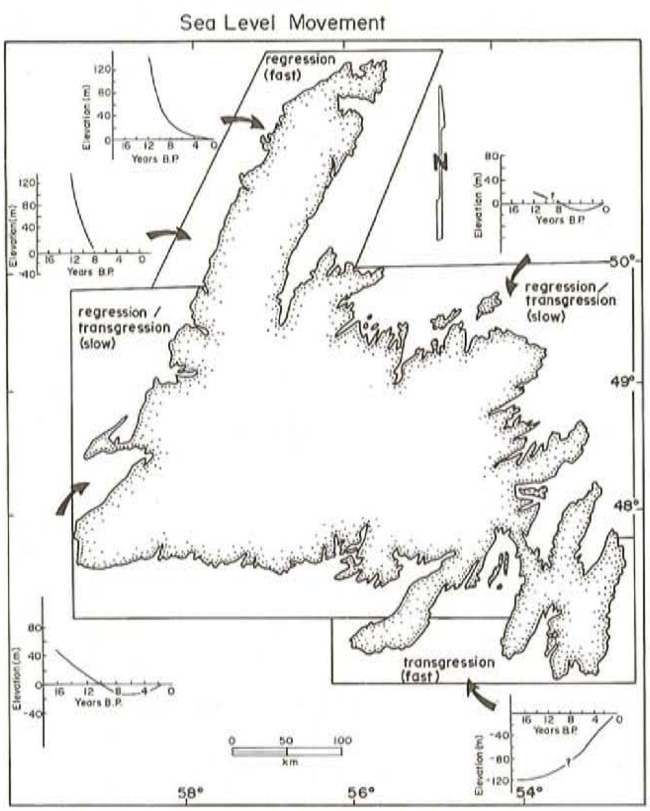

Figure 1. *Postglacial sea-level history of the Newfoundland shelf.*

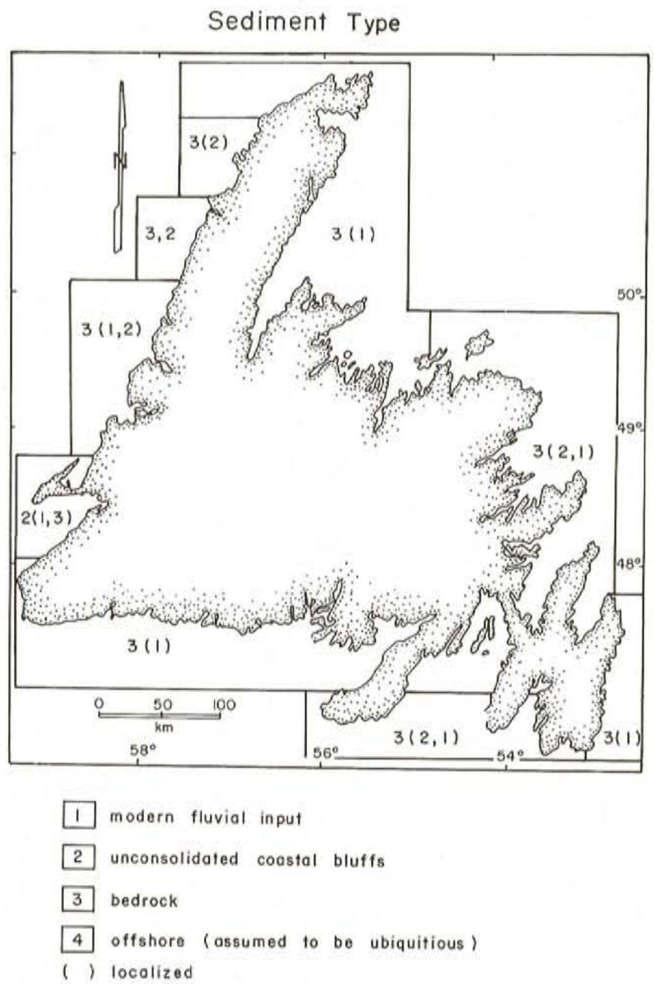

Figure 2. *Regional variation in coastal sediment sources.*

Marine Energy. As high latitude coasts are generally storm dominated, relative marine energies can be approximated by evaluating the degree of coastal exposure and to a lesser extent, the shelf gradient. Autochthonous placers form preferentially in areas having a high exposure to oceanic waves, as required for both the erosion of source rock and the erosion and selective removal of light mineral sands. Allochthonous placers form in areas of moderate coastal exposure where sediment is actively reworked and contemporaneously aggraded. Preservation of relict placers is favoured by moderate exposures as the sediment redistribution is minimal.

