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TABLE OF CONTENTS

Page

MORNING SESSION; Monday, April 7, 1980
Chairman - Richard C. Swainbank, Chairman of the Fairbanks Branch, AMA

CLASSIFICATION OF PLACER DEPOSITS 1
Mark Robinson, ADDGS

GEOLOGICAL GUIDES TO HEAVY MINERAL PLACERS 21
Tom Bundtzen, ADDGS

GEOLOGY OF BEACH PLACERS 45
James Madonna, Mining Extension, University of Alaska

PALEOPLACER DEPOSITS 52
Dr. John Sims, Dept. of Mining Engineering, Univ. of Alaska

AREAL DISTRIBUTION OF GOLD-SILVER RATIOS IN THE FAIRBANKS DISTRICT 71
Paul A. Metz, M.I.R.L., University of Alaska

CHEMICAL ZONATION IN PLACER GOLD NUGGETS 72
Dr. Robert Forbes, Senior Geological Consultant, Geophysical Institute, University of Alaska

LUNCHEON ADDRESS
Leo Mark Anthony - Master of Ceremonies

GOLD - THE ULTIMATE HEDGE 78
Peter A. Bushre, Deputy Commissioner of Revenue for the State of Alaska

AFTERNOON SESSION
Chairman - Robert B. Forbes

OVERVIEW OF EXPLORATION METHODS 84
Dr. Ernest N. Wolff, M.I.R.L., University of Alaska

EXPLORATION AND EVALUATION OF PLACER DEPOSITS BY SHAFTS AND PITS 95
Gordon Hilchey, Gordon Hilchey and Associates, Ltd.

BLM INVOLVEMENT IN PLACER MINING OPERATIONS 99
Richard Harty, Phoenix Training Center, BLM

APPLICATION OF NEUTRON CAPTURE SPECTROSCOPY METHODS OF EXPLORATION AND EVALUATION OF GOLD DEPOSITS 105
Dr. John Sims, Dept. of Mining Engineering, University of Alaska

PROBLEMS OF DEPRECIATION AND DEPLETION 120
Eugene C. Yurkovich, Accountant, Main Hurdman & Cranstoun

GOLD: CARATS, TROY WEIGHT AND FINENESS 125
Merle Thomas, Alaska Gold Sales

BANQUET ADDRESS
Earl H. Beistline - Master of Ceremonies

BANQUET SPEECH 128
Lt. Governor Terry Miller

MORNING SESSION; Tuesday, April 8, 1980
Chairman - John J. Mulligan, U.S. Bureau of Mines

ROUNDUP OF GOLD RECOVERY SYSTEMS AND DEVICES 135
Cleland Conwell, ADGGS (based on Paper by W.J. Mildren)

PIPE AND PUMP HYDRAULICS FOR THE PLACER MINE 137
Robert F. Carlson, Director, Institute of Water Resources, University of Alaska

CYANIDATION 142
William McClintock, Mining Services and Properties

ANNOUNCEMENT FROM THE WASHINGTON CONCENTRATES OF THE AMERICAN MINING COMPANY 146
Ron Sheardown, Vice-Chairman of the Anchorage Branch of the Alaska Miners Association

GOLD RECOVERY FROM PLACER CONCENTRATES BY CYANIDATION 147
Cleland Conwell, ADGGS

PLACER RESEARCH AT THE SCHOOL OF MINERAL INDUSTRY UNIVERSITY OF ALASKA, FAIRBANKS 158
Ernest N. Wolff, M.I.R.L., University of Alaska

DRIFT MINING 163
Carl Heflinger, Heflinger Mining Company

LUNCHEON ADDRESS
Howard Grey - Master of Ceremonies

PERMITS AND REGULATIONS 169
J.P. Tangen, President, Alaska Miners Association

AFTERNOON SESSION

Chairman - Chris Lambert

NATURAL REVEGETATION OF DREDGE TAILINGS AT FOX, ALASKA 175
Kay Holmes, Graduate Student, University of Alaska

A MINING OPERATION IN THE YENTNA DISTRICT 186
Bill Hall, Hall Gold Dredges

MINING ON SLATE CREEK 196
Douglas B. Colp, Placer Consultant

SECURITY FOR THE PLACER MINER 201
Mark Hewitt, Stanley Smith Security

CLASSIFICATION OF PLACER DEPOSITS

Mark S. Robinson
ADGGS

Placer deposits are deposits of sand, gravel, or other detrital or residual material containing a valuable mineral, that has accumulated through weathering and mechanical concentration processes. Taken as a whole, placer deposits have yielded more than two-thirds of the world's gold and are currently yielding a large percentage of the total production of gold, tin, uranium, ilmenite, rutile, zircon, monazite, xenotime, andalusite, diamonds, magnetite, ruby and sapphire in the world today. We shall concern ourselves only with gold placer deposits, although other commodities may occur in these placer deposit types.

The term placer is thought to have been derived from a term used by spanish miners in north and south America and seems to have meant sand bank or place in the river where gold was deposited.

Placer deposits vary greatly in form and location. These variables form the basis of several classification schemes that have been developed over the years in an effort to relate placer development to natural processes. One type of classification scheme that is widely used is based on the genesis or origin of any given deposit (see Figure 1). Another basic classification scheme is based on the geological location and tectonic history. You will note that this particular classification scheme (see Figure 2) only deals with alluvial placer deposits and therefore another classification must be used when dealing with other than alluvial placers.

In detail, the genetic classification can be divided into six major groups. Type I placers are residual placer deposits, and form as the result of weathering of lode sources and the residual accumulation of resistate minerals at or near the lode source (see Figure 3). The mechanical and chemical decay of the host rock results in the enrichment of the surface zone through the elimination of valueless material. Mineral commodities that might be expected in eluvial or residual placer accumulations include; gold, platinum, garnet, cassiterite, monazite, rutile, scheelite, diamonds, ilmenite, magnetite and barite. Type II placer deposits are slope placers, also known as eluvial placers, which are transitional between the residual placer deposit type and the alluvial deposits, and are locally difficult to distinguish from the residual and alluvial forms. The slope placers are usually found as irregular sheets of surface detritus mantling hillsides below a vein or other source of valuable mineral (see Figure 4). The sheetlike mass may move slowly downhill due to surface creep, allowing the lighter portions of the detritus to be removed by rainwash and wind. A rough stratification or concentration of the detrital mass may develop and result in a concentration of values. However, the stratification is rarely as well developed as it is in alluvial deposits.

Figure 1. Genetic classification of gold placers

Type	Sub-type
I. Residual	1. Zones of weathering of gold-quartz deposits 2. Zones of oxidation of auriferous sulphide deposits
II. Slope	1. Solifluction and land slide placers 2. Solifluction and deluvial placers 3. Deluvial and landslide placers
III. Watercourse	1. Alluvial placers 2. Proluvial placers 3. Lacustrine placers
IV. Glacial	1. Placers of main and lateral moraines 2. Placers related to interglacial and glacial streams and other water courses of glacial origin
V. Eolian	Placers in eolian sands
VI. Marine	1. Beach placers 2. Placers on underwater slopes 3. Placers in near shore still water (lagoons, coves)

Source: Kazakevitch (1972).

Figure 2. Classification of alluvial placers according to their geological location and tectonic history (uplift or depression)

Present form	Elevated equivalents	Depressed equivalents
1. Gulch, canyon & creek gravels	High level gulch & creek gravels	Deeply buried gulch & creek gravels
2. River and bar gravels	Bench gravels High level river & bar gravels	Deeply buried river & bar gravels
3. River flood-plain gravels	High level flood-plain gravels	Depressed (deeply buried) flood plain gravels
4. Deltaic gravels	Elevated deltaic gravels	Depressed deltaic gravels
5. Beach and shore line gravels	Elevated beach & shore line gravels	Depressed beach & shore line gravels

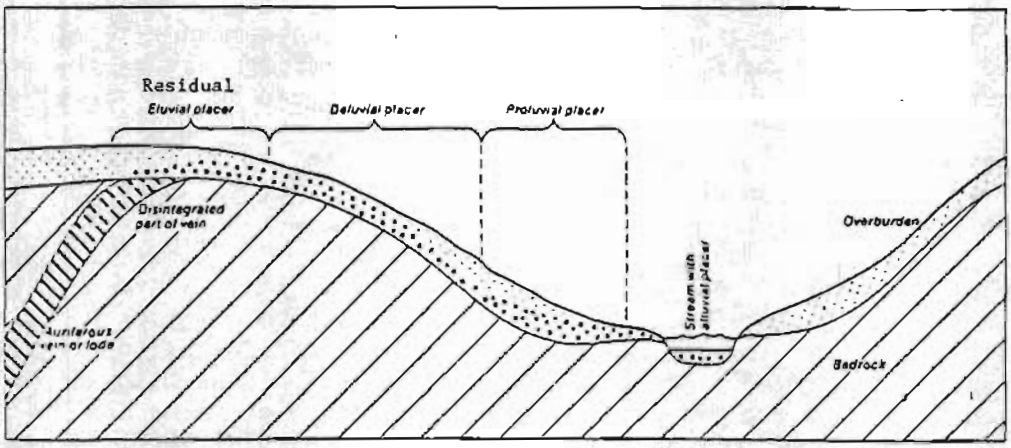

Figure 3. Sketch illustrating outcrop of a gold-quartz vein supplying material to form eluvial and alluvial placers. By one terminology, an eluvial placer embraces all materials not transported by streams. By another, only the placer materials over weathered and disintegrated deposits constitute an eluvial placer; downslope and other placer materials are classified as deluvial and proluvial as shown.

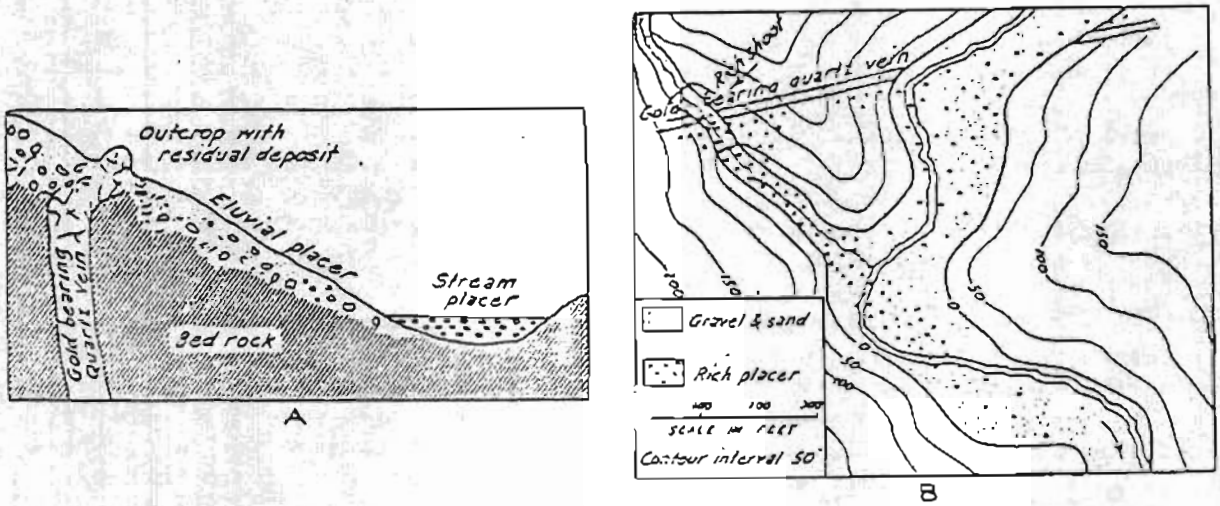

Figure 4. A, Diagrammatic cross-section showing the transitional stages in the development of placer deposits. First, the quartz vein; second, disintegration at the outcrop to form a residual placer; third, formation of eluvial placer by 'creep' of residual material down the hill slope; fourth, deposition of water-worked material as alluvium, forming an auriferous gravel deposit, or stream placer. B, Sketch map showing development of rich placers broken down directly from the disintegration of a gold-bearing vein (after Lindgren, Mineral Deposits).

Unlike bench deposits, slope deposits, also known as hillside placers, are generally not indicated by surface topography, nor do they rest on definitely flattened surfaces of bedrock. Type III placers are known as watercourse placers and are by far the most important and common type of placer deposit. Placer accumulations that have resulted from alluvial processes, those processes resulting from transport by water, can be classified into two general categories, modern and fossil. Fossil alluvial placers, such as the Witwatersrand of South Africa, will be discussed by Dr. John Sims later and we will concern ourselves only with "modern" placers, those that have developed during Tertiary and recent geologic times.

There are some general characteristics of alluvial placers that will serve as a basis for the description of these deposits. These characteristics include; gold in pay streaks near the lode source, where the gold tends to be coarse, and is usually found in the lower layers of the alluvium either on bedrock, in a zone a few feet above bedrock or in crevices and fractures in bedrock. An exception to this are false-bottomed placers developed on hard pans, clay layers, compacted sand layers or more rarely on limonite-cemented sand layers. Alluvial placer gold far from its source is generally finely divided, and while some gold may be on bedrock, near bedrock, or on false bedrock, most of it is dispersed throughout great thicknesses of sediments.

Alluvial placer deposits are generally composed of loose unconsolidated gravels and sands that have been deposited by flowing water. Flowing water is a most effective separator of light and heavy materials. The lower, slower-moving reaches of streams and the upper reaches, where high velocity environments occur, are not generally favorable sites for placer accumulations. However the transitional zones, where gentler gradients are present, provide an excellent environment for placer development. There are also physical and chemical controls involved in the development of alluvial placers, these include: an adequate source of primary gold, favorable oxidation processes for its release from the source and favorable concentration sites, all of which depend on the tectonic environment.

Within the broad category of watercoarse placers are placer deposits that have developed in specific concentration sites. Gulch Placers are usually confined to small areas within minor drainages where a permanent stream may or may not exist. The gulch placer deposits tend to be thin, poorly sorted and discontinuous because of the steep gradient of the host stream. Gold found in gulch placer deposits tends to be coarse and well concentrated on bedrock.

Creek Placers are the most important source of placer gold in many gold mining camps. This form of placer deposit generally occurs as well sorted, continuous deposits that may be modified by later fluvial processes. Although one might think of placer deposits as having formed by one or a series of sedimentary events, and therefore having a simple internal structure, it should be recognized that the sedimentary processes are dynamic processes and the resulting placer deposit may be quite complex. Figure 5 illustrates the complex nature and non-homogenous distribution of gold values in a cross-section of a watercourse placer in the Soviet Union. The

location of creek placers within valleys of streams having a meandering stream course may not coincide with the present stream course due to the lateral migration of the meanders.

