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Résumé de l'article

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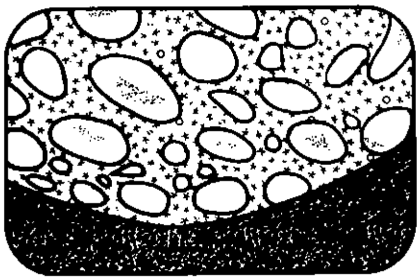

Witwatersrand-Type Paleoplacer Gold in the Huronian Supergroup of Ontario, Canada

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"The urgency of intensifying exploration efforts aimed at discovering another Witwatersrand cannot be exaggerated". -D.A. Pretorius, 19 February, 1981.

Summary

There are encouraging signs of the potential of the Huronian Supergroup to host Witwatersrand-type paleoplacer gold. A total of thirty-one Au or Au-U occurrences are recognized as being stratiform. Of these, two occur in the Cobalt Group, four in the Quirke Lake Group, nineteen in the Hough Lake Group and six in the Elliot Lake Group. The greatest number of occurrences are located in the Matinenda and Mississagi Formations of the Elliot Lake and Hough Lake Groups. Gold in basal Huronian rocks is related to basement geology and to a local source. Exciting recent finds in the upper Huronian Lorrain Formation in the northern half of the Cobalt Embayment represent extensively reworked fluvial deposits in braided streams distant from the provenance of the gold. Geological conditions closely resemble those of the Witwatersrand. Sedimentological studies hold the key to locating the more attractive concentrations of gold.

Introduction

During the last several years considerable effort has been made, in particular by the Ontario Geological Survey, to determine the potential of the Huronian Supergroup as a host for paleoplacer gold. The possibility of locating a Witwatersrand-type gold deposit in the Huronian has long been an objective of the mining industry. It cannot be doubted that such a search is worthy of the most serious endeavours, if the carefully considered commentary by Pretorius (1981b) is valid.

Basal strata of the Huronian Supergroup closely resemble, in general geological and sedimentological terms, the Witwatersrand rocks (Roscoe, 1973; Theis, 1979). However, there has been little to attract interest in the gold potential of the classic uranium mining areas of Elliot Lake and Blind River in the western portion of the Huronian Supergroup. This has been attributed to the fact that appropriate gold-bearing provenance rocks were lacking (Roscoe, 1973).

Differences between the Huronian metasediments and those of the Witwatersrand include compositional differences of sedimentary materials and style of basin evolution. Further, thin, highly auriferous kerogen-rich marker bands exist over extensive areas on the Witwatersrand. In the Huronian a carbon-rich material, possibly kerogen but generally referred to as "thucholite", occurs locally (Ruzicka and Steacy, 1976; Ruzicka, 1981). Its presence on a regional scale has not been demonstrated. However, results of neutron activation analysis of selected samples of "thucholite" from the Huronian reveal that it may be anomalously enriched (to 2000 ppb) in gold. Details of these results have been reported elsewhere (Dyer and Mossman, 1983).

In contrast to the granitic (Algoman) rocks which underlie the Huronian rocks in the west, auriferous Archean greenstone of the Abitibi belt underlies an extensive (northern) portion of the Huronian Supergroup in the east. Here in the Cobalt Embayment (Figs. 1 and 3), the Lower Proterozoic metasediments assume a marked polymictic character and extend north toward the great greenstone-hosted gold camps at Kirkland Lake, Timmins and Larder Lake. There, the syenitic host rocks to gold in the Kirkland Lake area were in place prior to the deposition of the upper Huronian strata (see Lovell and Grabowski, 1981 for details); thus appropriate source rocks were probably present in the Huronian drainage basin.

A complicated system of drainage probably developed southward from the Archean (highlands) into the Cobalt Embayment. In the northern part of this region some of the most encouraging finds of stratiform gold have recently been made. It is no longer an hypothesis that paleoplacer gold ought to have formed in this setting. The real question, as presented by Colvine (1982), is where did it form, in which formation, and in what quantity?

It is the purpose of this paper to review the known distribution of gold in the Huronian Supergroup in the light of the geology of these rocks and the geology of the similar Witwatersrand metasediments. In so doing, the potential for economic paleoplacer deposits of gold in the Huronian Supergroup may be brought into somewhat clearer focus. To facilitate the comparison, let's begin with the South African rocks.