The gradient of the shelf influences the wave energy and also determines the spatial extent of the zone of offshore-placer enrichment. The hydraulic conditions necessary for the concentration of particulate gold fall within a critical water depth range. On a shallow gradient shelf, this zone will be larger and thus more economically promising than on a narrow shelf. Conversely, a steep shelf favours the formation of autochthonous beach–nearshore placers where very high wave energies are required, and the degree of sediment reworking is not a function of water depth.

The highly irregular morphology of the Newfoundland coastline precludes the definition of any meaningful regional patterns in exposure. Exposure is, however, readily assessed in a detailed study. The gradient of the Newfoundland shelf is highly variable although regional patterns are evident (Figure 3).

Shelf Gradient

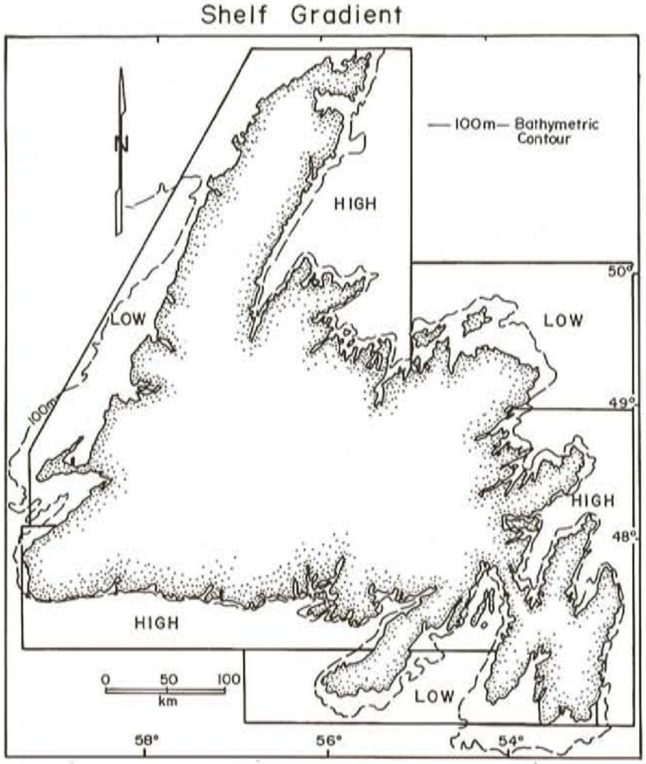

Figure 3. *Regional shelf gradient, offshore Newfoundland.*

Table 1 illustrates the role of the above factors in the formation of individual deposit types. The factors 'source type' and 'sea-level movement' are considered prerequisite factors in placer formation; a source of gold must be identified and mineral enrichment must occur (as controlled by sea level) before a marine-placer deposit will form. The other variables identified above (i.e., the rate of sea-level fluctuations, the net accumulation, the relative exposure and the shelf gradient) influence the effectiveness of enrichment processes and are, thus, not controlling factors but may be broadly considered enhancement factors.

Assessment Procedure

The above classification scheme and formation factors were used to assess the regional modern marine-placer gold potential of the Newfoundland shelf. Shelf areas that are likely to host specific placer types are identified using the following the procedures:

1) review of the literature to establish regional trends in sea-level movement, sediment supply and shelf gradient (Figures 1, 2 and 3);

2) constrain the geographical zonation of the shelf using the previously discussed variables (i.e., sea-level movement, sediment supply, and shelf gradient) (Figure 4); where one factor changes with respect to the other two, a new zone is created. In this manner, eleven zones were established, all having discrete combinations of control factors (Table 2);

