GOLD

by

John D. Godfrey

NOTE: This is a preliminary report and is subject to revision with a more comprehensive study. Information presented herein should not be published without prior approval of the Alberta Research Council.

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ACKNOWLEDGMENTS

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TABLE OF CONTENTS

FIGURES

TABLE

GOLD

INTRODUCTION

The series of reports attempts to review the status of geology-related studies (published and unpublished) which reflect on the evaluation of a specific resource or commodity.

Literature references are incorporated and classified according to the level and type of field exploration detail supplied.

These reports should provide the background and basis from which:

1. an assessment can be made of the level of exploration information currently available;
2. the most relevant literature can be selected through a system of classified references; and,
3. an economic feasibility for locating and/or developing a primary resource or commodity can be assessed from the geological characteristics and conditions as presently understood in Alberta.

Gold deposits are usually divided into two broad categories based on the grossly different mining and processing conditions normally required:

a) placer deposits;
b) lode deposits.

The geological history and makeup of Alberta readily defines areas which are prospective for each category of gold occurrence.

PLACER DEPOSITS

Placer deposits (that is, concentrations of heavy minerals) are formed under either river transported or shoreline conditions. These conditions can occur in sedimentary rocks of any geologic age.

Modern river systems flowing easterly and/or northerly across Alberta from the Rocky Mountains have suitable hydraulic conditions for the placer concentration of heavy minerals. All of these major rivers have been the subject of attention by early prospectors, particularly in the latter part of the 19th Century.

Prospecting activity in Alberta seems to have intensified at the time of the Klondike gold rush to the Dawson City area of the Yukon Territory (1896-99). Consequent upon that activity substantial dredging took place along the North Saskatchewan River in the vicinity of Edmonton.

Map (figure 1) (Government of Alberta, 1952) summarizes the extent of placer gold occurrences and activity in Alberta for the first part of the 20th Century. This figure is probably based on mineral (placer) permit applications, newspaper articles, production reports, and discussions between government and prospectors, rather than upon data gathered through a research-type methodology.

The production of placer gold in Alberta, as reported to the Provincial Government, is presented in table 1 and figure 2. The increase in activity and production reported from the 1970s and onward is primarily due to recoveries achieved from gravel washing plants that process preglacial (late Tertiary) gravels, particularly those in the Edmonton area.

In the last few years there has been renewed interest in attempting to recover the fine placer gold (flour gold) typically found in Alberta rivers such as the North Saskatchewan River. This interest was spurred by the surge in the price of gold in the 1970s.

Placer Gold Studies in Alberta

Very little technically reliable data are available on the placer gold occurrences of Alberta. Halferdahl (1965) conducted a survey of

Figure 1. Placer mining areaas of Alberta (Department of Mines and Mineral Resources, 1952)

Table 1. Gold Production in Alberta (MacGillivray et al, 1984)

Year	Kg	Year	Kg	Year	Kg	Year	Kg	
1887	3.2	1911	0.3	1935	4.7	1959	10.5	
1888	1.8	1912	2.3	1936	3.4	1960	5.9	
1889	30.0	1913	-	1937	1.4	1961	5.3	Kg[1]
1890	6.0	1914	1.5	1938	9.5	1962	5.8	4.1
1891	8.3	1915	6.1	1939	11.2	1963	4.1	1.3
1892	15.8	1916	2.6	1940	6.7	1964	1.8	6.3
1893	14.5	1917	-	1941	6.7	1965	6.2	4.7
1894	22.6	1918	0.8	1942	1.1	1966	5.7	5.2
1895	75.2	1919	0.7	1943	0.7	1967	4.5	-
1896	82.8	1920	-	1944	1.6	1968	4.5	3.1
1897	75.2	1921	1.5	1945	0.2	1969	4.1	5.0
1898	37.6	1922	-	1946	3.4	1970	4.7	2.6
1899	22.6	1923	-	1947	2.4	1971	2.5	2.1
1900	7.5	1924	-	1948	2.4	1972	0.1	-
1901	22.6	1925	-	1949	3.6	1973	5.4	4.1
1902	15.1	1926	-	1950	4.8	1974	3.0	6.0
1903	1.5	1927	1.3	1951	3.0	1975	7.7	8.5
1904	0.7	1928	2.1	1952	3.5	1976	5.6	19.2
1905	3.8	1929	0.2	1953	2.0	1977	2.1	10.6
1906	1.2	1930	-	1954	6.2	1978	34.7	26.6
1907	1.0	1931	6.1	1955	6.7	1979	42.0	19.5
1908	1.6	1932	2.6	1956	3.7	1980	133.0	12.9
1909	0.8	1933	10.1	1957	1.3	1981	121.0	30.6
1910	2.8	1934	12.1	1958	9.6	1982	11.0	15.6
						1983	21.0	