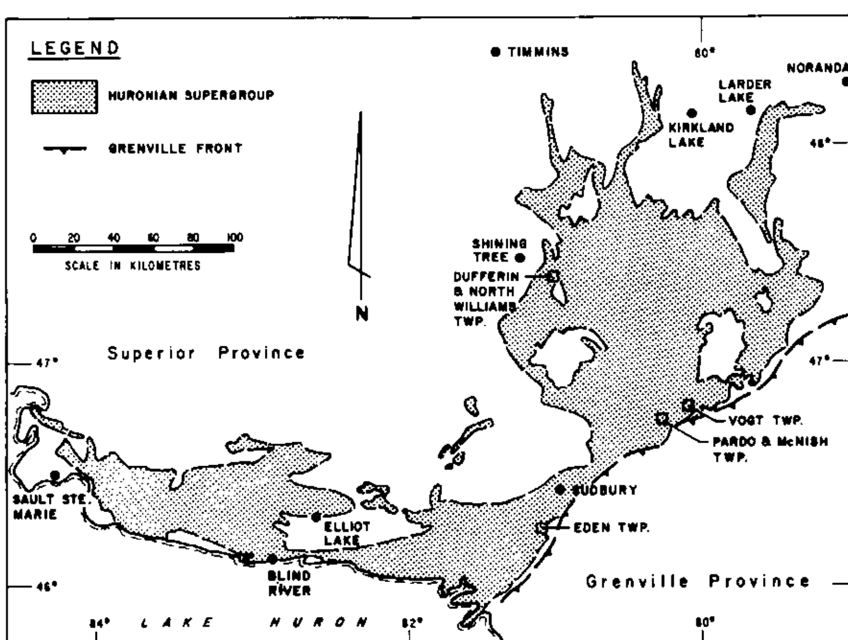

Figure 1 *Distribution of Huronian Supergroup (stippled); bulge northeast of Sudbury is the Cobalt Embayment. Note the digitation of paleovalley systems in which are preserved Gowganda metasediments, extending northward into the Abitibi greenstone belt*

The Witwatersrand Supergroup

The Proterozoic Era has certainly been golden in terms of the wealth won from rocks of this age in South Africa. Since mining began in 1886, more than 55% of the gold produced in the world has come from the Rand gold fields. The level of activity is immense, whether the measure be manpower, kilometres of underground development or tons of ore mined (Pretorius, 1981a; Tankard *et al.*, 1982; Dayton and Burger, 1982).

The Witwatersrand is one of a sequence of five Lower Aphebian basins preserved on the Kaapvaal craton. These are as follows: Waterberg (youngest), Transvaal, Ventersdorp, Witwatersrand and Pongola (oldest). The Witwatersrand is by far the largest producer of gold. Thickness of the Witwatersrand Supergroup (Table I) totals about 10,000 metres, more than 90% of which is clastic terrigenous sediment; the balance consists of lava and, toward the base, some pyroclastic materials. Age of the Witwatersrand sediments is bracketed between 2.3 Ga and 2.8 Ga (Van Niekirk and Burger, 1964, 1978). Fabric, texture and sedimentary structures in these early supracrustal rocks are well preserved, as metamorphism only attained lower greenschist facies.

The favoured alternative to Pretorius' (1976) fault-controlled tectonosedimentary model of deposition is the current concept that most of the sedimentary and structural aspects of the Witwatersrand basin can be accounted for by tilting and warping followed by basin closure due to granite doming (Tankard *et al.*, 1982). Geologists most familiar with this basin define formational units related to climatic-tectonic controls. This seems to be an appropriate procedure given a situation where numerous unconformity surfaces are associated with extensive placers that developed simply by bar and channel processes on alluvial fans. The reader is referred to Tankard *et al.* (1982) for an extensive treatment of the geology of various sedimentary groups of the Witwatersrand Basin.

In brief, each major goldfield on the Witwatersrand is made up of numerous sedimentary packages typically several tens of metres or, exceptionally, hundreds of metres thick, separated from each other by unconformities. The unconformities, like the sedimentary "packages", are the result of erosion and aggradation within individual tectonically controlled sedimentary basins. Generally, each placer was deposited in a braided stream environment in proximal to distal settings. Sedimentary models such as the South Saskatchewan, Platte, Scott and Donjek (Miall, 1978) are recognized locally and in some instances, where extensive paleoslopes existed, a broad range of facies are developed (Tankard *et al.*, 1982).

In the Witwatersrand repeated reworking of sediments during the course of basin evolution led to the development of economic concentrations of gold and/or uranium. According to Pretorius (1974), each horizon straddles an unconformity separating the coarse grained clastic sediments of the succeeding cycle of sedimentation from the fine grained sandstones and siltstones and kerogen (carbon) -rich upper layer of the preceeding terminal phase. Gold is intimately associated with pyrite, chromite, uraninite and brannerite, in a

Table I. *Stratigraphy of the Witwatersrand Supergroup with notes on depositional history, and occurrences of gold–data (after Pretorius 1974, 1976; Tankard* et al. *1982).*