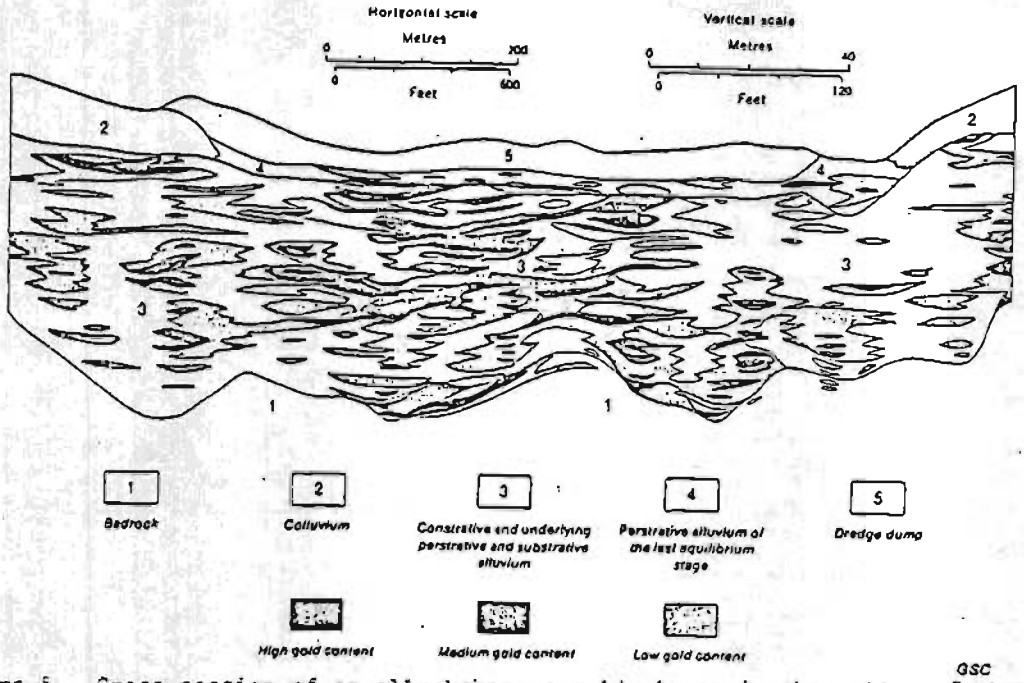

Figure 5. Cross-section of an allochthonous gold placer in the valley of the Kuranakh River, southern Yakutia, U.S.S.R. (after Kartashov, 1971).

Figure 6 illustrates the location within a meandering stream course where heavy mineral accumulations are most likely to develop. You will note that the most likely point of placer development is located near the leading edge of sand bars, in this case, where the high energy zone of water flow on the outside of a meander meets the slack water or low energy zone of the inside of a meander. Figure 7 illustrates the effect of pressure eddies and suction eddies on heavy mineral accumulations. Almost any obstruction in a stream course will generate a pressure eddy on the upstream side of the obstruction and a suction eddy downstream. Again, the concentration of heavy minerals in favorable sites along the stream course is generally related to the point where the rapid flow of water meets a slack flow. As the stream channel migrates laterally, the accumulated mineral-bearing gravels may become covered by later deposits and eventually lie at some distance from the active stream channel. Figure 8 illustrates the migration of meanders and the change of depositional sites within an idealized stream course. Where streams cross highly inclined or vertically layered bedrock, highly resistant dikes or other resistant material, less resistant material adjacent to the resistant material erodes away and creates natural riffles. Such natural riffles are excellent traps for placer minerals. Stream or creek junctions may also play an important role in the localization of placer deposits. The junctions are usually the site of enhanced sediment reworking due to increased turbulence, and may result in heavy mineral concentrations in or near depressions in bedrock related to turbulent

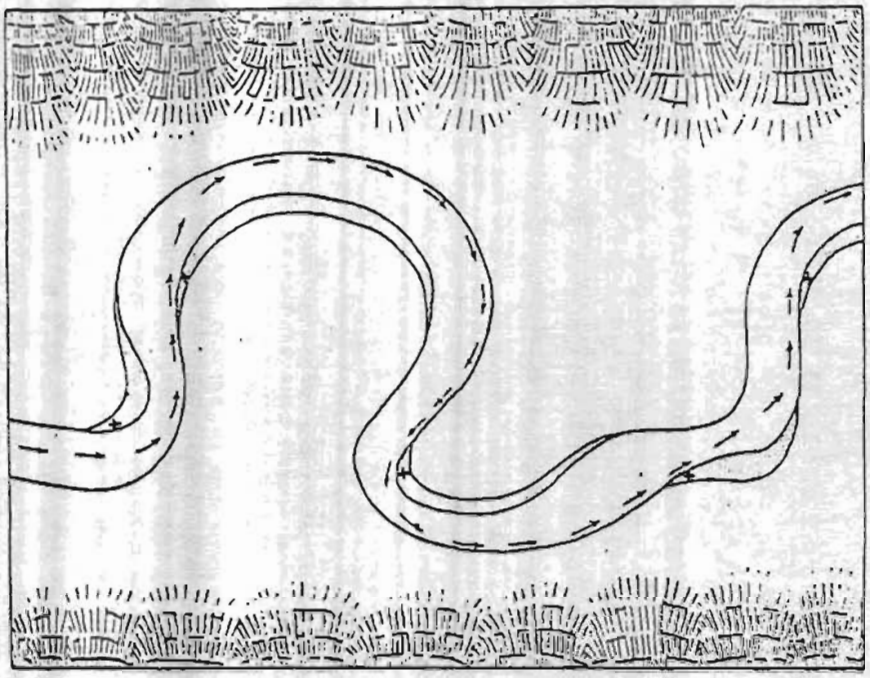

Figure 6. Diagram to illustrate the course of a river, indicating where gold particles are most likely to become concentrated (after Spurr, U.S. Geol. Sur. 18th Ann. Rept., 1898.

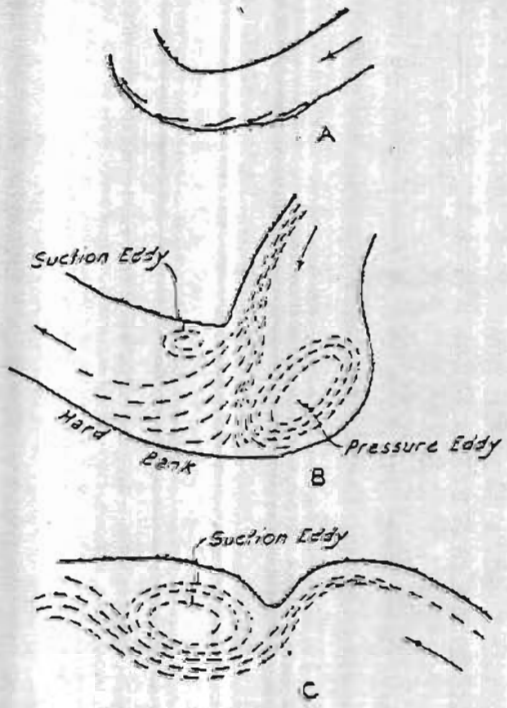

Figure 7. A. Diagram showing the place of greatest erosion on the bend of a river. B. Diagram to show positions of pressure and suction eddies in a river; gold is more likely to be deposited in the suction eddy than in the pressure eddy. C. Diagram to show how a suction eddy is formed in a river (after Thomas and Watt; see Ries and Watson, Engineering Geology).

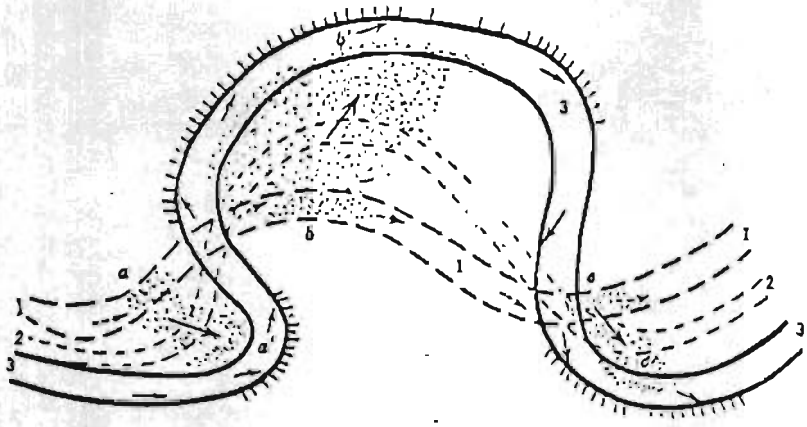

Figure 8. Gravel deposition and formation of pay streaks in rapidly flowing meandering stream, in which meanders migrate laterally and downstream. Stream arrows represent point of cutting. 1, Original position; 2, intermediate position; and 3, present position of stream. Deposits formed at a, b, c or inside of meanders of stream 1, become extended downstream and laterally in direction of heavy arrow growth to a', b', c' on present stream, and buried pay streaks result.

scouring. Stream or creek placers can also occur if the stream crosses a mineralized lode. The erosion of the lode deposit provides the heavy minerals, which often accumulate on the downstream side of the lode source. Figures 9 and 10 illustrate the development of heavy mineral accumulation as described above. River Deposits are another important source of placer gold. These deposits are similar to creek and stream deposits but usually contain finer gold that is contained in well-rounded gravels. Although the overall grade of these deposits may be low, pay streaks and bedrock concentrations rich enough to support large-scale mining ventures are not uncommon. Flood gold deposits are a special type of river deposit and usually consist of minute particles of gold that may be concentrated on accretion bars or skim bars during periods of high water. Figure 11 illustrates the location of flood gold deposition on accretion or skim bars. These deposits may yield spectacular pans, however care must be taken to recognize the presence of a flood gold deposit before launching into a large-scale mining operation. These deposits tend to be very thin and relatively low-grade overall.

One of the most neglected types of placer deposits in the past, and therefore one of the most important for future placer exploration are bench placers. Bench placers are remnants of deposits formed during an earlier stage of stream development and left behind as the stream cuts downward. There are commonly two or more sets of benches in which case they may be referred to as high benches and low benches. An excellent example of bench or terrace gravel development occurs in the Klondike district of Yukon Territory. On Bonanza Creek, high level creek gravels such as the White Channel gravels are ancient creek deposits laid down in the wide, flat bottom valleys, which characterized the region before the last general uplift. After deposition of the gravels, the region was uplifted 600 to 700

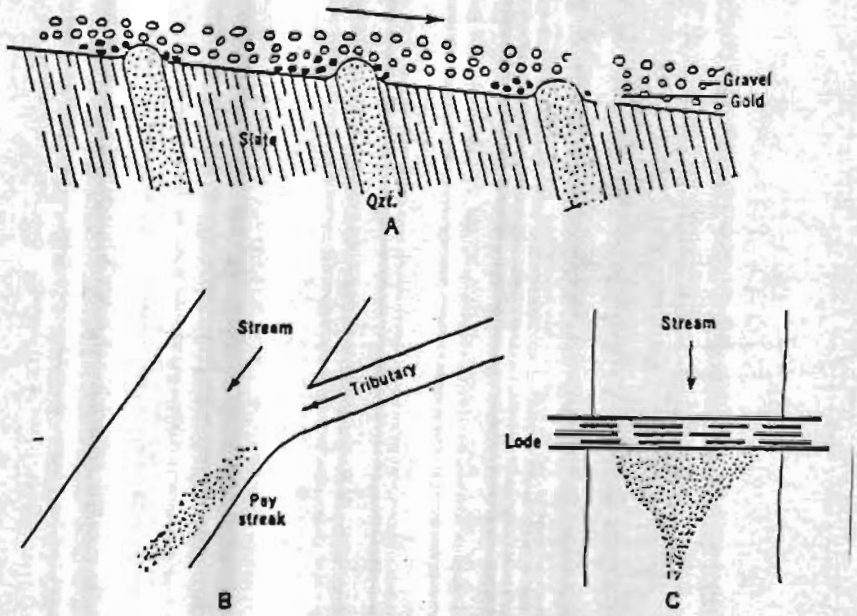

Figure 9. A, Quartzite ribs, interbedded with slate, which serve as natural riffles for collection of placer gold (black); B, pay streak formed where fast tributary enters slow master stream; C, pay streak formed below gold lode crossed by stream.

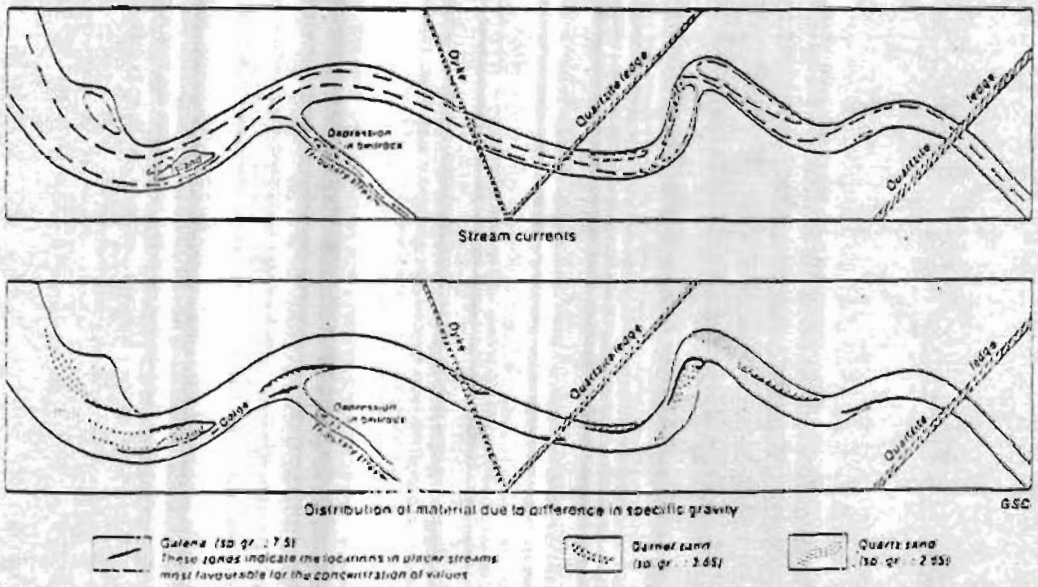

Figure 10. Diagram of a laboratory stream showing currents and distribution of sedimentary materials of different specific gravity (after MacKay, 1921). Galena was employed as the mineral of high specific gravity. The analogy with the placer conditions found in most rivers and streams with moderate gradient is excellent.

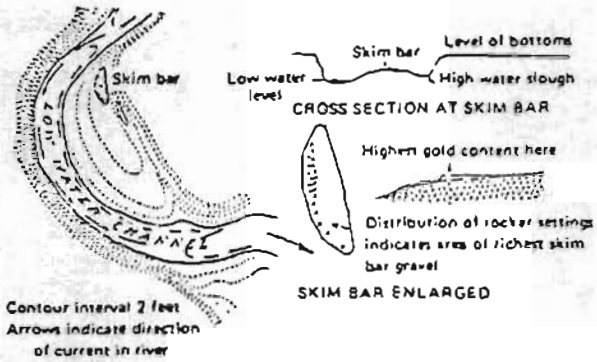

Figure 11. Sketch showing the location of flood gold on accretion, or skim bars (from USGS Bull. 620-L).

feet. The increased grades, resulting from the uplift, enabled the streams to cut down through their old gravel beds and into the bedrock beneath. The old gravels now occur on wide benches bordering the present valleys. Figure 12 illustrates the location of bench deposits along Bonanza Creek.

Type IV placers are deposits that are associated with glacial processes. Glaciation generally destroys preexisting placers and scatters the gold far and wide. Few glacial deposits such as till sheets, kames, eskers, terraces, stream gravels and outwash deposits contain concentrations of gold. However, the reworking of glacially-derived material by fluvial processes may result in placer development. Frequently, individuals may attribute the deposition of gold-bearing gravels to the action of glaciers. The misconception that glaciers themselves concentrate heavy minerals has lead to more than one unsuccessful mining venture. Glaciers do not concentrate minerals, however the streams issuing from melting ice may be efficient enough in the sorting of debris to form placers. Glaciers generally do not sort debris at all, in fact, preglacial gold-bearing gravels may be gouged out by advancing glaciers and the gold redistributed and deposited in useless till. It is possible under some circumstances to bury placer deposits under glacial debris without destroying them. Glacial streams may have the power to rework goldbearing glacial material, winnowing the rock and mineral matter according to size and density to produce placer accumulations. It could be stressed that glaciation does not preclude the presence of gold placers.

Type V placer deposits are eolian deposits, and owe their origin to wind processes. Eolian placers are formed by the removal of lighter material by wind, thus leading to a relative enrichment of the surface zone in heavy minerals. The continued winnowing process may result in patches of surface accumulations of gold and heavy minerals in a debris of wind-worn pebbles. This deposit type is relatively unimportant in Alaska.