1887-1934 from Robinson (1935)

1935-1948, 1953-1959 from Giusti (1983)

1949-1952, 1960-1983 from Statistics Canada Catalogue 26-201/Canadian Mineral Review

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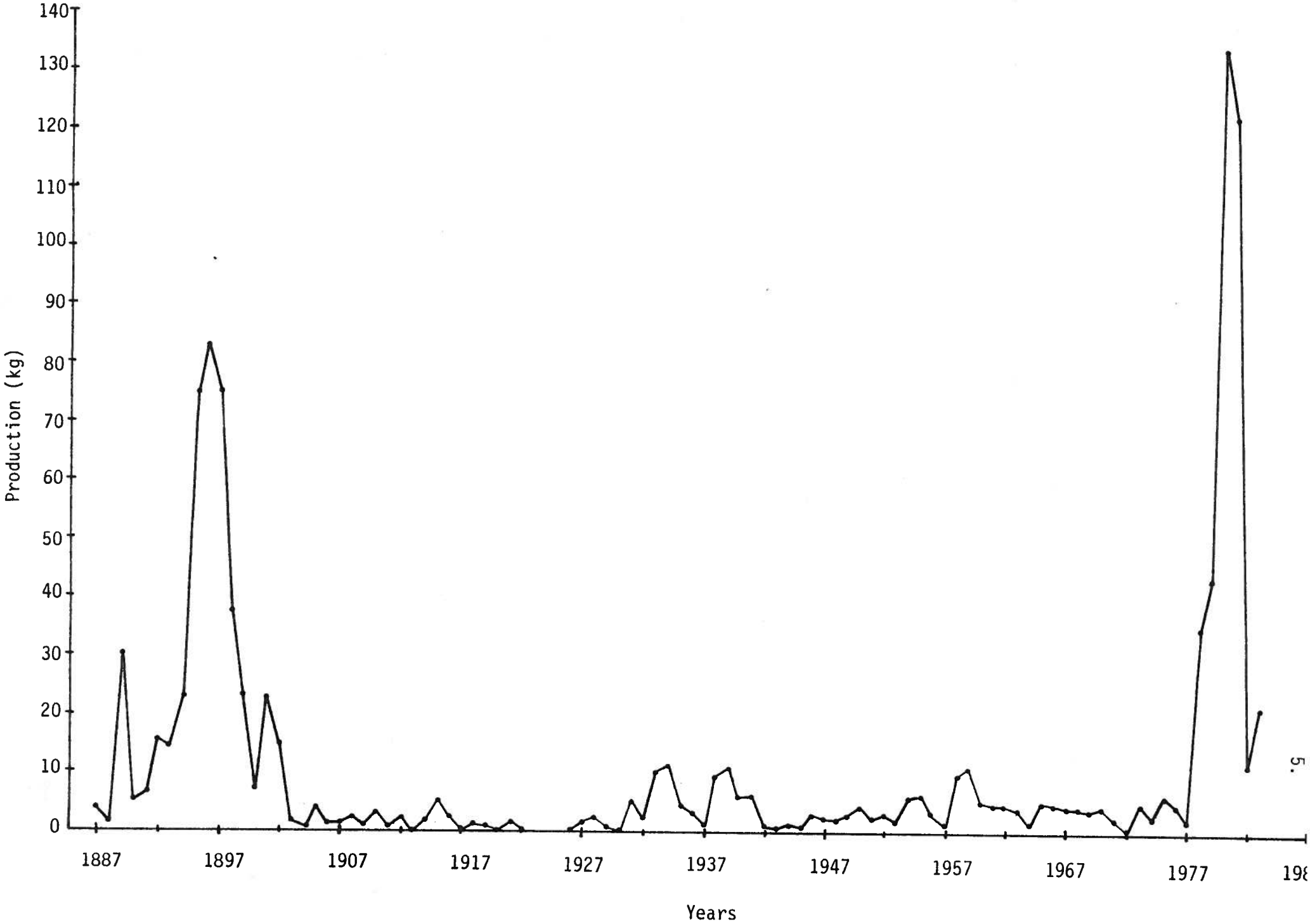
[1] 1962-1982 from Alberta Department of Energy and Natural Resources mineral royalties file.