GROUP	THICKNESS	SUB GROUP	GENERAL DEPOSITIONAL HISTORY	OCCURRENCE OF GOLD
Central Rand	2880 m. (max.)	Tuffontein	Diamictites common. Rocks predominantly coarse grained greywacke with <10% conglomerate, quartz arenite, subordinate shale, silt and minor lava. Rocks represent proximal deposits of which Johannesburg Sub Group are distal facies equivalent. A basin wide upward fining sequence is basis of subdivision	South Africa's largest producers, these gold fields are located over major entry points in the basin. Placer deposits are discontinuous and restricted to fans usually <30 km wide. Thin seams of kerogen common. Distribution of Au, U related to hydraulic conditions within alluvial fans.
		Johannesburg	These rocks prograde into Witwatersrand Basin from its margin, possibly as fan-delta complexes. Unconformities merge toward margin of the basin.	
		Jeppestown	Contains fan delta, beach and proximal shelf facies in the northern part of the basin and a distal shelf facies of magnetic shale. Prograding fan deltas not as widespread as in Government Sub-Group.	
West Rand	4650 m (Av.)	Government	Arenaceous, contains prograding fan-deltas, proximal shelf and distal shelf facies. Diamictite occurs at several localities and at Klerksdorp some contain striated pebbles.	
		Hospital Hill	Contains laterally persistent macrotidal sediments including beach, tidal-inlet and shelf mud facies reflecting sustained transgression.	Sequences contain shales and sandstones in about equal proportions. Minor lava. Deposition mainly in marine shelf and tidal environments with minor fluvial component. Upward fining sequences with basal auriferous gravels and multiple sets of planar and trough cross bedding overlain by shale have contributed relatively small amount of gold.
Dominion	2710 m (at Klerksdorp)	—	Volcanic rocks vastly predominant. The basal (60 m thick) Renosterspruit Formation is mainly sandstone with minor conglomerate and argillite confined by the paleorelief to areas between basement hills of granite.	The basal placer of Renosterspruit Formation was deposited in shallow braided streams following dendritic drainage systems developed on a gentle southwesterly paleoslope. Mined for Au in 1888 and for U from 1953-1963.

manner generally predictable on the basis of a placer mode of occurrence. Paleocurrent observations are used routinely to help delimit the extent of individual alluvial fans and their degree of coalescence, as well as to help locate and project orebodies.

Most South African geologists (e.g., Pretorius, 1976; Minter, 1978) are impressed by the predictive strength of the placer theory and therefore favour it, making due allowances for minor diagenetic and/or metamorphic modification of the ore. Other geologists (e.g., Dimroth, 1979; Clemmey, 1981; Clemmey and Badham, 1982) perceive an important role for diagenesis under oxidizing atmospheric conditions. Dimroth (1979), for example, maintains that diagenetic precipitation of uranium, gold and pyrite was the dominant ore forming process. Clemmey (1981, p. 406) proposes a Proterozoic counterpart to the "red-bed, roll front" Phanerozoic uranium deposits as the diagenetic mode in which substantial distribution of uranium occurred, although he acknowledges a good deal of support for the placer origin of the gold.

Much Witwatersrand gold is closely associated with carbonaceous material. According to Zumberge *et al.* (1978), the material is properly termed kerogen, and at least a portion originated as primitive organisms. Typically, the kerogen-rich beds occur at the top of the fining-upward sequence in any particular ore-bearing sedimentary cycle (Pretorius, 1974). Generally referred to as being of algal origin, the kerogenous material achieves its peak development in centimetre-thick, laterally extensive, highly auriferous (to several weight percent) marker beds (Liebenberg, 1955; De Kock, 1964). In the Witwatersrand about 40% of all payable conglomerate sheets contain kerogen (Tankard *et al.*, 1982, p. 133).

The Huronian Supergroup

Remnants of Aphebian metasedimentary rocks occur in various parts of the Canadian Shield. The Huronian Supergroup includes some of the most ancient strata known in this country (Frarey and Roscoe, 1970; Roscoe, 1981). The classic lower Proterozoic Huronian Supergroup extends in a belt about 325 km long X 60 km wide from Sault Ste. Marie, Ontario to Noranda, Quebec (Fig. 1). It was deposited 2.25 to 2.45 Ga. ago (Roscoe, 1973) along generally south to southeasterly drainage patterns both in nonmarine and paralic environments. Dominant coarse clastic materials, for the most part of alluvial origin (Frarey and Roscoe, 1970), compose a complex suite of sedimentary rocks subdivided into four groups (Table II) totalling 15 km in thickness (Colvine, 1981).

The initial distribution of the Huronian Supergroup was certainly far more extensive than that area shown in Figure 1. For example, Frarey and Roscoe (1970) have shown that the basins of deposition may have extended as far as 1000 km to the northeast into central Quebec. More recently Roscoe (1981) has discussed possible correlation of the Huronian Supergroup in North America. Rocks of the Huronian Supergroup show several features not seen elsewhere in Canadian Aphebian sequences, with the possible exception of those in the Montgomery Lake-Padlei area of the Northwest Territories (Roscoe, 1981). Features which distinguish Huronian sediments older than the Gowganda Formation include the extensive distribution of radioactive quartz-pebble conglomerate beds; the presence of pyrite in coarse clastic sediments, and the lack of both detrital iron oxides and red colouration. In contrast, metasediments younger than the Firstbrook Member of the Gowganda Formation commonly include red beds, the presence of which has been interpreted as signalling the oxyatmoversion (Owsiacki, 1981).