Type VI placer deposits are placers of marine origin. Generally, marine placers are those deposits on the sea floor below tide level. These deposits have a complex polygenetic history and are affected by a complex relationship between time, process and location. Eustatic changes in sea level during the pleistocene and Holocene resulted in the reworking and

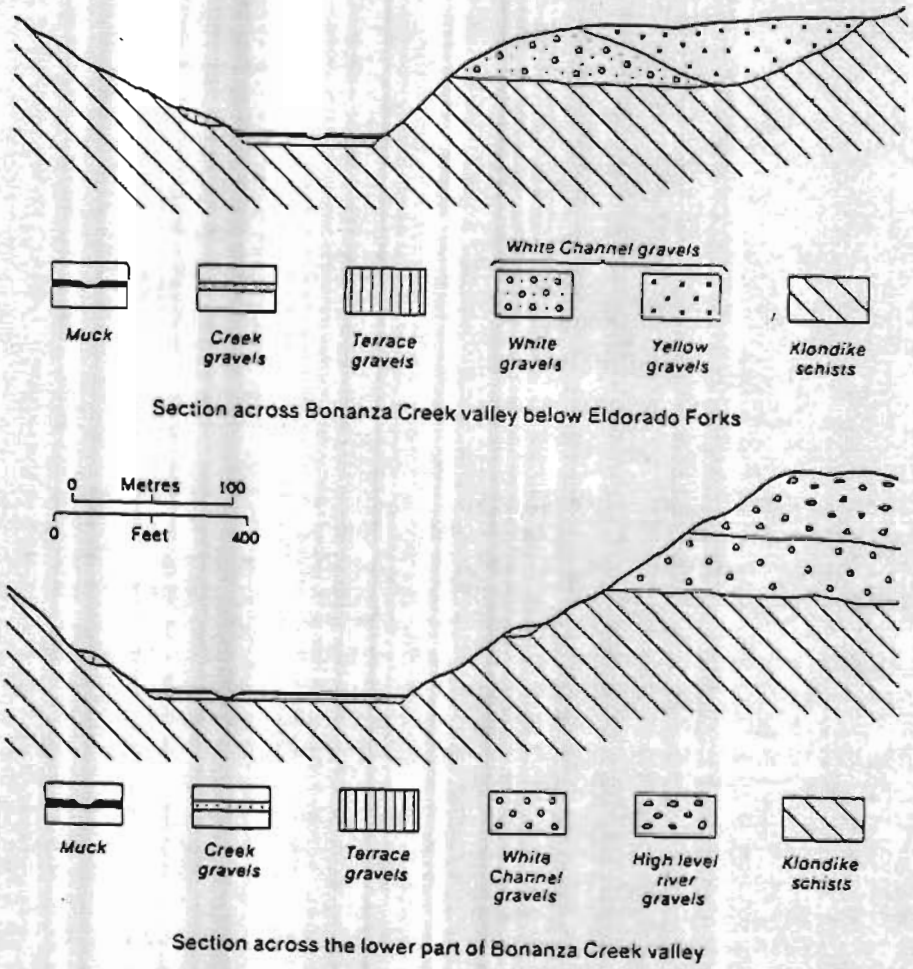

Figure 12. Generalized sections across the placer deposits of Bonanza Creek, Klondike (Dawson) district, Yukon (after McConnell, 1907).

transporting of heavy mineral deposits on the continental shelves of the world. Tooms (1970) has classified marine placers into four main subtypes: 1) Submerged alluvial placers; 2) eluvial deposits resulting from the weathering of underlying bedrock lodes; 3) drowned beach and dune heavy mineral deposits and 4) marine placers proper. The materials in marine clastic placer deposits are derived primarily from massive detritus from the mainland. The detrital material is carried into the oceans either as the result of coastal erosion or chiefly by river transportation of erosional products after atmospheric weathering of rock masses on continents and islands. Ocean currents and chemical modifications and differentiations in ocean water causes the material to be extensively sorted before deposition as sediment on the ocean floor; near shore, continental shelf or in the deep sea.

Again, several fundamental processes must be acting in sequence to produce submarine heavy mineral accumulations. This sequential process depends on 1) the existance of source rock; 2) a mechanism for weathering; 3) a means of transportation; and 4) some form of stratigraphic trap.

Schott (1976) describes the heavy mineral deposits of the nearshore and offshore regions and has subdivided them into 1) dune placers; 2) beach placer alongshore (partially submerged and partially raised in beach terraces); 3) placer on sand banks; 4) submarine deep leads; and 5) placers caused by submarine erosion.

Beach placers and placers on sand banks are formed directly or indirectly by the sorting effect of waves. Strong tides or tidal action may greatly influence this process. Wind may reinforce the sorting, whereby dune placers are formed at the beach, primarily by eolian processes. As the result of positive shifting of the beach by regression (lowering of sea level) of the ocean, placer deposits may occur in raised beach terraces. Excellent examples of raised beach terraces at Nome, Alaska contain a large resource of gold. Figure 13 is a cross section across the coastal plain at Nome. Note the presence of not only emergent beaches, but also the presence of submerged beach lines. Jim Madonna will give a detailed description of beach placer deposits later in this conference. Submarine placer deposits in the shelf region are predominantly of subrecent or glacial age. During the Pleistocene, the sea level was considerably lowered as a result of increased ice formation in the polar regions. On an average, it was 150 meters below the present sea level, close to the present continental shelf edge. Thus, beach placers were forming on the continental shelf. When the sea level rose again the Pleistocene beach placers on the shelf were submerged and have been subsequently reworked, destroyed and partly covered by recent sediments.

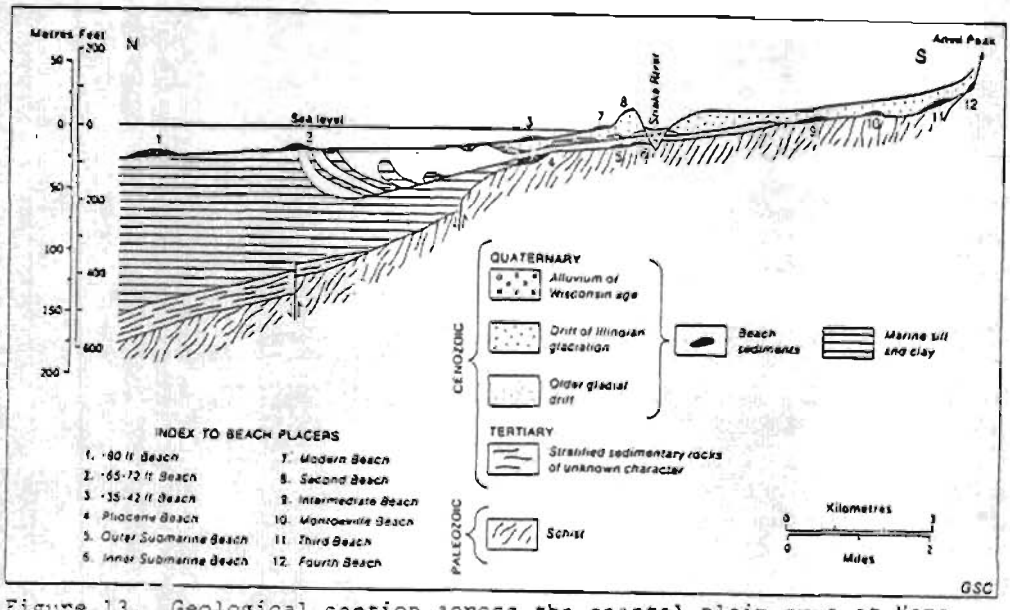

Figure 13. Geological section across the coastal plain area at Nome, Alaska showing the various auriferous beaches (after Nelson and Hopkins, 1972).

The deep leads of the shelf region are buried river channels containing fluvial mineral sands which have been preserved under younger sediments. Occurrences of placer deposits due to submarine erosion are possible when weathered source rocks outcrop on the floor of the shelf.

The most common minerals of economic value in placer deposits are; zircon, ilmenite, rutile, monazite, magnetite, garnet, epidote, topaz, tourmaline, corundum, gold, platinum, cassiterite and clinozoisite. The economic heavy minerals can be classified into three groups; 1) heavy-heavy minerals, those having a specific gravity range of 6.8-21, and including gold, tin, platinum and others; 2) light-heavy minerals, those having a specific gravity range of 4.2-5.3, and including zircon, ilmenite, rutile, monazite and others; and 3) gems, diamonds, rubies, sapphires etc., with low specific gravities but extreme hardness.

Of the heavy minerals of the offshore regions tin occurs predominantly in ancient river deposits which are submerged below sea level along the coast of Malaysia and Indonesia. These tin placers have been exploited for many years by large sea-going bucketlike dredges and large capacity suction dredges. Exploration for the offshore submerged channels is carried out by systematic surveying by means of seismic reflection profiling.

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GEOLOGICAL GUIDES TO HEAVY MINERAL PLACERS

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INTRODUCTION

Heavy mineral placers are defined as deposits of sand, gravel, and other detrital or residual material containing a valuable mineral which has usually concentrated by gravity through weathering and mechanical processes. In Alaska exploitation of heavy mineral placers (first initiated by the Russian mining engineer Peter Doroshin in 1848) has yielded over 21 million ounces of gold, 3 million ounces of silver, about 550,000 ounces of platinum-group metals, 4 million pounds of tin, and unspecified amounts of mercury and tungsten. This paper will summarize selected geological variables that affect the formation of heavy mineral placers with particular emphasis on controlling factors in the 49th state.

FACTORS CONTROLLING PLACER FORMATION

Sources

Some qualified prerequisites for heavy mineral placers have been summarized by Boyle (1979) as follows:

(1) Fairly rich lode source(s).
(2) A reasonably long period of chemical or mechanical weathering on a surface of submature to mature topography.
(3) Concentration by some agency--usually water.
(4) Absence of glaciation--but be careful with this one; districts such as Cassiar in British Columbia, Westland and Otago in New Zealand, the Lena district in the USSR, and selected Alaskan districts such as Koyukuk Nolan, Cache Creek, Chistochina etc., are important exceptions to this rule.

Placers inevitably have some type of hardrock-lode source as summarized in Table 1. Once a valuable mineral(s) has been released from this lode source they concentrate in weathered or disintegrated deposits termed 'alluvial' or 'residual' placers, and are eventually incorporated into stream drainage systems where they are worked, transported, and concentrated by the action of water. When lodes cross fluvial systems, heavy minerals become part of an alluvial placer immediately upon liberation from their hard rock source.

Another important mechanism responsible for formation of heavy placers is the beach placer, usually the result of movement of material by longshore drift along a coastline to form distinctive lines of heavy mineral concentrations at the beachline. This type of placer has been responsible for a large percentage of gold produced in the Nome district. A previous speaker, Jim Madonna, has summarized these placers in Alaska and they will not be discussed here.

TABLE 1

Selected Examples of Lode Sources for Heavy Mineral Placers
Emphasizing Alaskan Examples

Lode Source	Example	References
Auriferous veins and shear zones.	Fairbanks, Kantishna and Nome (Au, Ag, W, Sn, Pb, Sb) Denali (Au), Kenai district (Au)	Chapman and Foster (1969), Hill (1933), Wells (1933), Smith (1981), Bundtzen et al. (1976), Martin et al. (1915)
Stratiform massive sulfides.	Bonnifield (Au, Sn); Fairbanks, Kantishna and Nome (see above); Tofty(?) (Sn, Au)	Moffit (1932), Hawley (1976), Wayland (1961), Thomas (1956)
Fault zones and dike swarms.	Richardson District (Au, Ag, Sn, Hg) Innoko (Au, Wr, Ni) Cinnabar Creek (Hg)	Bundtzen & Reger (1977), Bundtzen & Laird (1980), Mertie (1936), Sainsbury & MacKevett(1965)
Paleoplacers.	Witwaterswand conglomerate and other important Pre-Cambrian conglomerates in shield areas (Au, U), Tertiary Nenana Gravel in Bonnifield district (Au); Tertiary Gravels scattered throughout Yukon Tanana Upland (Au, Ag); Chisto-chinadistrict (Au, Pt) Wiseman Area (Au)	Moffit (1933), Mertie (1937), Yeend (1980), Boyle (1979)
Metalliferous rock sequences.	Red Mountain dunite body, Goodnews Bay (Pt, Au); Totatlanika Schist, Bonnifield district (Au); Haast Schist, New Zealand (Au, W); LaPerouse ultramafic complex-Lituya Bay (Pt, Au, Ti)	Mertie (1976), Moffit (1933), Gilbert & Bundtzen (1979), Williams (1974), Rossman (1957)
Disseminated stockwork or mineralized intrusive.	Flat (Au, W, Cr); Candle Creek Innoko (Au, Hg, Pt); Democrat Creek, Richardson District (Au, Ag); Grubstake Creek, Tok cutoff (Au, Ag); Port Clarence District (Au, Sn, W)	Mertie (1936), Bundtzen & Laird (1980), Bundtzen & Reger (1977)

Gold Size Characteristics

Gold from various types of placers have characteristic physical parameters that result from the mode of formation and preservation. Residual placers have produced some exceptionally large nuggets. It is generally believed that the 'Welcome Stranger' Nugget from Australia and the Carson Nugget from California were derived from residual placers. At the opposite end of the spectrum, glacially workedgold is usually very fine grained due to the milling effects of glaciation. However, the size range, shape and composition (i.e. impurities) exhibited upon release from lode sources are important variables that determine the physical parameters of placer gold. Some believe that gold nuggets increase in size with their distribution downstream in an alluvial system by geochemical means (i.e. plating).

Geography of Placer Districts

Alaskan world class placer districts such as Fairbanks, Iditarod, and Circle have subdued topography marked by broad, often terraced, entrenched valleys, deeply weathered hills, and accordant ridge summits (fig. 1). The formation of large and rich heavy mineral placers in these areas resulted, in part, from long periods of erosion of highly mineralized bedrock; factors not enjoyed by Alaskan Districts that have undergone either extensive late Quaternary Glaciation or recent and rapid uplift.

Mechanical rather than chemical erosion appears to be typical of arid regions of Interior and Western Alaska. Mechanisms such as freeze-thaw cycles (that result in shattering of bedrock and liberation of heavy minerals from lodes), solifluction, seasonal flooding, and burial by wind blown materials are a few of the important erosional factors that affect placer formation in the interior of the state.

The fluvial history of the placer streams bears importantly upon the distribution, geometry, extent and grade of deposits. Steep stream drainages characteristic of recently eroded, uplifted mountainous terrane generally contain immature placers with heavy minerals in a constant state of migration downstream to stable base levels. In a previous paper Robinson has described stream kinetics and distributions of various mineral fractions within a meandering stream system. Point bars are usually excellent exploration targets in such systems. Important mechanisms for preservation of Alaskan placer deposits would include stream abandonment, uplift with resultant terrace formation, and burial by, for example, wind blown loess.

Heavy Mineral Compositions are Clues

Heavy mineral contents of placer concentrates are clues to the types of contributing lode sources. Chrome, nickel, and cobalt anomalies along with olivine, pyroxene, and mafic mineralogy would suggest a mafic or ultramafic igneous source. Alaskan examples include Goodnews and Lituya Bays. The presence of fluorite, tin (as cassiterite), tourmaline, beryllium values, tantalum, niobium, and cesium minerals such as aeschyite would lead the

Figure 1. USSR & M Cripple Creek Operation, Fairbanks District (Circa 1953). A thick frozen muck layer has been hydraulically removed from frozen gravel deposits; subsequently, cold water thawing techniques thaw the paystreaks. Photo courtesy of Alaska Div. of Geol. & Geophy. Surveys.

prospector to suspect the lode source was a tin bearing granite system. Lost River and the general Western Seward Peninsula are Alaskan examples of this type of lode and resultant placer association. More often than not, however, several types of hard rock sources are contributing metallics to the stream placers, making the heavy mineral provenance difficult to determine.