Figure 2. Placer Fine Gold **Production in Alberta** (Based on MacGillivray et al, 1984)



the major drainage basins in Alberta. The study was regional in scope, therefore the conclusions are accordingly abbreviated and reconnaissance in nature.

Two studies have been undertaken as theses requirements at the University of Alberta. Giusti (1983), under the supervision of Professor R.D. Morton, made a survey of placer gold occurrences in Alberta and also examined the mineralogy of raw gold with the aid of a scanning electron microscope. The latter study was directed in part towards determining the source of the placer gold in the Alberta river deposits.

One site-specific study has been conducted by a student in the Department of Mineral Processing (Romaniuk, 1981) under the supervision of Professor Vern Pitt. The object of this study was an evaluation of the placer gold content of preglacial gravels in the pit of Consolidated Concrete Ltd., Villeneuve, Alberta.

The Alberta Research Council (MacGillivray et al., 1984) undertook a critical placer gold study of sediments along a 17 km section of the North Saskatchewan River. The objectives were twofold:

1. To develop a reliable method for the representative sampling and estimation of gold concentrations in placer gold-bearing sediments;

2. To check the relationship between the placer gold contents of a preglacial channel (exposed in the modern river banks) and the adjacent downstream sediments of the modern North Saskatchewan River.

Their conclusions are that a gravity sluice recovery technique yields qualitative results only and there is a correlation between the preglacial channel and anomalous placer gold in the adjacent modern river sediments.

Problems, Outlook

1. The source of the placer gold in the modern Alberta river sediments is a matter of considerable interest for those engaged in placer exploration. It is unlikely that there is a single, unique answer to this question in that the placer gold is probably derived from several sources. The possible contributing sources are:
   a. glacial deposits;
   b. preglacial river channel deposits (upland preglacial gravels and Saskatchewan Sands and Gravels);
   c. Tertiary bedrock;
   d. Cretaceous bedrock.

   Bayrock (1960) suggests that glacial deposits are not a major source of placer gold for the modern river sediments of Alberta, despite the claims of Allan (1920). Limited knowledge of the distribution and concentration of placer gold in the modern river sediments points to the preglacial river channel deposits as a major contributor.

   Yet, significant contributions may also be expected from other placer concentrations within the Tertiary and Cretaceous bedrock of Alberta. Like the preglacial, Saskatchewan Sand and Gravel channel deposits, other contributions can be expected to be of a local, though significant nature. A definitive study is needed to isolate contributions from each of these possible sources.