Regional Zonation

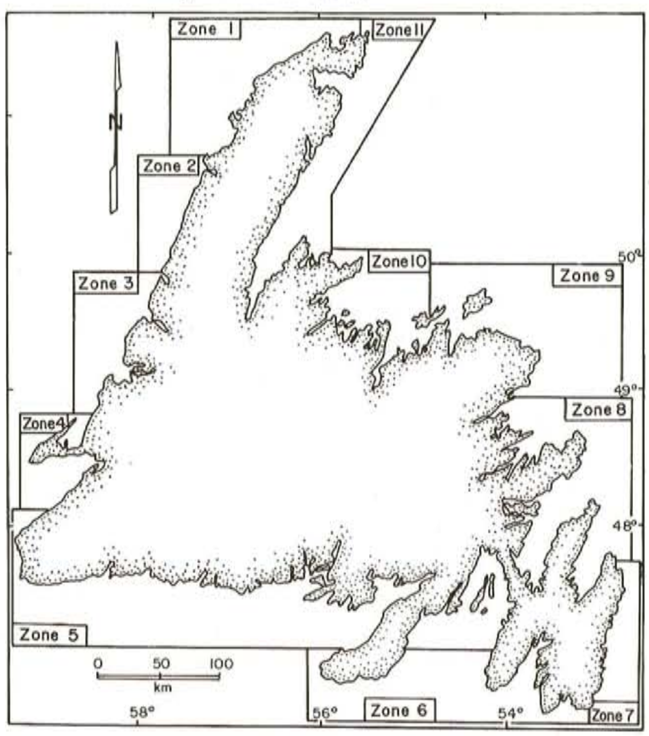

Figure 4. *Zonation scheme used in the regional assessment of marine-placer potential offshore Newfoundland.*

Table 2. Control factors used in the assessment of marine-placer potential on the Newfoundland shelf (dashed check indicates a localized source).

ZONE	Sea Level					Wave Energy				Sediment Supply					
	Movement			Rate		Exposure		Shelf Gradient		Source Type				Net Accumulation	
	trans.	stable	regress	fast	slow	high	mod.	steep	shallow	bedrock	offshore	bluffs	fluvial	high	low
1			√	√					√	√	√				
2			√	√					√	√	√	√			
3	√		√		√				√	√	√	√			
4	√		√		√				√	√ (dashed)	√	√	√ (dashed)		
5	√		√		√			√		√	√		√		
6	√			√					√	√	√	√ (dashed)			
7	√			√				√		√	√				
8	√		√		√			√		√	√				
9	√		√		√				√	√	√	√	√ (dashed)		
10	√		√		√			√		√	√		√ (dashed)		
11			√	√				√		√	√		√ (dashed)		

3) compare the prerequisite factors (i.e., sea-level movement and source type) identified for each zone on the Newfoundland shelf (Table 2) with those identified for individual deposit types (Table 1); where both factors are present, the deposit type may occur in the specified geographic zone. The likelihood of occurrence for a given deposit type is then estimated by counting the number of enhancement factors (i.e., rate of sea-level movement and shelf gradient). For example, secondary offshore autochthonous deposits (Table 1, type # 4) are more likely to occur in Zone 9 (Table 2) where the two enhancement factors (i.e., shelf gradient and rate of sea-level movement) are present than in Zone 7, where neither of the enhancement factors are present. The results are presented in Table 3; and

4) those zones where primary gold mineralization occurs in proximity to the Newfoundland coast were identified (Figure 5) and will be the focus of further work.

DISCUSSION

The assessment scheme is restricted to simplified formation conditions and is not amenable to the evaluation of pre-Late Wisconsinan events and their possible role in placer formation. Like classical fluvial placers where multiple rejuvenation and down-cutting events create increasingly rich deposits (Sutherland, 1985), multiple glaciations may have served to alternately concentrate and disperse placers of all types, creating locally enriched glacigenic deposits (e.g., Westland, New Zealand; Henley and Adams, 1979). A further restriction of the assessment scheme is the use of relative indicators (i.e., a 'high' rate of sea-level fluctuation versus a 'low' rate). Information is not available with which to establish absolute values. The assessment scheme does, however, provide a geological framework and rationale for the assessment of relative marine-placer potential.

Table 3. Relative likelihood of occurrence for individual deposit types within the geographic zones on the Newfoundland shelf (brackets indicate localized occurrences).

ZONE	DEPOSIT TYPE 1	2	3	4	5	6	7	8	9
1	-	1	-	1	-	-	-	-	-
2	-	1	-	1	-	-	-	-	-
3	1	2	1	2	(2)	-	-	-	-
4	(1)	(2)	1	2	2	2	-	-	-
5	2	1	-	1	1	(1)	-	-	-
6	0	1	(0)	1	1	-	-	-	-
7	1	0	-	0	0	-	-	-	-
8	2	1	-	1	1	-	-	-	-
9	1	2	1	2	2	(2)	-	-	-
10	2	1	-	1	1	(1)	-	-	-
11	1	0	-	0	0	(0)	-	-	-

Of the eleven zones identified on the Newfoundland shelf, five are associated with on-shore primary gold mineralization (zones 5, 8, 9, 10 and 11). Table 3 provides a listing of the deposit types and a ranking of their relative potential for occurrence within each zone.