Effects of Glaciation

As a general rule, recently glaciated areas do not host 'world class' heavy mineral placers because glacial ice tends to scour out, disseminate, or bury the heavy mineral placers. This generalization can be demonstrated for mining districts in Alaska (fig. 2). Approximately 55-60 percent of Alaska has experienced late Quaternary Glaciation, but 73 percent of the placer gold produced in Alaska has been produced from non-glaciated areas. Only six percent of the recorded placer gold production has been derived directly from areas that have been overridden by Wisconsinan Glaciers. Twenty-one percent, however, have been produced from the recently glaciated Nome, and Bluff districts, from which a substantial portion of the production is derived from beach placers. The Gulf of Alaska districts have also been glaciated during late Quaternary time. It should also be noted that platinum placer formation at Goodnews Bay has also been affected by Quaternary Glaciation.

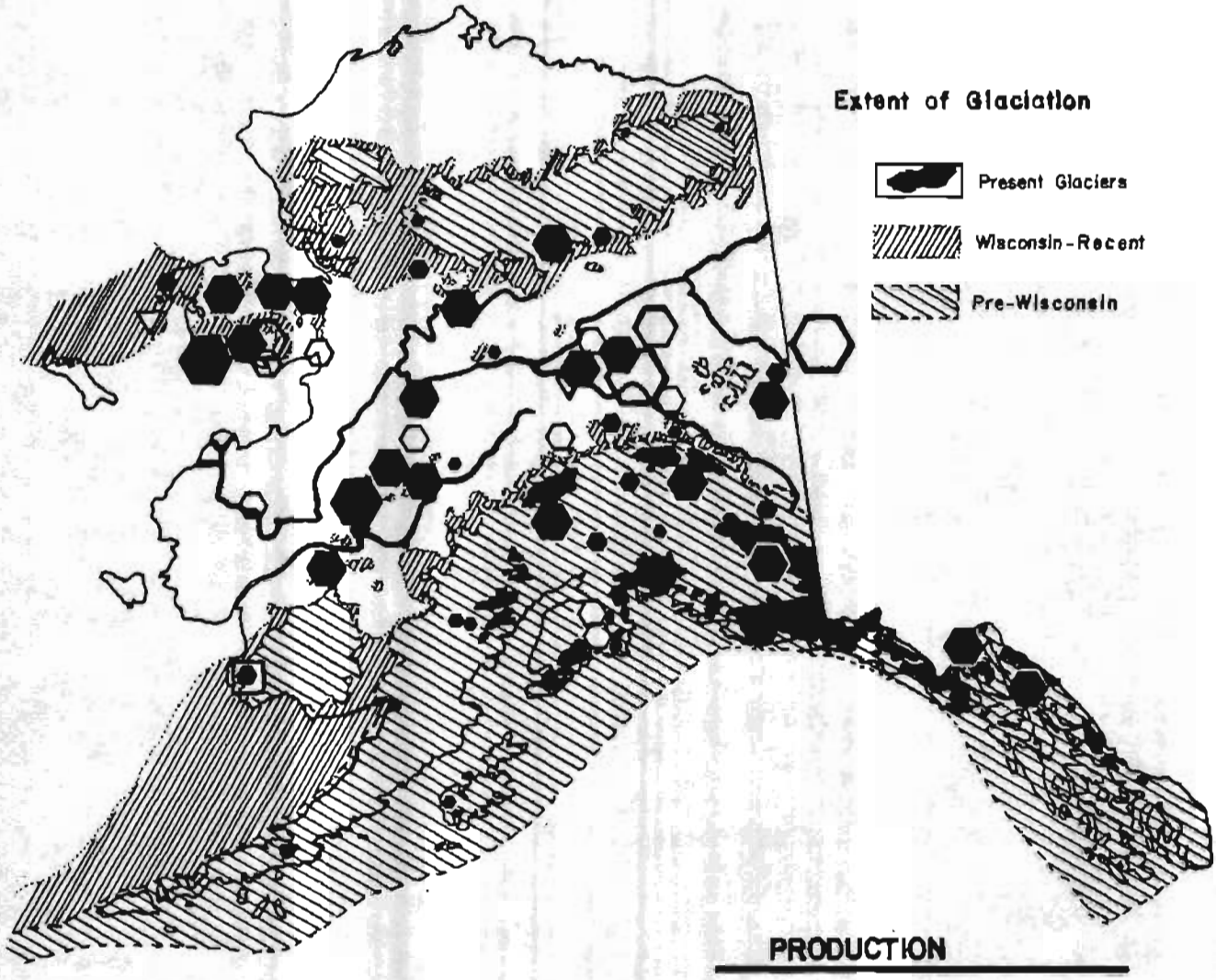
Good Alaskan examples of the negative effect of glaciation on placer development is the Southeastern Panhandle, where since 1880, approximately 250,000 ounces of placer gold production has been recorded while 8,000,000 ounces of gold has been won from lodes in the region. The lack of large placer deposits and/or distribution in the Panhandle can be attributed to the erosional effects of glaciation.

Alternatively the Yukon-Tanana Upland has received only restricted Quaternary valley glaciation in higher mountainous terrane. In this general region, placer gold production derived from at least seven districts exceeds 10,000,000 ounces while recorded lode production amounts to less than 300,000 ounces.

However, caution is recommended concerning the above generalization. Notable exceptions include:

(1) The Caribou district of northern British Columbia which has been extensively modified by Wisconsinan Glaciers and has produced between 2-1/2 and 3 million ounces of placer gold.
(2) Westland district, South Island of New Zealand from which a significant portion of the several million ounces of recorded gold production has been derived from prograding outwash gravels adjacent to glacial moraines of Quaternary age.
(3) Major Alaskan districts such as Kokukuk-Nolan, Cache Creek, Willow Creek, Valdez Creek, Chistochina, Porcupine, and Nizina, all of which have been strongly influenced by late Quaternary Glaciation.

Important positive effects that glaciation can have on heavy mineral placer formation include:



PRODUCTION

- 10,000 oz gold
- 10-50,000 oz gold
- 50-100,000 oz gold
- 100-500,000 oz gold
- 500-1,000,000 oz gold
- 1-5,000,000 oz gold
- 5,000,000 oz gold
- 532,000 oz platinum
- 4,000,000 lbs tin

Figure 2 Placer gold production and Quaternary glaciation. Maximum glacial extent modified from Pewe (1975).

GOLD PRODUCTION vs. GLACIATION

Glaciated Areas = 1,222,500 oz. (6%)
Non-Glaciated Areas = 14,613,200 oz. (73%)
Nome Beach Placers = 4,051,000 oz. (21%)

(1) Heavy mineral liberation can be greatly enhanced by the milling effects of glaciation.
(2) Tremendous tonnages of mineralized rock can be rapidly plucked and transported resulting in deposition at specific locations such as terminal ice positions of prograding glaciers.

Bedrock Collection Sites of Heavy Mineral Placers

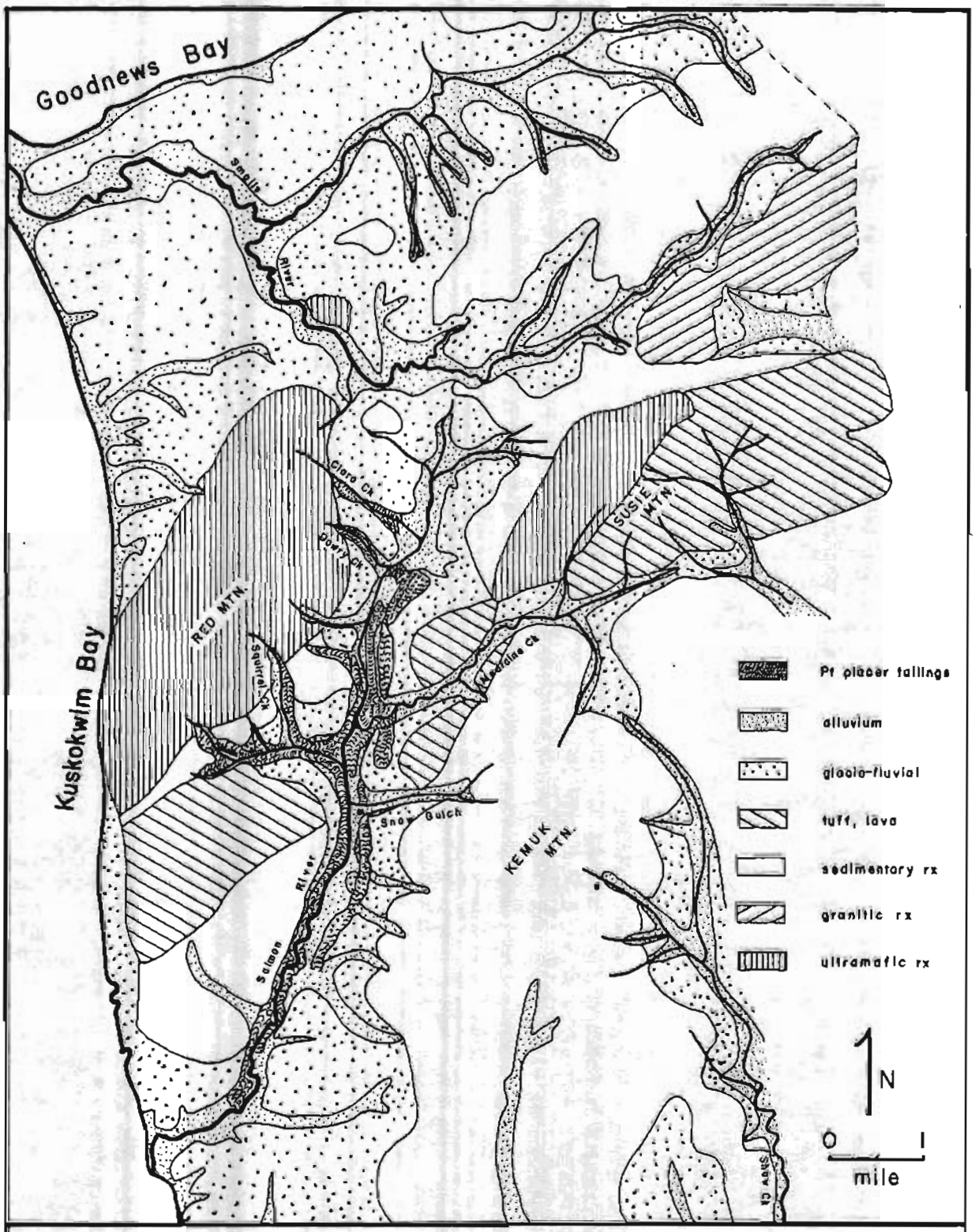
Important catagories here are 'simple' versus 'false' bottom placers, the latter of which can be manifested on complex surfaces within an alluvial system. 'False bottoms' are usually impermeable clay layers or rooted organic paleozol horizons (soils) that form in response to seasonal flooding, damming (as a morinal dam lake) or soil progradation during temporary channel abandonment. The Lena district of the USSR illustrates a complex of false bottom placers. On 'true' bedrock surfaces, important mineral catchment parameters include (1) rock fabric, i.e., bedded or foliated versus massive units, (2) attitudes or orientation of bedding within layered rocks and (3) weathering characteristics of bedrock at base of channel; i.e., flaggy, blocky, fissle, state of oxidation, etc. These bedrock parameters influence natural riffling, depth of concentration into the weathered zone, and general geometry of paystreaks. Often steep to vertical dipping beds form poor bedrock catchment surfaces for placer gold while shallowly dipping, resistant beds or intrusive dikes protruding above the level of other rock layers may create effective mechanical riffles. The author has observed rhyolite to basalt dike swarms intruding Cretaceous slate in the Innoko district of Western Alaska; these dikes form effective mechanical riffles in terrace and modern stream gravels of Spruce, Ganes, and Yankee Creeks. Understanding the depth of the weathering zone of a bedrock surface enables the placer operator to know how deep his rippers must cut to recover the pay zone below the channel-bedrock interface.

SELECTED GEOLOGICAL SUMMARIES OF PLACER DISTRICTS

Goodnews Bay

A geological summary of Alaska's premier platinum placer district is provided in figure 3. Platinum was discovered 25 years after the initial turn-of-the century gold discovery by Walter Smith, an Eskimo prospector. Smith sent his concentrates to the Territorial assay office at the University of Alaska which confirmed his platinum group metal find. A small platinum rush subsequently occurred; by the mid 1930's, several mining companies utilizing draglines were operating on tributaries of the Salmon River. The Goodnews Bay Mining Company dredge (fig. 4) began operations in 1937 and through 1976, approximately 545,000 ounces of platinum-group metals have been recovered from the district which is the largest production of platinum group metals (PGM) in the United States.

An analyses of platinum metal concentrate (PGM) at Goodnews Bay has been summarized by Mertie (1969) as: 73% Pt; 9% Fe; 1.15% Rh; .34% Pd; .15% Ru; 1.9% Os; 9% Ir. Large platinum nuggets are uncommon at Goodnews Bay and



Generalized Geology, Goodnews Bay, Alaska.

Figure 3 modified from Mertie (1976)

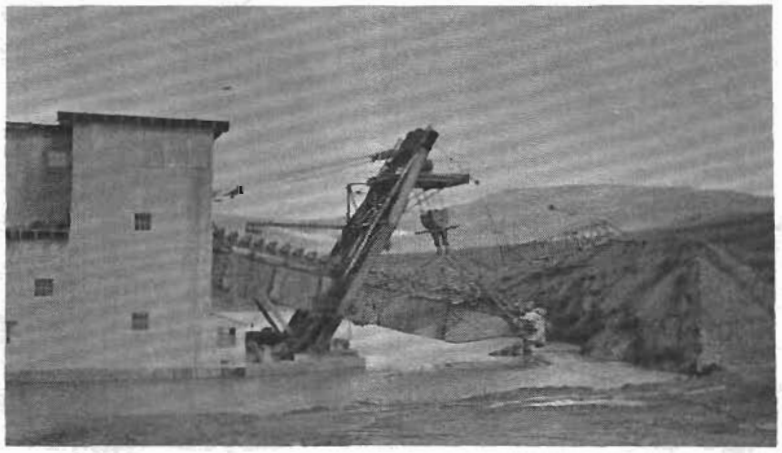


Figure 4. The Yuba bucket line dredge of the Goodnews Mining Co., Goodnews, AK. (Terr. Dept. Mines Photo, 1939).

the largest recovered weighed about 4 ounces. Heavy concentrates include magnetite, ilmenite, chromite, and free gold. The gold comprises up to 10% of the precious metal concentrates by volume and has been a significant by-product. Some platinum nuggets have chromite grains attached to them. The paystreak is 300-450 feet wide with a maximum width of 600 feet reached on Platinum Creek. Most of the mining has been with an 8 cubic foot capacity, Yuba bucket line dredge (fig. 4). The PGM Lode Source is unquestionably the Cretaceous (?) Red Mountain dunite (fig. 3). Susie Mountain, which is predominantly pyroxenite, has evidently not contributed significant PGM values to the Salmon River drainage.

According to Mertie (1976) three glaciations have affected PGM placer distribution at Goodnews Bay. Wisconsinan ice probably had the least erosional effect. Pre-Wisconsinan ice advances affected distribution by (1) stream capture of the preglacial upper part of the Salmon River by the Smalls River, (2) heavy influx and aggradation of outwash gravels, (3) rise and fall of sea level due either to regional subsidence (graben?) or Pleistocene sea level changes in response to melting and accumulation of ice caps world-wide. The average bedrock gradient of Salmon River Bench is much steeper than the present valley floor; the gravel-bedrock interface at today's shoreline is 200 feet below sea level.