2. The fine particle size of the placer gold in the modern river sediments of Alberta, and particularly those of the North Saskatchewan River (probably the best studied and documented drainage basin in Alberta) makes recovery extremely difficult. Recoveries of this far-travelled, fine-sized gold, by traditional sluice box methods, are thought to be inefficient; that is, it is difficult to estimate the losses, and hence to establish the efficiency of a system.

The limitations of gravity recovery systems on gold particles less than 100 mesh in size are well documented (figure 3; Wang, 1979). An evaluation is needed of the gravity and alternate devices used in the recovery of gold from these types of modern fluvial sediments.

3. There are dozens, even hundreds, of at least intermittently active gravel-washing operations in Alberta each summer. In each case, at least in theory, there is an opportunity to recover the placer gold (or rather a heavy mineral concentrate containing placer gold). Not all gravels being prepared by washing, etc. for industrial use contain significant concentrations of gold; however, considerably more than the two or three in the west Edmonton region (where gold is now being recovered) would qualify as being in the range of economic interest and feasibility. This placer gold is now being lost.

4. The occurrence of precious metals other than gold are well known in the North Saskatchewan River sediments (Allan, 1920), however, precise knowledge is far more scanty than is the case for placer gold. Platinum is more difficult to detect or recover, and the cost of assays on a routine basis is generally forbidding for the individual prospector. There is also a further lack of knowledge amongst prospectors regarding the possibilities for the presence of platinum in Alberta river sediments.

   The distribution pattern of placer platinum is very unclear, but it would be surprising if it matched that of placer gold. Consequently, the same geological exercise needs to be followed as that used in the exploration and evaluation of the occurrence of placer gold, namely:

   a) Systematic sampling and assaying to determine the distribution pattern and concentrations for the modern