Fralick and Miall (1981) suggest the Huronian Supergroup may have accumulated on a rifted margin. However, whereas sediments older than Gowganda were deposited in an easterly-trending, fault-bounded trough (Young, 1981), upper Huronian strata are not so restricted. In the Cobalt Embayment they record deposition under conditions of crustal downwarping over areas which do not appear coincident with original sedimentary basins for lower Huronian sediments (Card and Lumbers, 1977; Wood, 1979).

The result of recent investigations (Colvine, 1981, 1982; Fralick and Miall, 1981; Long, 1982; Long and Leslie, 1981; Owsiacki, 1982 and others) continue to fill out the sedimentological history of the Huronian. One suggested outline of this history (Fig. 2) is that of Fralick and Miall (1981). In it either glaciation or tectonism may be held to account for the recognized stratigraphic divisions. However, the particular tectonic regime in which the Huronian succession evolved is currently a matter of much speculation (e.g., Sims *et al.*, 1980). Neither does glaciation provide the answers, for as Fralick and Miall (1981) point out, the major change (Fig. 2) from deep-water to shallow-water sedimentation seems unrelated to the glacial episodes.

Table II. *Outline of the stratigraphy of the Huronian Supergroup, slightly modified after Robertson* et al. *(1969). Thickness (a maximum in each case) is shown for each group and the number and kind of Au or Au-U occurrences known in each formation are listed (see Text for details). *At Thessalon the basal arkosic to conglomeratic Livingstone Formation, considered equivalent to the Matinenda Formation (Frarey, 1977), is overlain by the dominantly volcanic Thessalon Formation. †Note: 17 of these are in "Mississagi" Formation and may not be correlative with the classical Mississagi Formation of the Hough Lake Group—unfortunately, this cannot be proved due to lack of marker beds (D.G.F. Long—pers. comm., 1983).*

THICKNESS	GROUP	FORMATION	NUMBER OF OCCURRENCES Vein	Stratiform	
6000 m	Cobalt	Bar River	0	0	
		Gordon Lake	0	0	
		Lorrain	3	2	(new)
		Gowganda	47	0	
1500 m	Quirke Lake	Serpent	7	1	(new/partly in Mississagi Fm)
		Espanola	5	1	
		Bruce	3	2	
3500 m	Hough Lake	Mississagi	13	19†	
		Pecors	1	0	
		Ramsay Lake	0	0	
4000 m	Elliot Lake	McKim	2	0	
		Matinenda	4	5	
		*Thessalon	0	1	
		Livingston Creek	0	0	
15,000 m			85	31	

According to Long (1981) most of the basal Huronian metasediments in the southern Cobalt Embayment originated as braided fluvial deposits, although some pond and lake deposits are present. Platte-type braided streams with low sinuosities (high width to depth ratios, etc.) predominate in the upper member of the "Mississagi" Formation. Following Long (1976), the "Mississagi" Formation is understood here to equate with, at least in part, the Matinenda Formation. However, in the lower parts of the "Mississagi" succession more proximal Donjek and Scott-type deposits occur, together with minor examples of Bijou Creek-type deposits (Miall, 1980) and pond and lake deposits.

In these fluvial deposits the highest gold concentrations accompany concentrations of uranium and pyrite in "... large and very large pebble conglomerates... all within a few tens of metres of the basal unconformity..." (Long, 1981). Long (*ibid.*) attributes the anomalous gold contents to winnowing in mid or distal regions of humid alluvial fans, an environment resembling that suggested by Pretorius (1974) as one capable of supporting growth of "algal mats" during sedimentation. However, Long (written communication, June 10, 1983) now prefers a model involving precursor magnetite/ilmenite replaced by pyrite ± gold through action of acid ground water. Kerogenous seams comparable to those that are routinely sought as markers, and mined for their gold content, in South Africa are so far unknown from the eastern portion of the Huronian Supergroup. However, possible analogues (Ruzicka, 1981) exist in the Elliot Lake region, where, for example, Hallbauer (as recorded by Theis, 1979) reported filamentous carbonaceous material from Rio Algom's Nordic mine (see Mossman and Harron, 1983).

Along the northern margin of the Cobalt Embayment several extensive finger-like areas of Huronian metasediments extend northward into the Abitibi greenstone belts (Fig. 1). These paleovalley systems were recognized several decades ago (e.g., Thompson, 1943). They may have developed along existing north-trending zones of weakness (grabens?) present in the Archean basement, by valley glaciation (Lovell, 1971) or by re-excavation of pre-Gowganda valleys. Evidence of syntectonic activity supportive of the concept of graben structures has been advanced by several workers, including McIlwaine (1978) and Long and Leslie (1982).

In a study of paleogeographic constraints on sedimentary styles in the paleovalleys (Long and Leslie, 1982) no evidence was found to support a simple valley-glacier model. Lack of marginal-ice deposits and talus along the edges of the paleovalleys seems to indicate that erosion and deposition took place beneath a continental ice sheet or ice shelf (Legun, 1981). The results of recent studies reported by Miall (1983) support the latter concept. The plain fact is that the absence of fluvial strata in the Gowganda rather dims the prospects for paleoplacer gold in the Gowganda Formation north of Cobalt. Analyses of samples of tillite collected from the paleovalley which drained the Larder Lake area have, at best, yielded 10 ppb gold (Mandziuk, 1980). Long (D.G.F. Long, written communication, June 1983) likewise has reported disappointingly low gold content in samples returned from the Gowganda Formation.