Future mining potential at Goodnews Bay lies in:

(1) Potential beach placers similar to Nome. These deposits have been inadequately evaluated in the past years.
(2) Glaciated areas in the Salmon River valley have been intentionally overlooked by churn drilling programs in past years.
(3) Deep ground remaining could be mined with improved equipment and technology.
(4) Much of the PGMs at Goodnews Bay are on clay rich false bedrock surfaces and in a disintegrated unit on true bedrock. PGM recovery has been a chronic problem; enhanced recovery techniques could result in the profitable mining of tailings.

Tofty Tin Belt, Manley District

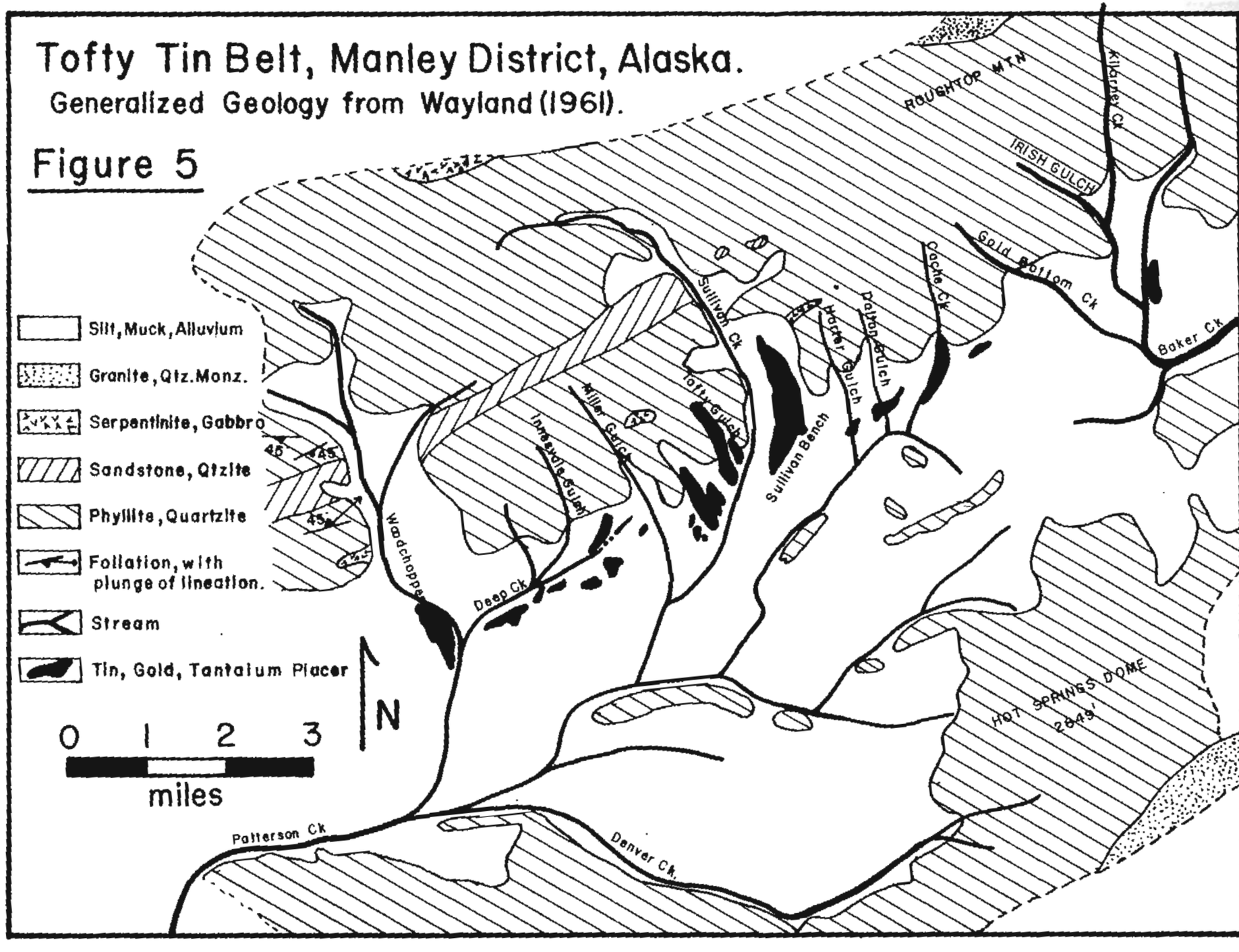
Bedrock and surficial geologic units of the Tofty Tin Belt (fig. 5) as mapped by Wayland (1961) consist of low grade regionally metamorphosed metasandstone, phyllite and quartzite intruded by serpentenite, gabbro, quartz monzonite, and granite. The placers occur in a 12 mile long northeast trending belt of elevated bench deposits containing gold and by-product tin minerals, mainly cassiterite.

Cumulative production through 1979 is estimated at several hundred thousand ounces of gold and 630,000 pounds of by-product tin. Reserve estimates of approximately 4,000,000 pounds of tin are provided by Wayland (1961). Major heavy minerals in the concentrates include brown tourmaline, cassiterite (locally the 'wood' tin variety), chromite, aeschyite, and high tantalum and niobium assays. No in-place exposures of lode tin mineralization have been identified. The origin of the placer tin remains con-

Tofty Tin Belt, Manley District, Alaska.

Generalized Geology from Wayland (1961).

Figure 5



troversial. Normally one would assume that a nearby tin bearing intrusive stockwork is responsible for the placer tin concentrations. However, the following lines of evidence has been presented by Wayland (1961) and Thomas (1957):

(1) No tin has been found in streams draining the granitic rock exposures.
(2) The chemistry of the granitic body to the NE is not typical of of a tin bearing granite.
(3) Neither tourmaline nor cassiterite are recognized in the Roughtop Mountain intrusive.
(4) Country rock phyllite and brecciated quartz are usually found in the masses of cassiterite.
(5) Hot Springs Dome to the south has a chemistry more typical of 'tin granite' worldwide; however, it has been difficult for past workers to envision this as the tin source based on the geometry and position of the known bench deposits.
(6) Presence of minor wood tin in Deep, Troublesome, and Baker Creek may imply a volcanogenic tin source that has been eroded away.

In summary, clasts of phyllite and quartz breccia found with larger masses of cassiterite indicate that at least some of the tin is hosted in the metamorphic rocks as veins, replacements, or other types of deposits. 'Wood' tin is often considered an indicator of volcanic stratiform mineralization and its presence in the Deep, Troublesome, and Baker Creek placers may be important clues to a premetamorphic origin.

Westland District, New Zealand

Glacio-fluvial deposits of Pleistocene to recent age host rich placer gold deposits in portions of the Westland District, South Island New Zealand (figure 6). The most important placers are in outwash gravels immediately juxtaposed to terminal moraine of late Quaternary age. Gold richness decreases rapidly with increasing distance from the moraine. In some instances, esker and kame complexes (gravel that formed under glacial ice through the agency of running water) were profitably worked for gold. Gold is fine grained and nuggets are uncommon. Some New Zealand geologists believe that the terminal positions of the glaciers remained relatively constant for many thousands of years. Additionally, a rich mineralized bedrock source was 'plucked', scoured, and milled by the glacier which deposited and liberated heavy minerals in the terminal ice positions; stream processes then concentrated the gold.

Valdez Creek

An Alaskan analogy to Westland in New Zealand is the Valdez Creek district described by Smith (1981) and shown in Figure 7.

Gold is being derived from auriferous veins hosted mainly in intrusive rocks in the Timberline and Lucky Hill areas east of the Denali placer area.

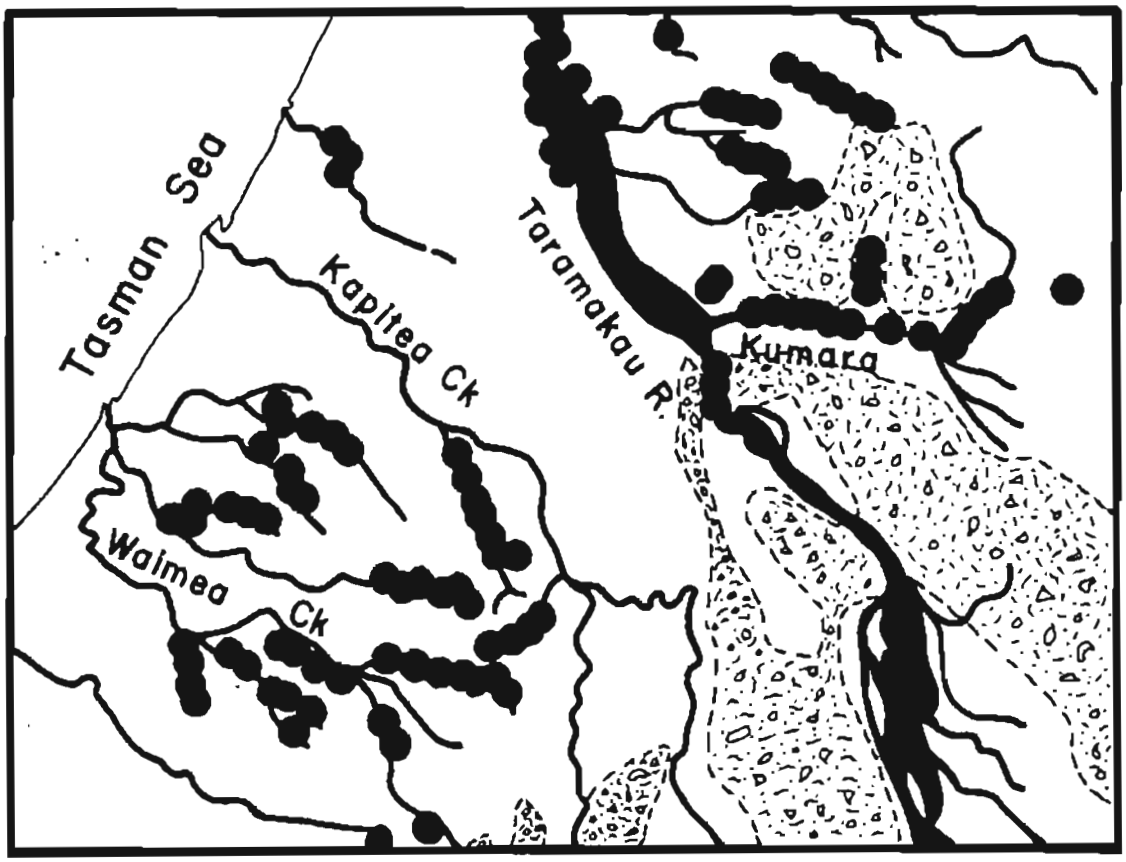


Figure 6 Placer Gold Mines in Glacio-Fluvial Outwash Gravels Derived from Late Quaternary Drift, Kumara, Westland, New Zealand. (simplified from Williams, 1965)

Recent Outwash

Moraine

Au Placer

0 1 2 miles

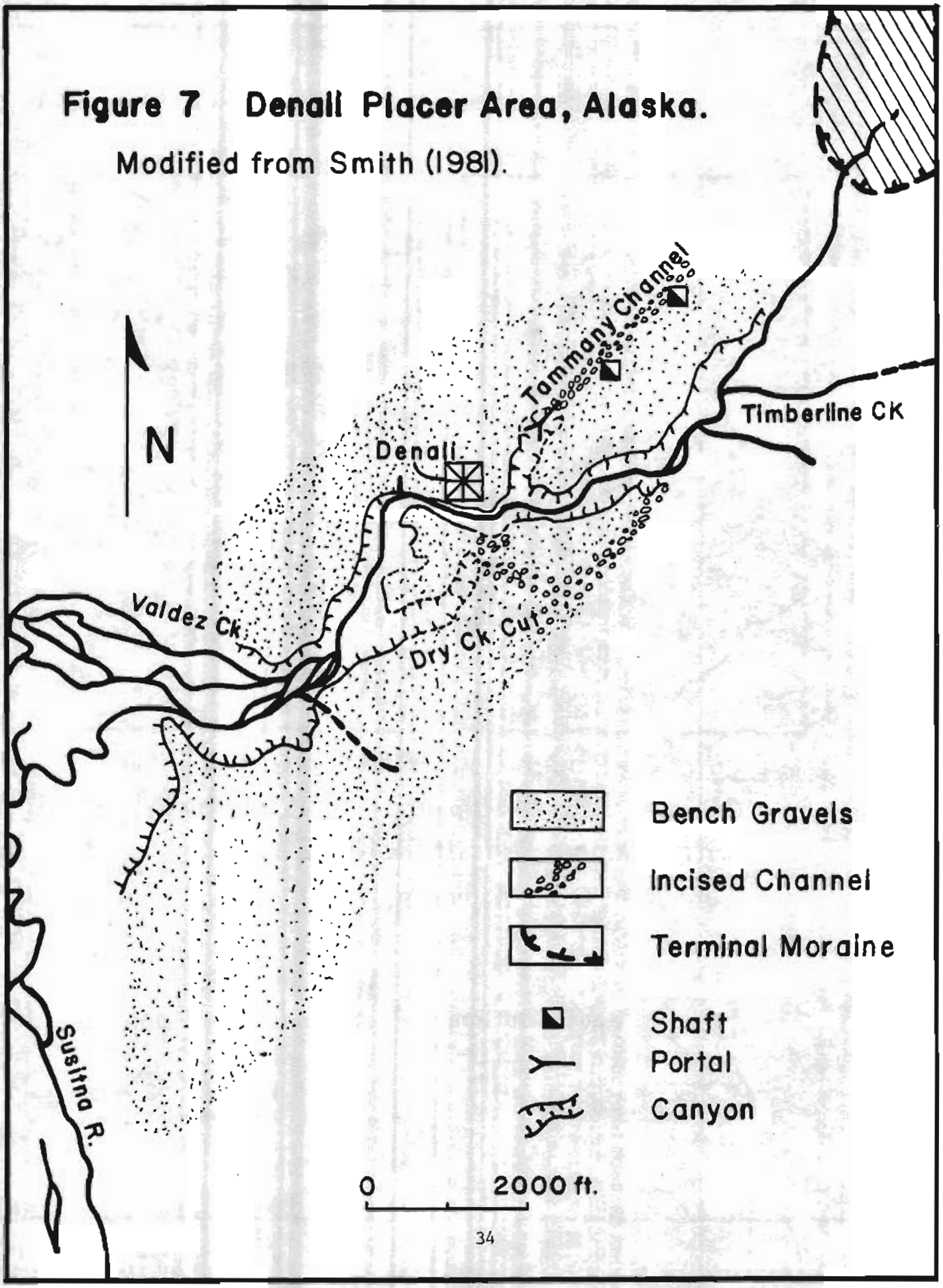


Figure 7 Denali Placer Area, Alaska.

Modified from Smith (1981).

This district has undergone substantial Late Wisconsinan glaciation and much of the past production has been confined to rich pockets on bedrock depressions and deeply incised glacio-fluvial outwash channels of Pleistocene age. The Tammany Channel is the major abandoned outwash train derived from terminal ice positions several miles upstream to the east.

Gold in the Tammany Channel is rounded and fine grained which is typical of gold worked by glacio-fluvial processes. Placer gold found in 'pups' of Valdez Creek above the Tammany Channel is exceptionally coarse and may be residual from hardrock sources. Smith (1981) has evaluated broad outwash bench deposits in the district and has defined with geophysical techniques at least 35 million cubic yards of auriferous gravels.