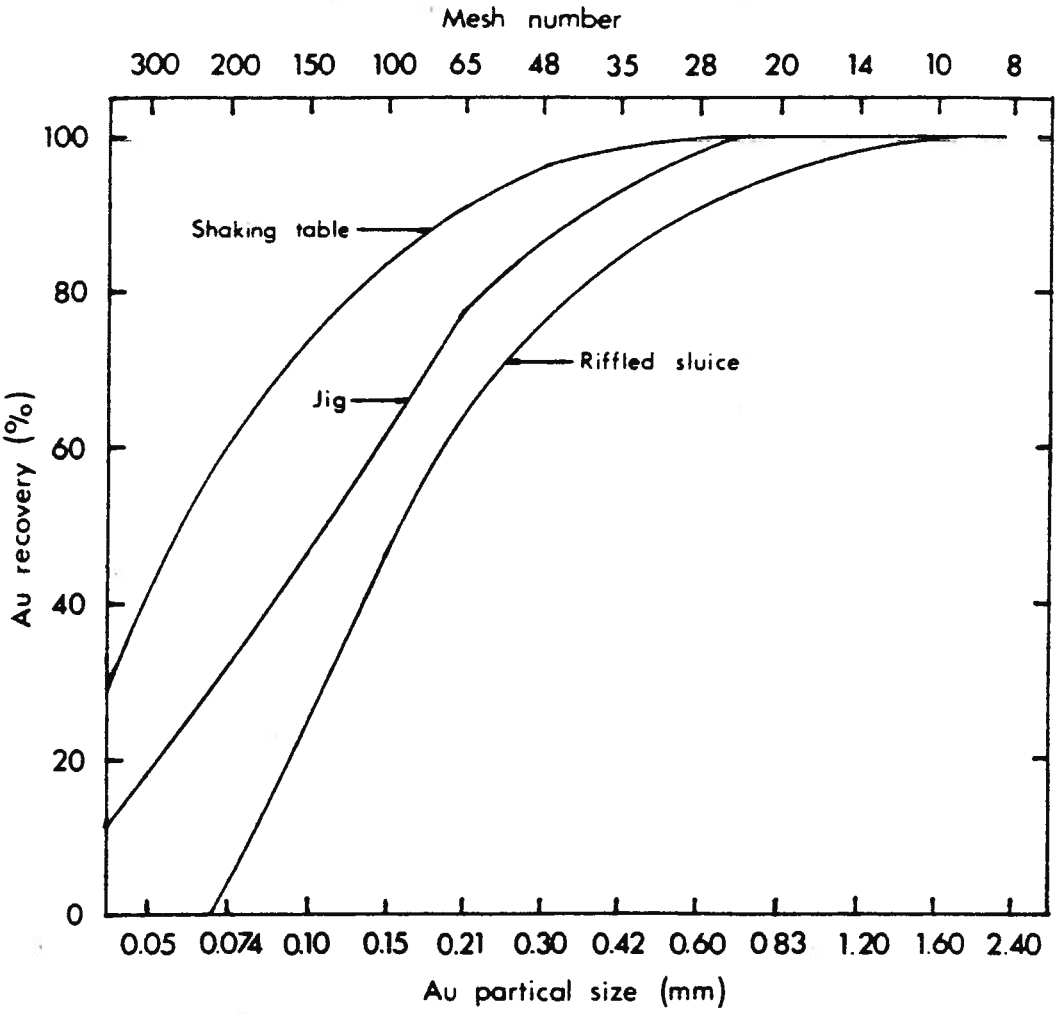


FIGURE 3 : Recovery of different size gold particles by gravity devices (from Wang, 1979).

river sediments;

b) Systematic sampling and assaying to determine the source rock(s) for the platinum.

Assay that identify the different platinoid metals would be of further interest.

5. Insofar as heavy mineral concentrates are the primary raw materials directly recovered by the traditional gravity placer systems (yielding in the order of about one to two pounds per cubic yard of feed gravels, thereby representing a concentration ratio of about 2000:1) it would seem appropriate to closely examine such concentrates. Heavy mineral concentrates from major drainage basins can potentially contain a variety of economically interesting (industrial) minerals (for example, magnetite, ilmenite, garnet, monazite, platinum). Focus on placer gold values alone may lead to overlooking a combination of smaller economic benefits which together could contribute significantly to the economic feasibility of a mining operation.

Research Projects

1. Systematic analysis of potential sources of placer gold within each major drainage basin, giving particular attention to: preglacial river channels, exposed Tertiary and Cretaceous lithologies.

   a) A great deal is known about preglacial bedrock river channels, because of their significance as subsurface aquifers, beginning with the studies of Farvolden (1963). However, a great deal more regional synthesis has taken place since that time and a careful province-wide synthesis, with heavy minerals in mind, would be appropriate at this time.

b) Investigation of bedrock units should be undertaken using appropriate sampling and study methods.

2. Close and continuing attention should be paid to research efforts (for example, Wang, Wenquian and Poling, 1983) directed towards the recovery of placer gold at the finer particle-size end of the spectrum.

3. Gravel-washing operations should be monitored and possibly classified according to their capability of producing black sand-heavy mineral concentrates. Assistance should be given to gravel companies and producers in the form of expertise in evaluating their deposits for gold content. Does this potentially represent a wasted resource in Alberta?

4. The occurrence of placer platinum is probably far more widespread in Alberta than is presently realized. Efforts should be directed towards an evaluation of the distribution, concentrations and primary sources of placer platinum in the modern major river sediments of Alberta.

5. Heavy mineral concentrates (commonly black sand) are the primary products of the traditional gravity placer recovery systems. A quantitative appraisal of potentially interesting industrial minerals should be made of Alberta river sediments.

6. This report cannot be considered to be an exhaustive study of all the relevant literature and ideas on the gold resources of Alberta. The input has been far too limited to arrive at an in-depth study. The report incorporates information and ideas largely based on personal knowledge. A broader base of information is available: in the literature, in the offices of the practicing professional geologist and engineer, and in the gold pan, sluice box and 'black box' of the explorationist-prospector. The provision for an in-depth study

is recommended for this commodity in the near future. There is considerable scope for assistance and development of this neglected industry in Alberta.