In the Lorrain Formation near the top of the Huronian Supergroup, as well as in clastic strata at the base, higher concentrations of paleoplacer gold have been noted (Colvine, 1982, Long *et al.*, 1982). These new occurrences of paleoplacer gold in the Huronian Supergroup are additional to numerous others reported during the last several decades. Specific information on all known individual occurrences of gold, paleoplacer and otherwise, throughout the Huronian Supergroup, are reported by Mossman and Harron (1983).

Distribution of Gold in the Huronian Supergroup

The number of important Au or Au-U occurrences in the Huronian Supergroup totals one hundred and twenty-seven, according to the results of Mossman and Harron's (1983) study. We recognize three types of occurrences (Table III):

1. Vein—auriferous quartz or quartz/carbonate veins;
2. Diabase related—mineralization in or adjacent to diabase dikes;
3. Stratiform—paleoplacer occurrences or slight modifications thereof.

Gold occurs in all four groups of metasediments (Table II). Eleven deposits occur in or directly adjoining diabase. The remaining one hundred and sixteen occurrences are listed in Table II. Of this total, thirty-one Au or Au-U occurrences are stratiform (see Table III). Distribution is as follows: two in the Cobalt Group; four in Quirke Lake Group; nineteen in the Hough Lake Group, and six in the Elliot Lake Group.

Mossman and Harron (1983) have shown that the vein type deposits are usually a good deal richer in gold than the stratiform (paleoplacer) type. In a general way the frequency of occurrence relates to progradational episodes in the sedimentary cycles. In this mode most occurrences are in the Matinenda and Mississagi Formations overlying the Archean-Huronian unconformity.

Host rocks for the stratiform deposits of paleoplacer gold (Table III) are predominantly pyritic conglomerates. Other rock types include arkose, argillite (siltstone), greywacke and sandy limestones. In most, but apparently not all, cases (Meyn and Matthews, 1980) the concentrations of gold are closely associated with pyrite. In many instances stratiform gold occurrences were discovered by virtue of radioactive anomalies due to associated heavy minerals such as zircon, brannerite, uraninite and coffinite. However, in some occurrences, for

Group	Formation	Depositional Environment
Cobalt	Bar River	coastal-beach
	Gordon Lake	tidal flat
	Lorrain	fluvial to near-shore
	Gowganda	glacial to glacio-marine
Quirke Lake	Serpent	distal stream
	Espanola	fluvial through deltaic and shallow marine to deeper marine
	Bruce	glacial to glacio-marine
Hough Lake	Mississagi	deltaic, fluvial and shallow marine
	Pecors	turbidite basin
	Ramsay Lake	glacial to glacio-marine
Elliot Lake	McKim	turbidite basin
	Matinenda	fluvial

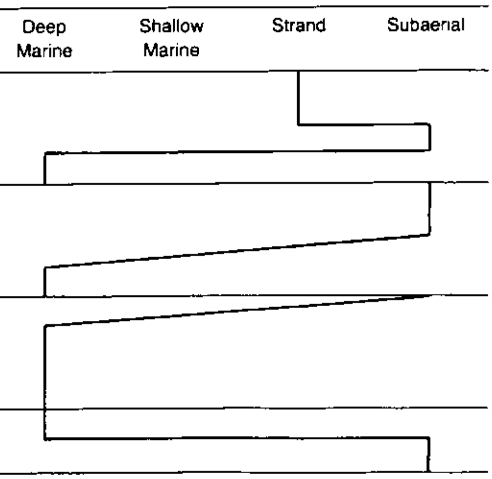

Figure 2 *Sedimentation history of the Huronian Supergroup from Fralick & Miall (1981)*

Table III. *Known occurrences of (stratiform) paleoplacer Au or Au-U throughout the Huronian Supergroup*

Note: the occurrences placed in "Mississagi" may possibly be from the Elliot Lake Group (D.G.F. Long–pers. comm.) *probably "Mississagi"