Richardson District

Structurally controlled distribution of placer deposits in this district has been summarized by Bundtzen and Reger (1977, fig. 8). Rounded bedrock ridges composed of regionally metamorphosed schist and Cretaceous rhyolite porphyry plugs are blanketed by windblown organic silt of variable thickness. These silts are subsequently retransported to form valley fills that are perennially frozen. Extensive surficial cover means only a bedrock 'outcrop' map is available. The Richardson Lineament extends 25 miles from lower Tenderfoot Creek through Democrat and Redmond Creek to the Salcha River. Former production shafts, associated tailing cones, and open-pit workings are concentrated along, downstream, and downslope from the Richardson Lineament on Tenderfoot, Buckeye, Redmond, and Banner Creeks, in Hinkley Gulch, and near the head of Junction Creek downstream from the point of its beheading by Democrat Creek. This lineament controls distribution of lode and known placers. The rhyolite porphyry plugs intrude parallel to and in the Richardson Lineament system. Placer deposits have yielded 95,000 ounces of recorded gold through 1968. Heavy minerals in concentrates include cinnabar, cassiterite, scheelite, monazite, ilmenite, magnetite, and zircon probably indicating a mixed provenance from metamorphic and igneous bedrock sources.

Innoko District

The Innoko placer mineral district is located in low rounded hills of the Kuskokwim Mountains west of McGrath, Alaska. Placer gold deposits have been mined from modern and older stream terraces in the Ophir mining precinct and the Candle Hills; total production is believed to be at least 500,000 ounces of gold. The gold placers in the Ophir area are found downslope and downstream from basaltic to rhyolitic dike swarms and are also concentrated along faults and dikes trending across the stream channels. The dike swarms contain anomalous amounts of gold, nickel, yittrium, chromium, and zirconium. Fractures in plutons and nearby hornfels zones locally contain anomalous amounts of base and precious metals and are probably the lode source of gold placers in the Candle Hills which are similar to deposits in the Iditarod District (fig. 9). A relationship of further exploration significance lies in the specific distribution of economic concentrations of gold within the

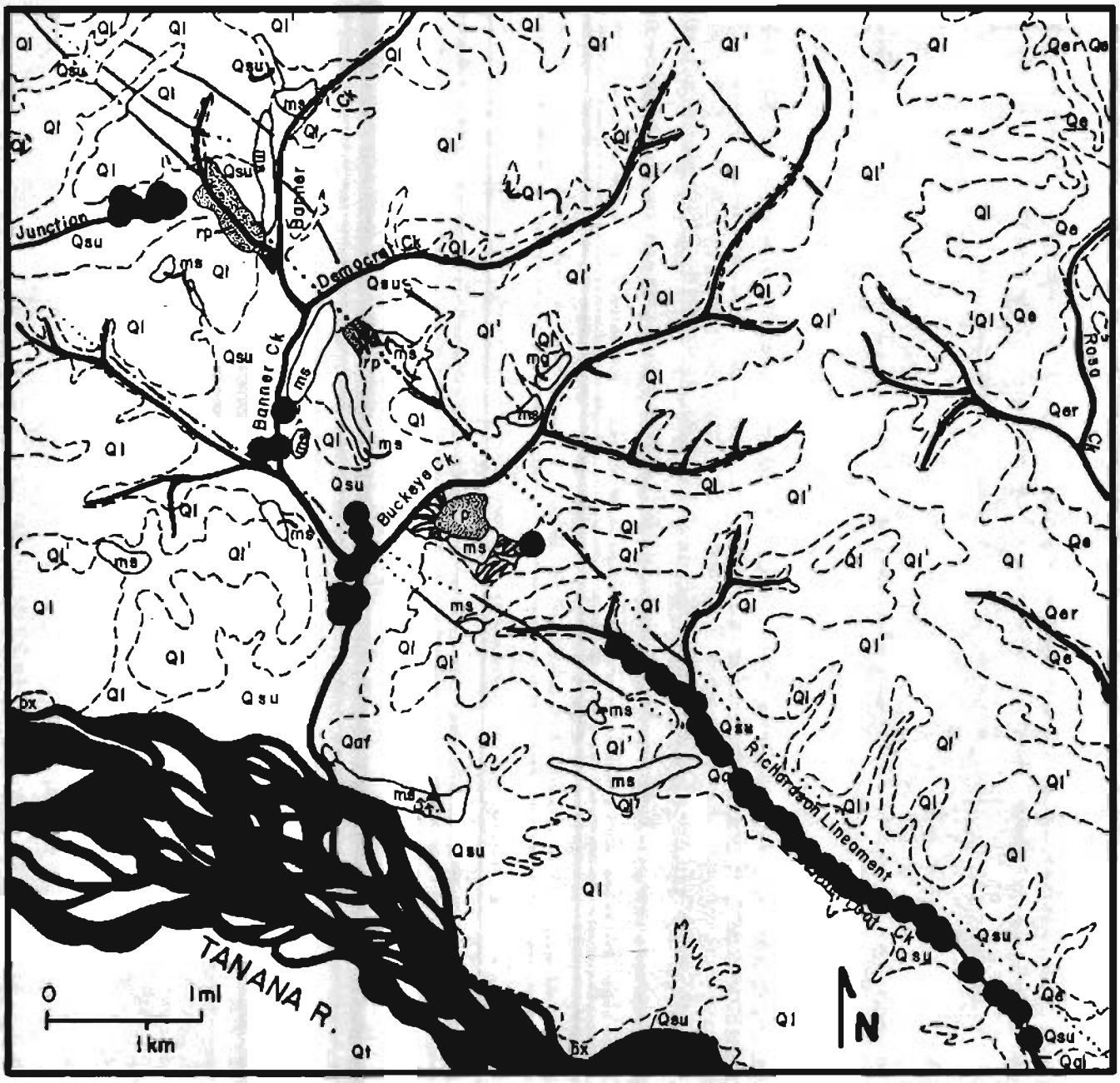


Figure 8 Generalized Geology of the Richardson District, Alaska.

Qal Qt	gravels, alluvium
Qsu Qer	muck
Ql Ql' Qe	loess, minor sand
ms mg bx	metamorphic rocks
rp	intrusive porphyry

airphoto lineament

stream drainage

drift mine tailing cones, production shafts.

open cut tailings

55 foliation attitude

Geology modified from Bundtzen and Reger (1977).

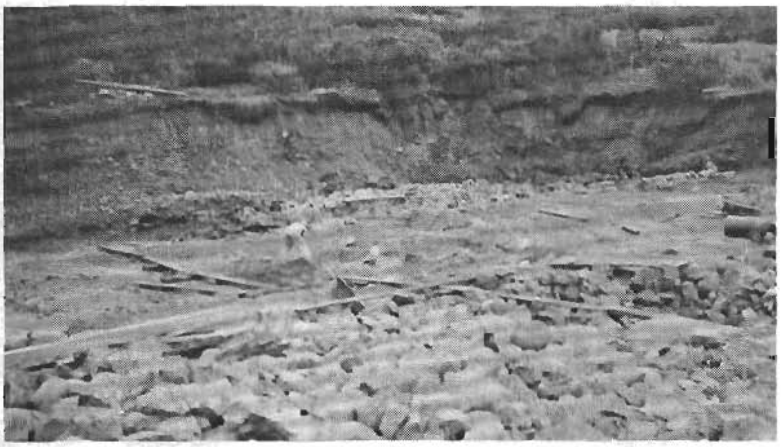


Figure 9. Placer pit on Alpha Claim near Flat, Alaska, showing decomposed Monzonite bedrock as residual gold source (Circa 1908). Most of the recorded 1,329,404 troy ounces of placer gold produced in the Iditarod district was derived from two decomposed Monzonite intrusives (Kimball, 1968), the same source for heavy mineral concentrations at Moore and Candle Creeks to the north. Terr. Dept. of Mines Photo.

known paystreaks. For example the best concentrations of gold on Yankee Creek are at the intersections of 'pups' or tributaries with the main stream (fig. 10); hence, heavy minerals appear to be concentrating at the hydraulic flexure point of the higher and lower energy fluvial environments.

Kantishna-Fairbanks

The last geological examples discussed here are districts that have very similar lode sources for gold and other heavy mineral placers but contrasting types of placer deposits. The heavy mineral placers from both districts (fig. 11, 13) are derived from several hundred structurally and strata(?) controlled mineralized vein-faults that contain gold, silver, antimony and other minerals hosted in regionally metamorphosed basement rocks. Predictably the known paystreaks are localized downslope and downstream from these hardrock sources.

The Kantishna district (fig. 11) contains a rich lode source for heavy mineral placers but, to date, placer production has been modest, amounting to 50-60 thousand ounces of gold. Several factors bear on distribution, richness and extent of the stream placers:

(1). The southern portion of the area has been affected by Early to Late Wisconsinan advances of the Muldrow glacier system that override low divides into the Moose Creek, Eldorado Creek, and Clearwater Fork stream drainages. Prograding glacio-fluvial outwash trains developed in front of the various advances have added great amounts of fluvial deposits into the mineralized areas and substantially diluted locally derived stream placers.

(2) Area has undergone rapid uplift with resulting pronounced 'V' shaped incision of streams (fig. 12), strath terrace evolution, steep stream gradients, and incised bedrock canyons. Hence heavy mineral placers are immature and in a state of constant migration downstream.

The Fairbanks district (fig. 13) contains rich lode sources for gold and other placers that are remarkably similar to those of the Kantishna district. Here surficial erosional processes have had a positive effect on placer formation as reflected in the 7.5 million ounces of recorded placer gold through 1980. According to Pewe (1975) the area has not been influenced by Quaternary glaciation. The Late Tertiary to Middle Quaternary auriferous creek gravels are now buried by frozen silt and other sediments. Larger streams such as lower Goldstream and the Chatanika River have rounded gravels while smaller streams characteristically contain angular and poorly sorted gravel. Alluviation caused in part by tectonic action and/or the rise of local base levels resulted in formation of 200 feet of coarse gravel deposits. A later period of erosion resulted in removal of much of the gravel but basal rock paystreaks probably remained largely intact. Streams reconcentrated much of the gold in the earlier placers and deposited additional gold placers. A second cycle of alluviation occurred during middle Pleistocene time and resulted in yet a third concentration of gold. All placers have been subsequently buried by windblown loess.

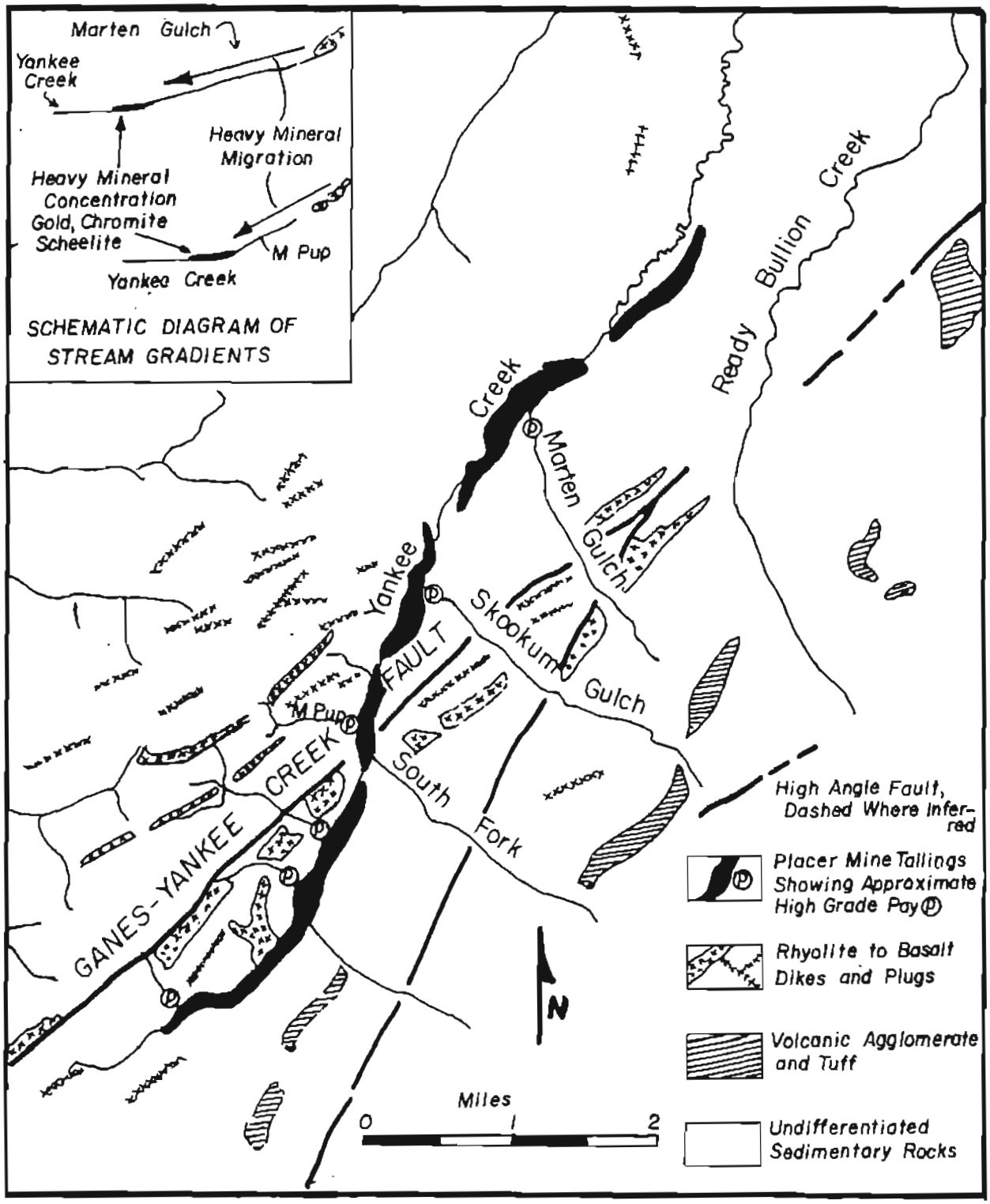


Figure 10 Placer Concentration Model Yankee Creek, Innoko District, Simplified From Bundtzen and Laird (1980)