LODE DEPOSITS

Lode gold deposits are commonly associated with: 1) igneous-metamorphic (Shield) terrains; 2) strata-bound conditions as in sedimentary sequences; or 3) volcanic piles characteristic of ocean floor spreading centers. In Alberta, these associations can be used to develop an exploration guide within the appropriate geological environments which identify the following exploration regions.

Igneous-Metamorphic Terrain

The Canadian Precambrian Shield of northeastern Alberta and the minor plutonic occurrences in extreme southwestern Alberta, for example, the Clark Range.

Sedimentary (Strata-Bound) Terrain

Cretaceous and/or Tertiary strata could be most prospective, especially those of fluvial origin (that is, potential paleo-placer deposits).

Thick Volcanic Piles

Thick volcanic piles, which have accumulated on the ocean floor associated with spreading centers have not been identified anywhere in the geology of Alberta, either at surface or in the subsurface.

Outlook

1. a) Studies in Igneous-Metamorphic (Shield) Terrain
   i) The Precambrian Shield of northeastern Alberta, exposed for about 11 000 km^2 north of Lake Athabasca and

400 km^2 south of the Lake, has been extensively mapped by the Alberta Research Council. Good prospecting maps are available on a scale of two inches to one mile.

The best prospects for gold are at Waugh Lake, associated with a series of low-grade (greenschist facies) volcanogenic-clastic metasediments in which arsenopyrite is disseminated and tourmaline-quartz veins are locally concentrated. Both arsenopyrite and tourmaline are good indicator minerals for gold mineralization at the exploration stage.

Other metalliferous showings, some with arsenopyrite, are typically found in association with gossans within high-grade metasediments (granulite facies). Minor showings have been found also in the closely associated Archean granite gneisses.

Limited assays show low values of nickel and silver (pyrrhotite, arsenopyrite, pyrite) at Lindgren Lake; there are no gold assays. Hudson's Bay Oil and Gas Co. Ltd. (Burgan, 1971) prospected the Waugh Lake low-grade, metasedimentary-volcanic band and found sub-economic values in uranium and minor amounts of copper, nickel, silver and gold. There is scope for much more conventional surface prospecting in the Shield of Alberta, knowing that the metasediments, underlying about 10 percent of the outcrop area, are the primary prospecting target.

ii) Fort McMurray Drill Hole; it is understood that in 1911, when Sidney Ells drilled for the oil pool that was the supposed source of the oil found in the overlying oil sands, he cut gold-bearing "Laurentian granite" in the basement at a depth from 1105 to 1130 feet. An unconfirmed assay (possibly estimated by

panning of crushed rock chips) suggests a gold value of about two-thirds of an ounce per ton. A value of $13.00 per ton is reported (Allan, 1920) (gold was $20.67/oz at that time). A mineral claim is now held over the drill hole site by Milton McDougall, and surrounding permits are held by Duncan Campbell, both of Edmonton.

b) Plutons of Southwest Alberta (Clark Range): Bosses of granitoid plutons are known in Alberta close to the interprovincial boundary with British Columbia just north of Waterton National Park. Late Proterozoic strata are cut by plutons and by basic sills and dykes, possibly of the Purcell Series.

Strata-bound copper mineralization has been found in the Grinnell and adjacent formations (Goble, 1970; Halferdahl, 1971). These showings have been prospected and the literature (mineral exploration reports) needs to be searched and checked for possible gold assays.

The unroofing and appearance of shallow-buried granitoid plutons should provide metalliferous prospecting opportunities. The potential area for the legendary "Lost Lemon Mine" should be viewed from this geological perspective.