Number of Occurrence (Mossman & Harron 1983)	Name	Township	Formation	GRADE		
				Au oz/t	U_3O_8%	Other%
11	Corbold Lake	Montgomery	Bruce	0.05	—	0.24 Cu
18	Picton U	Jogues	Mississagi	0.002	—	0.12 Cu
19	Pronto	Long	Matinenda	tr	0.12	—
20	Denison	Bouck	Matinenda	0.005-0.03	0.08-1.73	—
21	Silvermaque	Gunterman	Bruce & Mississagi	0.01	—	—
22	Nordic	Gunterman	Matinenda	0.01	—	0.06 Ag
23	Stanleigh	Gunterman	Matinenda	0.005-0.03	0.043-0.63	—
25	B.C. Explor. #2	Gaiashk	Matinenda	0.02	0.006	—
34	Cons. Moncierg	Baldwin	Mississagi	0.01	—	1.01 Cu
49	Hess Lake	Hess	Espanola	0.002	—	0.18 Ag
56	Roberts Lake	Roberts	"Mississagi"	0.02	0.19	—
57	Nordic	Roberts	"Mississagi"	0.02	0.11	—
59	Leslie	Creelman	"Mississagi"	0.003	0.05	—
60	North Hutton	Hutton	"Mississagi"	0.003	0.44	—
61	Central Hutton	Hutton	"Mississagi"	0.01	0.17	—
62	Banagan Lake	Hutton	"Mississagi"	0.003	0.19	—
64	C.J.M.	Grigg	"Mississagi"	0.01	0.009	—
66	Flesher Lake	Parkin	"Mississagi"	0.002	0.004	—
68	Powerline Rd.	Parkin	Serpent*	0.001	0.015	—
70	Bouma	Parkin	"Mississagi"	0.0003	0.002	—
74	C.J.M.	Stobie	"Mississagi"	0.005	0.021-0.03	—
81	T. Saville	Turner	"Mississagi"	0.01	0.06	—
109	T. Saville	McNish	"Mississagi"		no records	
114	Pickle Crow	Pardo	"Mississagi"	0.05	0.028	—
116	Wright	Vogt	"Mississagi"	0.4/2'	0.052	—
122	Inco DDH #54060	Telfer	"Mississagi"	max 0.004 oz/t Au/1'		—
123	Inco DDH #54061	DeMorest	Serpent and "Mississagi"	to 0.021 oz/t Au/2'8 to 0.032 oz/t Au/2'		—
124	Inco DDH #54062	DeMorest	"Mississagi"	to 0.026 oz/t Au/2.2'		—
125	—	Lundy (North Half)	Lorrain	180 ppb		—
126	—	Dufferin & North Williams	Lorrain	to 0.04		—
127	Cullis Lake	Day	Thessalon	to 4300 ppb		—

example Long Lake in Eden Township (Mossman and Harron, 1983), uranium is lacking. The implication is that the occurrence of gold in the Huronian Supergroup may be much more widespread than is presently recognized.

According to Long *et al.* (1982) paleoplacer gold occurs at the base of the Huronian Supergroup in the Matinenda and Thessalon Formations in the southern Huronian belt, and in the "Mississagi" Formation in the southern third of the Cobalt Embayment. Most often it is found in resistate pebble conglomerates (Long, 1981; Long *et al.*, 1982) of the Mississagi Formation in a proximal braided stream environment. Deposits which originated in a mid to upper alluvial fan setting or in confined valley fill settings are regarded as particularly good targets. Examples of such deposits, replete with associated heavy mineral suites, include in Turner Township: braided stream (Donjek type) with Au present in channel and splay deposits; in Vogt Township: sediment is a valley fill sequence with Au present in a stream thalweg; in Pardo and McNish Townships: the sediment is more distal than Vogt, and consequently shows higher quartz content indicative of greater reworking of sediment (Long *et al.*, 1982).

Gold is also present (Long *et al.*, 1982) at the top of the Huronian Supergroup, certainly in the Lorrain Formation but possibly also in the Bar River and Gordon Lake Formations. In the Lorrain Formation throughout the western half of the Cobalt Embayment gold occurs (e.g., Dufferin-North Williams Twp. occurrence 126; Mossman and Harron, 1983) "...in extremely well sorted, well rounded, small pebble, oligomict, quartz pebble conglomerates..." (Long *et al.*, 1982). These occurrences are taken to represent fluvial deposits reworked in a braided stream system of low to intermediate sinuosity, located distal from the provenance of the gold.

Discrimination of environments of deposition of specific sedimentary successions is of great importance. In the Huronian, just as in the Witwatersrand, sedimentological studies appear to hold the key to locating the more attractive concentrations of gold. Thus, gold in basal Huronian rocks can be related to basement geology, and in some instances (see Mossman and Harron, 1983), to a surprisingly local source. In contrast, gold in upper Huronian metasediments, such as in the ferruginous orthoquartzites of the Lorrain Formation, may represent, as Long *et al.* (1982) report, an advanced stage of placer development which involves reworking lower grade material. Alternatively, as Lovell and Grabowski (1981) have suggested, it is possibly a Western Australian desert-type auriferous soil horizon.

The concept that gold in the upper Huronian is hosted in more mature sediments and has a distant provenance finds close analogy with the geology of the Witwatersrand Basin. If valid, it follows that the upper Huronian rocks are the most likely target for Witwatersrand-type deposits. However, for those who see Witwatersrand-type deposits as unique to a Proterozoic suite of sediments deposited under reducing conditions, the age of the Gowganda and younger formations may prove troublesome. Thus Fairbairn *et al.* (1969) dated the first occurrence of red beds from the

Firstbrook member of the Gowganda Formation, at 2.28 Ga. The occurrence has been interpreted by Owsiacki (1981) and others as signalling oxyatmoversion. The date is nearly coincident with the (tentatively established) upper age limit (2.3 Ga) of the Witwatersrand sediments (Tankard *et al.*, 1982), a system lacking red beds.