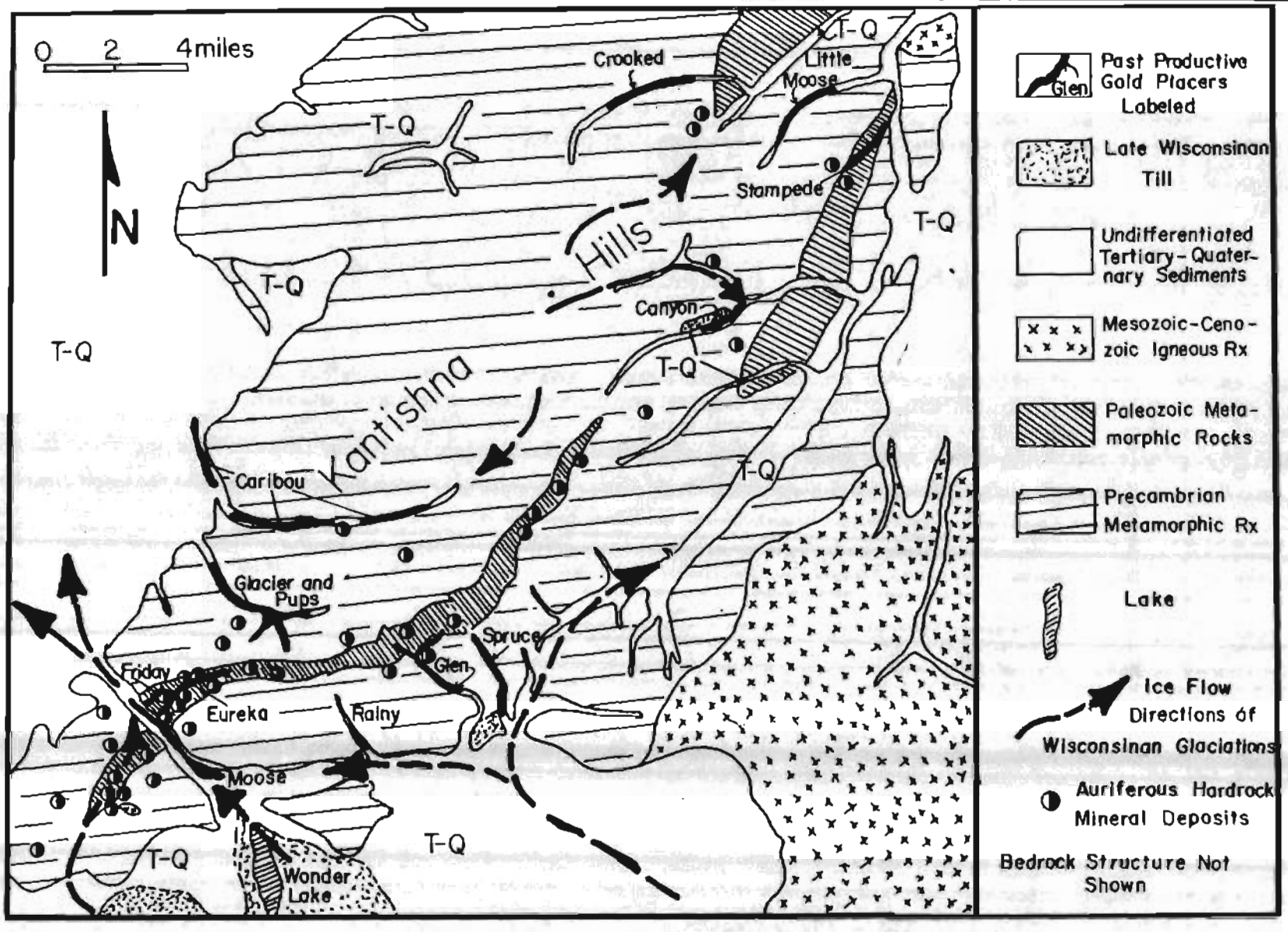


Figure 11 Geologic Sketch of Kantishna District Showing Approximate Extent of Wiconsinan Glaciations

Figure 12. Placer mine on Moose Creek at the mouth of Eldorado Creek, Kantishna District, Alaska. The paystreak is confined to glacio-fluvial outwash gravels of late Wisconsinan Age. Eldorado Creek in the foreground was scoured by late Wisconsinan ice; rapid uplift and "v" shaped incision since ice receded has prevented the formation of mature placer deposits, even though rich lode sources are abundant in the drainage.

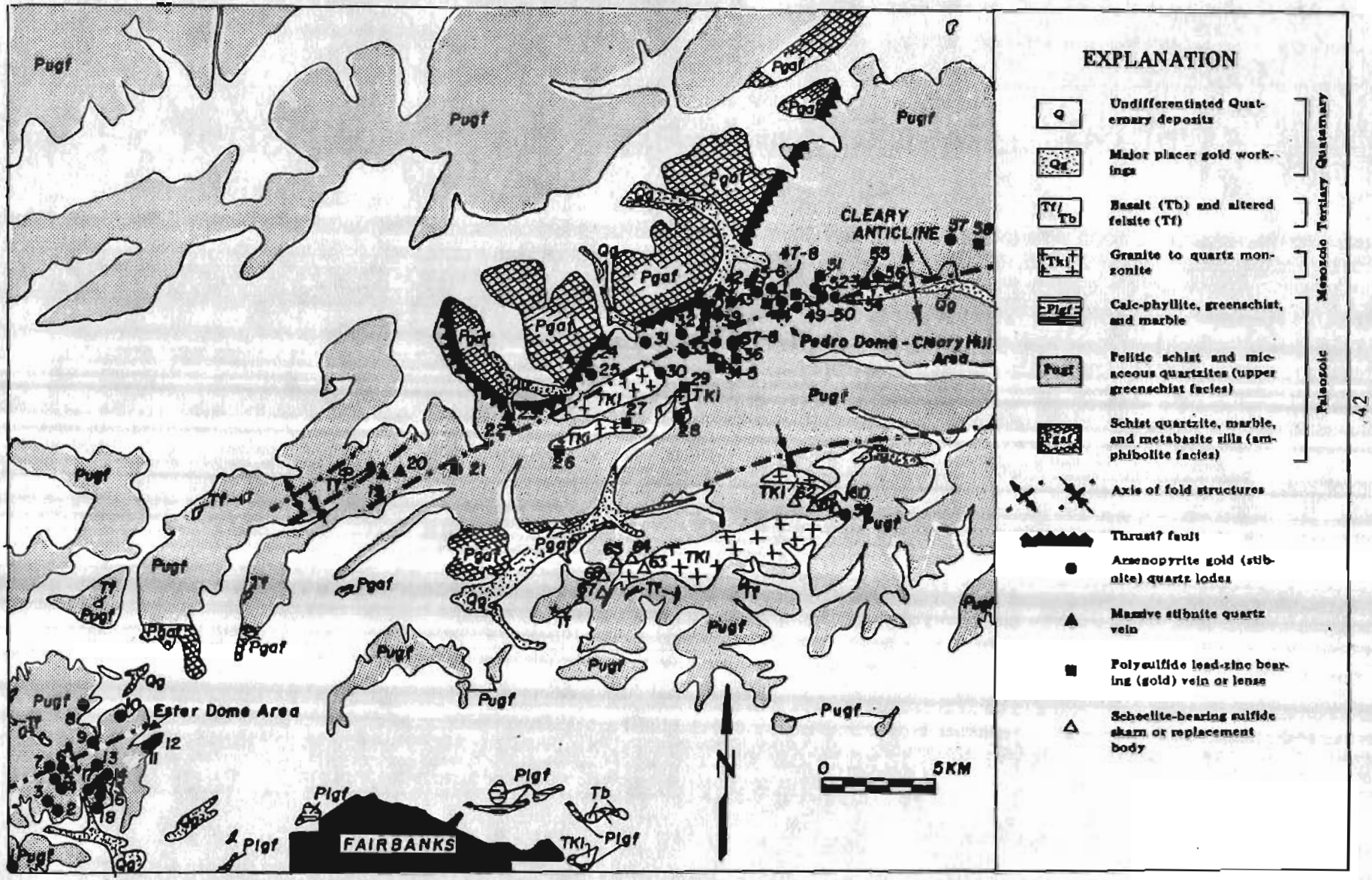


Figure 13 Geologic Map of Fairbanks District

The subdued topography present today reflects the long erosional cycles that have stripped the mineralized bedrock into fluvial systems. Uplift was mild and cyclic enough to allow for sufficient time to reconcentrate gold into rich paystreaks.

Concluding Remarks

This presentation was designed to present the important parameters related to the formation of placer deposits. These principals were applied non-rigorously to selected placer districts in hopes that the reader could better grasp the concepts of placer formation.

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GEOLOGY OF BEACH PLACERS

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Man has been mining gold for over 6,000 years. In that period of time, he has moved enough hardrock, relocated enough gravel and sifted through enough sand to produce a mountain larger than Mt. McKinley. Much more remarkable than this, if we brought all the gold that had ever been mined together into one location (that includes all the gold hidden away in treasury vaults; all the gold hanging from earlobes and all the gold embracing fingers, as well as all the gold that you Alaskans have secretly tucked away in your safety deposit boxes) and melted it down into a single brick, it would not make a cube 60 feet long, 60 feet high and 60 feet wide. Furthermore, some believe (rather optimistically) that only half of this gold is safely tucked out of reach in the rotting hulks of Spanish gallions, at the bottom of the sea.

This presentation does not dwell on the movement of hardrock so necessary in the mining of lode deposits. Secondly, it does not touch on the movement of stream gravel, so necessary in the location of valuable paystreaks. It does, however, encompass the rather optimistic possibility of becoming rich by "sifting sand". In capsule form, valuable gold deposits have accumulated on mineralized beaches in mineable forms or in mineable concentrations. Although the volume of gold produced in marine or beach deposits does not compare with those paystreak deposits found in inland streams, such as the Klondike, it does represent a significant portion of the gold produced in Alaska.

Possibly the best place to start is with the history of the most colorful and dynamic sand sifting event that has taken place in modern history, the Nome beach deposits. The sequence of events that led to the discovery of the Nome beach deposits began as early as 1865, when the Western Union Telegraph Company failed, after several attempts, to lay a line beneath the Atlantic Ocean, in hopes of global communication, and decided on an overland route. They planned to set a telegraph line across the Seward Peninsula, leading from Golovnin Bay to Port Clarence. One of the hardy men dispatched to set poles across the Seward Penninsula was Daniel B. Libbey. It was Daniel B. Libbey who, while setting poles in the vicinity of the Niukluk River, took a few pans of gravel, and, much to his surprise, was rewarded with several flakes of gold. Unfortunately, his crew was not permitted delays, and they moved on. They reached the coast in 1867 and were met by a small ship called the Andrea Anchor. They were informed of two rather shocking events. First, Alaska had just been purchased from Russia by the United States. Secondly, they learned that the Western Union Telegraph Company had just succeeded in laying a line beneath the Atlantic. There was no longer any need for an overland route.

Thirty years later Daniel B. Libbey returned to the Seward Peninsula, during the height of the Klondike Stampede. This time he was accompanied by

two partners and ample mining equipment. They retraced his steps to his previous discovery on the Niukluk. In the fall of the year, Daniel B. Libbey and his partners (before freeze-up) set up their equipment and extracted $75,000 worth of gold from the auriferous gravel. Others heard of the strike and moved into the area. Among the men who came to the area was an aging prospector by the name of John Hummel. John Hummel was suffering from scurvy. He was advised by his friends to go down to the beach and soak up some sun and salt air, "a sure fire cure for scurvy, well-known to all sailors," they said. It was John Hummel, down "sifting the sands on the beach", who made the discovery of beach gold. He tested up and down the beach, and he got gold in each and every pan. Of course, the discovery could not be kept a secret and it soon spread to other parts of Alaska and outside. The Gold Rush was on.

The mining of the Nome Beach Sands was typical of the mining of beach deposits. Compared to the mining and logistics of the interior stream deposits, beach deposits are fairly attractive.

There were no cruel passes to cross, such as the Chilkoot Pass, or the White Pass (which some believe was the cruelist path of them all). The name of the White Pass was soon changed to the Deadhorse Trail. There were no dangerous rapids to shoot, such as the White Horse rapids, which took many a miner's life. It was not necessary to drop a shaft, 30 to 40 feet through frozen river gravels to reach often barren bedrock. Secondly, it was not necessary to pick and shovel down in those frozen rat holes, hoist this material to the surface, and dump it into great piles, so that it could be sluiced when the spring thaw brought the water. In contrast, to reach Nome, one simply boarded a ship at a port; sailed off the shore of Nome; boarded a Barge, which brought him ashore and left him up to his ankles in gold bearing sands the moment he jumped onto the beach.

Mining of the interior deposits often required rather sophisticated and expensive equipment. In contrast, mining the Nome beach sands required rather simple equipment. For example, it was not necessary to build cribbing to support the soil so that it wouldn't cave in on the miners who might be mining below. It wasn't necessary to construct a windlass to hoist the auriferous gravels to the surface. It wasn't necessary to bring in ore cars to transport auriferous gravels down a drift to the central shaft. Furthermore, it wasn't necessary to have steam engines; a winch, to hoist buckets full of gravel to the surface, or a gin pole, where the gravel would be dumped into a rather cumbersome sluice box. Furthermore, it wasn't necessary to bring in hydraulic monitors to wash away the barren overburden. In contrast to that, mining on the Nome beach sands could be conducted with a simple pan. The more sophisticated equipment might be a surf washer, small sluice boxes, or rocker boxes, which, of course, were the most efficient implement used on the beach sands.

The dance hall girls certainly found that it was easier to rock out in the Nome beach sands during the day, than it was to rock out in the dance halls at night. Of course, the rocker was the most efficient method of mining these beach sands. The miners in the area found it more efficient if they amalgamated the gold, due to its fine size. Consequently, by amalga-

mating the gold with mercury, they increased their yield. They would simply line the bottom of their rocker box with a copper plate. Mercury has an affinity for copper, silver and gold. Next they would cover this copper plate with a layer of mercury. They would then begin the rocker operation, and as the gold bearing sand passed across the amalgamation plates the gold would be caught up on the amalgamation plate and the light weight sands, which had no affinity for mercury, would pass out the end of the rocker box. When there were no copper plates available to the miners, they simply lined the bottom of their rocker box with silver dollars and coated these with mercury, which provided a very fine amalgamation plate.

Figure 1 shows a generalized geologic profile of Nome beaches. Figure 2 shows mining regions and districts in Alaska.

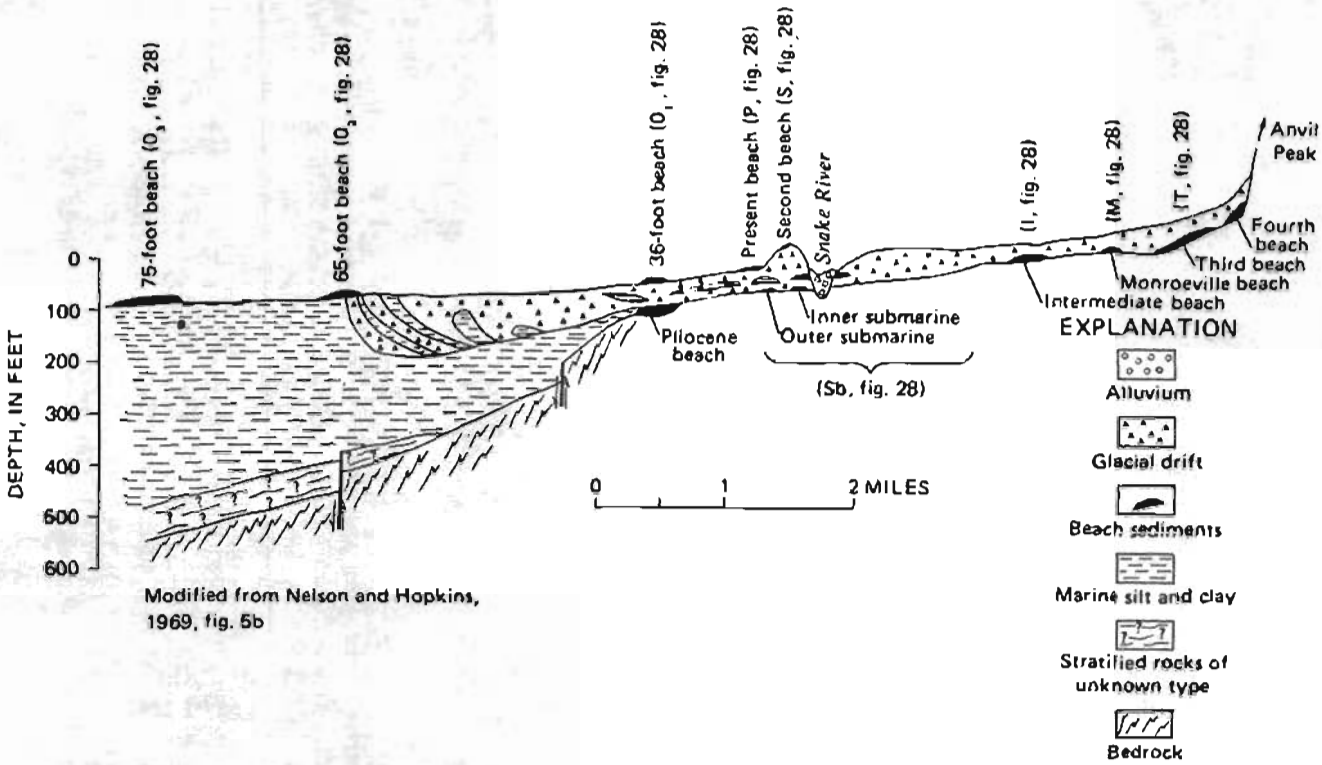

Figure 1. Generalized geologic profile of Nome beaches.