2. Strata-Bound (Sedimentary) Exploration Potential

Cretaceous and Tertiary Bedrock: These sequences contain thick sections of clastic sediments, many of them deposited in continental or coastal environments. Therefore, in concept there should have been considerable opportunity for the development of drainage systems in which placer deposits could have formed.

The Lower Cretaceous of Alberta is well known for its fluvially transported, clean quartz sands (Peace River, Fort McMurray), which are indications of mature sediments, formed under rigorous climatic conditions. If geochemical conditions have remained favourable, the relatively stable mineral gold, and other heavy minerals, could have formed placer concentrations.

The Tertiary sediments of Alberta are essentially of continental origin and therefore should have been favourable for the accumulation of placers in fluvial channel deposits. The source(s) of these clastic sediments constitutes crucial data for the evaluation of this concept. It is possible that the transportation path of eroded lode and ancient placer gold deposits from interior B.C. (for example, Barkerville) can be traced (or even speculated upon) from interior B.C. to the Cretaceous strata of western Alberta, then reworked in part as source material for the Tertiary sediments. In turn, these Tertiary strata were a contributing source of sediment for the later alluvial deposits, including those of the modern river systems. Thus, in the course of reworking, the primary gold sources of interior B.C. could be responsible for the progressive and stepwise concentration of placer gold in successive clastic sediments of several geologic ages.

Research Projects

1. Shield terrains. A literature search should be undertaken of exploration reports, in particular with respect to gold assays, host lithologies, and indicator minerals and including the Fort McMurray drill hole to basement.

2. Granitoid plutons in the Clark Range of southwestern Alberta. A literature survey is needed to outline prospective areas, compile gold assays, and host lithologies, using government and mineral exploration reports, university theses, etc.

3. Paleo-placers, require extensive literature research, possibly supported by fieldwork, once segments of fluvial channel systems can be identified. Literature research is required into the compilation of gold assays in obvious fluvial channel-fill sediments. Failing the availability of suitable, decisive data, fieldwork (sampling) should be conducted at accessible, appropriate outcrops.

SUMMARY OF DATA GAPS

1. A reliable and methodically developed set of data are needed to evaluate placer gold concentrations in those segments of major modern river sediments known to contain anomalously high gold values.

2. A methodically developed and reliable data set are needed to quantitatively examine relationships between placer gold in the network of preglacial river channel deposits and placer gold in major modern alluvial deposits. Although all preglacial channels are theoretically prospective, some of these drainage systems, channels, and even segments of channels, will be more significant than others.

3. A methodically developed and reliable quantitative data set are needed to evaluate possible placer gold occurrences in the exposed Tertiary and Cretaceous bedrock of Alberta. The identification of paleo-fluvial systems and deposits is needed. This phase of research will require fieldwork to supplement data from existing literature.

4. Reliable quantitative and methodically developed data are needed on the mineralogy of heavy mineral concentrates (with special reference to platinum) from the major modern alluvial deposits.

5. Qualitative and quantitative data are needed on heavy minerals, placer gold and platinum values not being recovered from existing gravel-washing operations.

6. Synthesis and analysis of numerous exploration permit reports is needed to assess the potential of igneous-metamorphic related gold occurrences. Field work may be needed to supplement the findings of these reports in order to better establish the prospective mineral potential, especially for the little known granitoid-associated area of southwest Alberta.

OUTLINE FOR REFERENCE CLASSIFICATION: RESOURCE INVENTORY

A. Resource (Commodity) Evaluation References
   1. General Overview
   2. Specific Commodity Overview
   3. Exploration - Reconnaissance Scale
   4. Exploration - Site Specific Scale

B. Supporting References
   1. Concepts and Principles
   2. Indirect Exploration - Reconnaissance Scale
   3. Indirect Exploration - Site Specific Scale

C. Background and Miscellaneous References

REFERENCES

A. RESOURCE (COMMODITY) EVALUATION REFERENCES

1. General Overview

2. Specific Commodity Overview

3. Exploration - Reconnaissance Scale

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