Clemmey and Badham (1982) and Clemmey (1981) have argued that the development of red beds and (associated) styles of mineralization in the Precambrian owe more to geotectonic and metallogenetic factors than to atmospheric conditions of the early Earth. Although problems highlighting this controversy are beyond the scope of this paper they will be examined in a subsequent paper (Mossman and Grosovsky, in prep.).

Discussion and Conclusions

Although the potential for paleoplacer gold in the Huronian Supergroup has not yet been fully evaluated there are encouraging signs. An important start has been made. The Cobalt Embayment, particularly the northern half, is in several respects very attractive ground. It is close to the Abitibi greenstone belt, and if the presence of modern gold placers in the region (Ferguson and Freeman, 1978) is any indication, then, as Long and Leslie (1982) have suggested, gold ought to be present in outwash deposits of the Gowganda Formation (Fig. 3). Miall's (1983) interpretation is that the Gowganda sediments were deposited in *submarine* outwash fans, that is, in relatively deep water. If this is true then the Gowganda Formation may not hold as much potential for gold as some overlying formations. While this may very well prove to be the case it should nevertheless be instructive to compare these strata more closely with diamictite-bearing strata of the Witwatersrand. For example, the Government Sub Group (Table I) contains numerous diamictites, some of which are of glacial origin (Tankard *et al.*, 1982).

In the Lorrain Formation lithological and sedimentological features are consistent with deposition in a fluvial, or possibly an alluvial fan system (Colvine, 1982). On the western margin of the Cobalt Embayment, south of Shining Tree, Colvine (*ibid.*) interpreted a section of the Lorrain Formation over 2500 m. thick as follows:

clear orthoquartzite
hematitic orthoquartzite
micaceous sandstone
feldspathic sandstone

In places the hematitic orthoquartzite carries anamalous gold values (to 1200 ppb). The unit is inferred by Colvine (1982) to be present over an extensive area. It is also likely to be relatively accessible because of the predominantly shallow dip of Huronian strata in this region. Dips are generally toward the south of the Embayment and have resulted in a saucer-like form that Colvine (*ibid.*), by means of paleocurrent data, has shown to be of structural rather than depositional origin.

Shallow dips and generally poor exposures, coupled with block faulting throughout the Cobalt Embayment have not facilitated prospecting in the region. However, a recent development promises to take advantage of structural conditions to unravel the aspects of paleogeomorphology: in the Cobalt Embayment Gupta's (1982) analysis of aeromagnetic anomalies (due to buried iron formations) and gravity data has allowed calculation of the thickness of the Huronian metasediments. The picture that is emerging from Gupta's (*ibid.*) work is that the early Precambrian basement in the Cobalt Embayment is, in the western half, granitic and of gentle relief, whereas the eastern half has a relief of several hundreds of metres with fairly well defined paleovalleys and highlands and is probably greenstone in composition. Thus, if Long's (1982) thesis is correct, namely that gold in basal sediments is derived from local sources, then Gupta's (*ibid.*) map of basement lithologies will provide for some interesting speculation as to where, in the basal Huronian, more Au-U might be found.

Colvine (1982) has postulated that the coarser units of the Lorrain Formation resulted from the dumping of several rivers into a system of coalescing alluvial fans and that these were subsequently reworked to produce the upper auriferous portions of the Lorrain. Regional scale distribution of gold and uranium in the Witwatersrand paleoplacers is intimately related to development of alluvial fans. On this significant basis, the resemblance of the Lorrain metasediments to those on the Witwatersrand seems clear.