Given the wide range of deposit types that may occur on the Newfoundland shelf (see Table 3) it is important to establish which deposit types hold the strongest economic promise and where these deposits might occur. The following generalizations may be made:

1) 'primary' placer deposits are limited by the effectiveness of post-glacial weathering and the extent of exposed mineralized bedrock. They are generally low volume although locally high grade (e.g., the beach placers of the Ovens district, Nova Scotia; Samson, 1984);

2) secondary allochthonous placer deposits may attain sufficient grade and tonnage but the particulate gold is frequently very fine grained and, thus, problematic in processing using standard gravity separation techniques; and

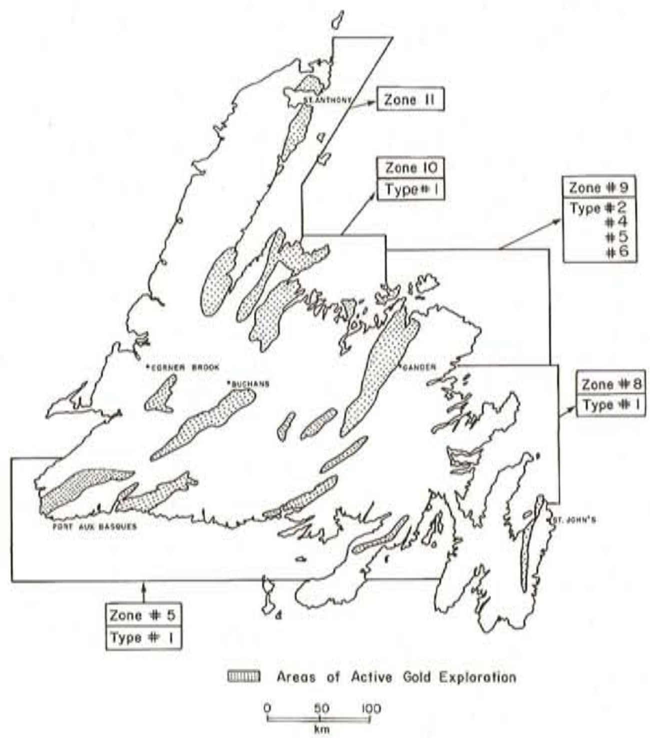

Figure 5. *Regional distribution of gold placer deposit types, which have the highest relative likelihood of occurrence on the Newfoundland shelf (i.e., those deposit types that satisified both enhancement factors; see text).*

3) secondary autochthonous placer deposits are neither restricted by a low availability of source material nor the grain size of gold. In areas of primary gold mineralization, glaciation has resulted in the provision of ample low-grade auriferous material. When subject to marine processes, the extent of the deposit is limited to the critical zone of sediment reworking, which during periods of sea-level transgression, can attain substantial breadth (e.g., gold placers offshore Alaska; Nelson and Hopkins, 1972).

Based on these generalizations, primary placer deposits are considered the least economically prospective. However, primary deposits are easily mined with minimal operating costs. Areas within zones 8, 9, 10 and 11, which are associated with wave erosion of mineralized bedrock, hold a strong potential for this deposit type and are worthy of consideration, particularly by local prospectors. The gold within the mineralized bedrock of Zone 5 is fine grained and, thus, the deposits are restricted to allochthonous varieties.

Allochthonous beach deposits may occur in zones 5, 8, 9 and 10. As the assumed source of sediment in zone 10 is offshore, and given that the sea-level transgression was limited, the potential for allochthonous deposits is less than in zones 5, 8 or 9. In all areas, the formation of allochthonous beach deposits requires a high volume of sediment supply and will be highly localized.

Offshore allochthonous deposits may be found in zones 5, 9, 10 and 11. They are most likely to occur in zones 10 and 11 where a large fall in sea level has generated large volumes of sediment at the mouths of major rivers (e.g., at the head of White Bay).

Areas characterized by a wide transgressive range are the most ideally suited for the formation of 'relict' placer deposits. In this respect, on the Newfoundland shelf, zones 6 and 7 are the most prospective and yet do not host significant gold mineralization on-land. Zones 5 and 8, which are influenced to a lesser extent by a transgressive phase, have the necessary source rock and are thus worthy of closer examination.

Zone 9 has the highest overall marine-placer gold potential with respect to both the wide range of potential deposit types and the high relative potential for secondary autochthonous deposits. A more detailed examination of this area is now underway. The same scheme of assessment will be used but on a detailed scale.

Finally, the assessment of marine-placer gold potential of the Newfoundland shelf as presented here is based on available data, which in some areas is meager. As new data become available, a re-assessment will be necessary.

ACKNOWLEDGMENTS

This work is funded by the Canada–Newfoundland Mineral Development Agreement under the scientific authority of D. Proudfoot. D. Liverman, D. Proudfoot and M. Batterson are acknowledged for their review of earlier versions of the manuscript; R. Muise for assistance in data compilation. I. Penny and D. King provided drafting support.

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