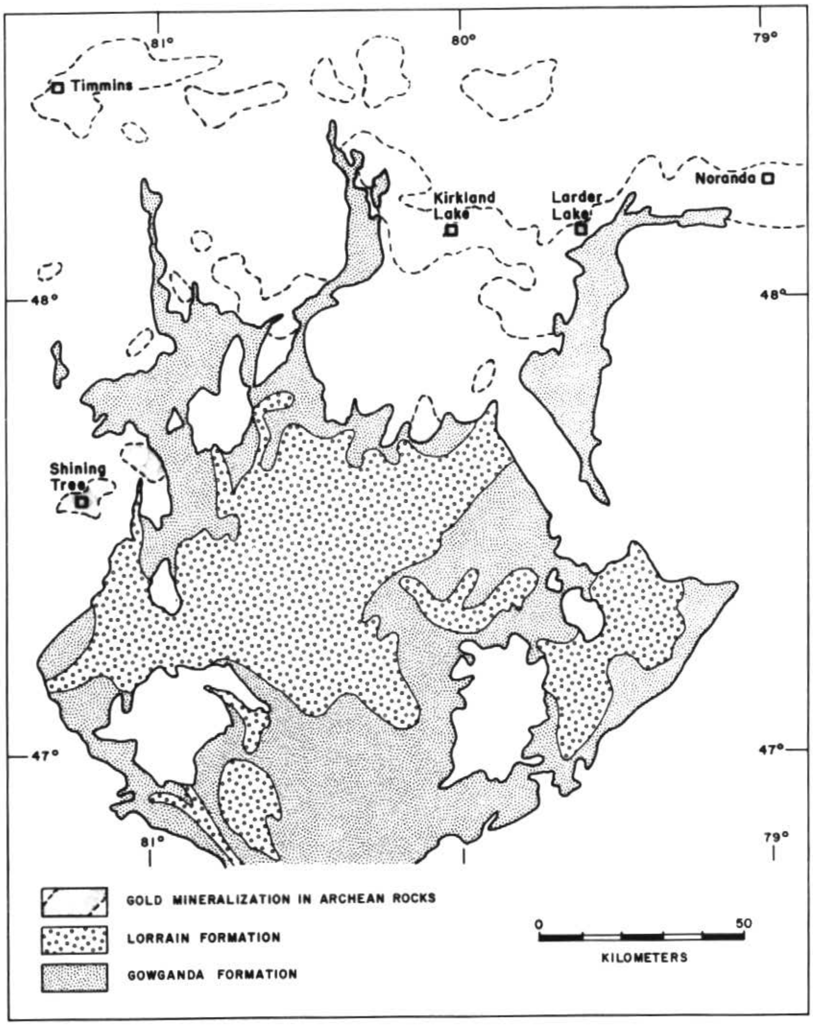

Figure 3 *Generalized geology of the Cobalt Embayment and location of gold occurrences in basement rocks*

Colvine's (1982) suggestion that the sedimentary conditions in the upper Lorrain resemble those of the Welkom Gold Fields appears valid. Indeed conditions described (see Fig. 4) by Colvine (*ibid.*) are remarkably like those of the Welkom Gold Fields Steyn placer (Minter, 1978). There, sequences closely resembling Miall's (1978, 1982) South Saskatchewan braided-stream model are well developed. The location of these and other important Witwatersrand gold placers in alluvial fans seems to have been governed by bar and channel processes responding to longer scale geomorphic processes (Tankard *et al.*, 1982). It is precisely more information about these processes that is needed on the Huronian metasediments to help establish whether a closer analogy exists—particularly in the economic sense—with the Witwatersrand.

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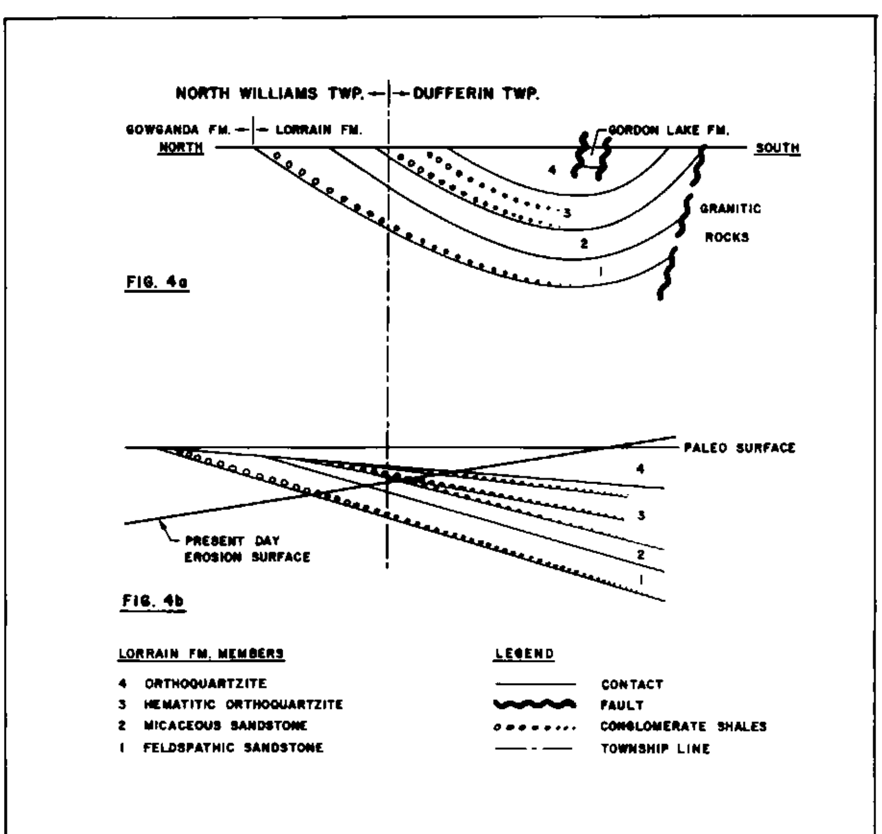

Figure 4 *(a) Schematic section of Lorrain Formation (see Fig. 1 for location) and, (b) interpretive depositional section showing reworking of earlier deposited upper fan sediments (not to scale), after Colvine (1982)*

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