Geology of Beach Placers

The primary source of gold, as pointed out in other papers, is from lode deposits. The lode deposits may exist in inland mineralized zones, in mountainous areas or along the shore as mineralized beach cliffs. Once the gold is liberated from the lode, it works its way downslope by the effects of gravity and running water to the low places. In the case of the highland areas, other high specific gravity material, such as magnetite and garnet, follows the gold down to the creek, then works its way down within the creek gravels and distributes itself into a longate pattern down the valley trough, called the paystreak.

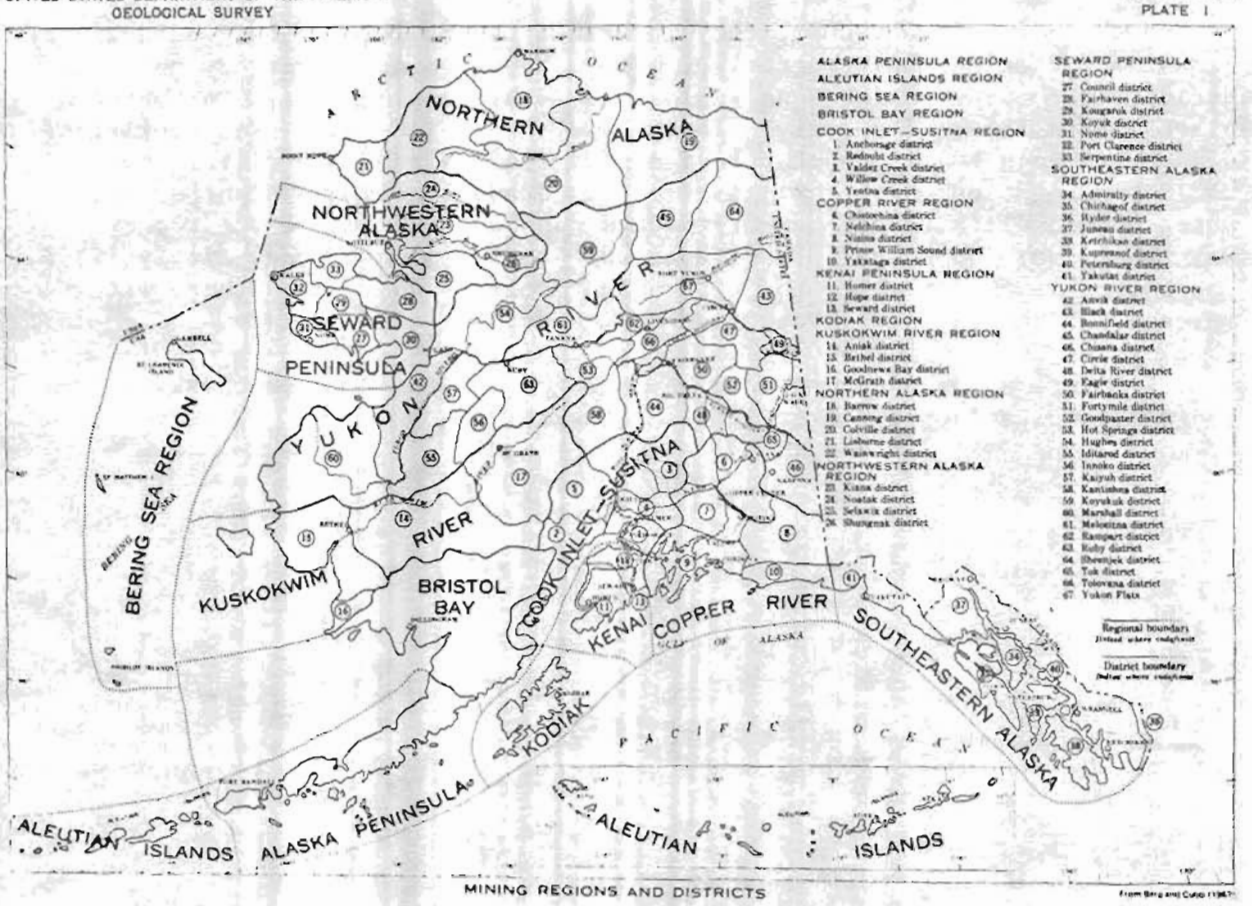

Figure 2. Mining regions and districts in Alaska.

But there is another type of gold called flood gold. Flood gold is that gold which is small enough and light enough to be carried along by the mechanical energy of the stream. Every once in a while this flood gold becomes deposited on river bars (where it will rest for a while) but after a time during the new flood stage, the gold will be picked up once again and carried farther down the river channel. This process may occur over and over again, until ultimately the gold finds its way into the ocean. Once it is discharged into the ocean, it may be picked up by longshore currents and distributed in an elongate belt, paralleling the coast, along the beach line.

This is one method of secondary concentration of gold in marine placers. There are several others. Primary among these is the encroachment of the ocean upon the land, in which river terraces and river gravels can be reworked by the force of wave action. Another source, again, is the encroachment upon the land and the reworking of gravel plains. The gravel plains may be outwashed deposits from the interior highlands. The most common gravel plains adjacent to the Coast in Alaska are glacially derived. Finally, there is the reworking of ancient beach terraces.

The type of beach that is produced by the reworking of gravel plains is a very cobblely, sandy, complex beach, with very fine gold. One will obtain coarse gold if the source area is very near to the Coast, such as the marine abrasion of mineralized sea bluffs. Then, the coarser gold will accumulate at the foot of the bluff.

Gold is concentrated in mineable deposits along the beach in response to wave action. Seaward sediment is thrust upon the shore; the subsequent backtow carries the lightweight sands back out to sea, leaving the higher specific gravity materials concentrated on the coastline. This is especially true during periods of storm. During a stormy period the entire beach may become agitated; the high specific gravity materials will work their way down into the beach sands and the lighter materials will accumulate on the surface. Additional sorting may occur from wave action. The circular motion of this wave action will selectively collect the lightweight grains, carring these out to sea, leaving the high specific gravity gold and other heavy minerals concentrated on the beach line.

The effects of the longshore currents, the pounding of the waves and, of course, the winowing affect of wave action develops a lens-like strip of concentrate paralleling the beach. These lens-like belts are erratically distributed along the beach sands. They are seldom more than 100 feet long or 2 to 3 feet thick. These lens-like belts can be exposed on the beach, but they are more commonly buried beneath 2 to 3 feet of lightweight sand. Other depositional patterns occur where the bedrock is very shallow. The concentrate may develop right on the bedrock and again be overlain by several feet of lightweight sand. Finally, the concentrate may be deposited in and around boulders that are resting on bedrock. Of course, all these characteristics can exist in elevated beach terraces.

We have touched on these factors and are now in position to take a look at the more interesting, and possibly the more valuable, beach deposits within the State of Alaska. Valuable deposits have been located in the Southeastern region, Copper River region, Kenai region, Kodiak region, Alaska Peninsula region, Bristol Bay and of course the Seward Peninsula region. In the Southeastern region, valuable deposits have been discovered at Yakitat, Dry Bay and Lituya Bay. This material was derived from marine abrasion of glacial debris with subsequent concentration of the gold by wave action. The major mining method utilized in these deposits was small equipment, rockers and small sluice boxes with a total yield of approximately 3,700 ounces.

In the Copper River region, gold has been found in the Yakutat district and the Prince William Sound district. At Yakutat the gold was produced by marine abrasion of glacial debris with subsequent concentration of the gold into mineable patches by wave action. The gold was mined with simple equipment, yielding between 16,000 and 17,000 fine ounces. The deposit at Middleton Island was derived by marine abrasion of tertiary sedimentary rocks. They are suspected to have been deposited, in part, at least, by floating ice. Mining here was again by simple methods, with a yield of approximately 500 ounces. In addition to the fine gold extracted, there were several small nuggets obtained, up to about a pennyweight in size.

In the Kenai Peninsula area, gold was discovered at Anchor Point and in Ninilchik. The Anchor Point deposit was the most interesting. The source of the material was river reworking of inland glacial material. The river transported the fine flood gold to the ocean. The gold was picked up, upon entering the ocean, by longshore currents, and distributed in an elongate belt, overlain by about 2 feet of lightweight sand on the beach. Mining of the gold required a ditch, approximately 2 miles long, which supplied water for sluicing the fine gold.

In the Kodiak Island region, gold was found on several beaches, including the westcoast beaches, Seven Mile Beach, Miners Point and Raspberry Beach. The source of the gold was reworking of glacial material. Again, the gold was deposited into mineable patches and belts by wave action. Mining was by small methods. Although the exact amount of gold taken from these beaches is not known, it is suspected to be several thousand ounces.

In the Alaska Peninsula region there are several beach deposits that were of interest, but the most important was that at Popov Island. The source of the material was erosion of inland lode deposits. The material was transported to the ocean by streams. It was picked up by longshore currents which carried the gold along a belt about 3/4 of a mile in length and deposited among the rocks (at the low tide line). Mining here was by rocker boxes. In a period of two years, the miners had extracted approximately 580 ounces of fine gold.

In the Bristol Bay region traces of gold were found at Goose Point, but the most interesting deposit was at Hagemeister Strait. The source of the gold at Hagemeister Strait is sulphide veins that occurred inland. They were eroded by glaciation. The waves concentrated the gold from the glacial debris on the beach. In 1937, an overly optimistic report of gold on the Hagemeister Beach sent a gold rush to that area. Yet, of all the men that went in there, only 500 ounces of gold was taken from the beach.

In the Seward Peninsula region, there have been valuable beach gold deposits found in the Fairhaven District, the Nome District and the Council District.

In the Fairhaven District, gold was found in 1899 at the mouth of Alder Creek. The stream supplied the fine gold to the beach. It was picked up by longshore currents and distributed along the beach, right along a schist bedrock. This, in turn, was overlain by about 1 1/2 foot of beach gravel. Mining was by simple method, with a total yield of about 200-300 ounces.

The most valuable deposits, of course, were in the Nome District. The Nome beach sands occur as far inland as the mountains, and as far out as the 75 foot beach about 5 miles off shore. This is due to world-wide fluctuations of sea level throughout the past few million years.

During the early 1900's, the inland beaches were mined by drift mining methods. However, because of the great expense involved in drift mining, combined with the general scarcity of water, these claim holders amalgamated their holdings. Subsequent mining by large dredges then permitted these inland beach deposits to be mined at a profit.

The last deposit is the Council district. Gold was discovered at the mouth of Daniel's Creek in 1899. In two years time, the miners extracted $600,000 of gold from that beach. Now, you want to remember that that was $20 gold. If it were $500 gold, this beach would have been worth $15 million. This is an excellent monitary stimulus to look at beach placers. Don't forget that Alaska is bounded by 6,640 miles of coastline and scarcely 100 miles of these sands have been sifted for gold. One would be pessimistic to conclude that there were no more valuable beach deposits in the State of Alaska. However, it might be a bit optimistic to think that there are many more around as valuable as the Nome Beach deposit. Although the location of a deposit as rich as that found at Daniel's Creek is not completely out of the question.

We want to keep in mind that miners and prospectors are very optimistic. If gold is not found in a particular stream or creek, it is certain to be found just over the ridge in the next stream. Furthermore, if gold is not found in a particular beach deposit, it is certain to be found just up the coast.

PALEOPLACER DEPOSITS

Dr. John Sims
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I am at once both a placer and a hard rock gold geologist, having spent most of my professional career working on a class of deposits known as paleoplacers.

A paleoplacer is a geologically ancient placer deposit which may be tens of thousands of years old, or hundreds of millions of years old. In a sense, we can look upon recent placers as transient ephemeral accumulations of heavy minerals in gravels and sands on the present day land surface. Modern placers are dynamic entities being formed and reformed by active processes.

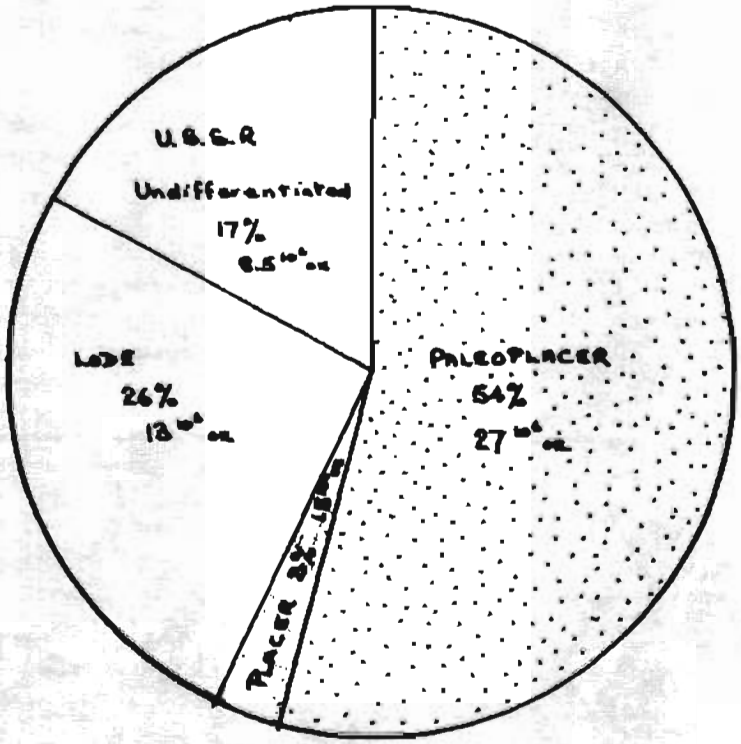
Paleoplacers were formed as sand and gravel beds on earlier land surfaces, essentially by the same processes which are taking place today. However, subsequent to their deposition, they were subjected to further geologic change, which buried and consolidated them beneath successive blankets of younger rocks, hardened, tilted, folded and fractured them. Some paleoplacers are almost as old as the earth itself, having formed in the early period of crustal development.

Placer deposits in their very nature are derived from an earlier mineral body, the source or provenance. The source may or may not have had enhanced values of the commodity, be it gold, platinum, tin or some other physically and chemically stable mineral. Many source environments do contain elevated values but some do not.

How important are paleoplacers in the production of newly mined gold? The truth may surprise you.

Gold from paleoplacer deposits accounts for 54% of the world's production (Fig. 1). Taking 1979 as a base year, we know that the global production amounted to some 50 million ounces. Twenty-seven million ounces were mined from paleoplacers. Lode gold accounted for 26%, or 13 million ounces produced from quartz veins, polymetallic veins and as a by-product of base metal mining. True or recent placers accounted for only 3% of global production. The production by deposit type shown on Figure 1 includes 8 1/2 million ounces, amounting to 8 1/2 million ounces undifferentiated from the USSR. The dominance of paleoplacer gold is a tribute to the enormous extent and richness of the ancient conglomerate or banker ores of the Rand in South Africa, which alone accounts for more than 1/2 of the supply of newly mined gold, and will continue to be a major producer for several decades to come. Although apparently unique in size and economic importance, the Rand deposits do have analogues on all major continents.

Paleoplacers constitute a neglected exploration target, not only for gold but for other heavy, physically and chemically stable mineral commodities. My own enthusiasm stems from a long association with the geology and mining of paleoplacer gold deposits on these continents. Although the



GOLD PRODUCTION 1979

50 million ounces

Figure 1.

geologically ancient examples are extremely important, there are deposits in much younger geologic settings such as are characteristic of Alaska, which have been neglected in exploration. There are numerous paleoplacer deposits known in younger mobile belt settings, some of which have produced substantial amounts of gold.

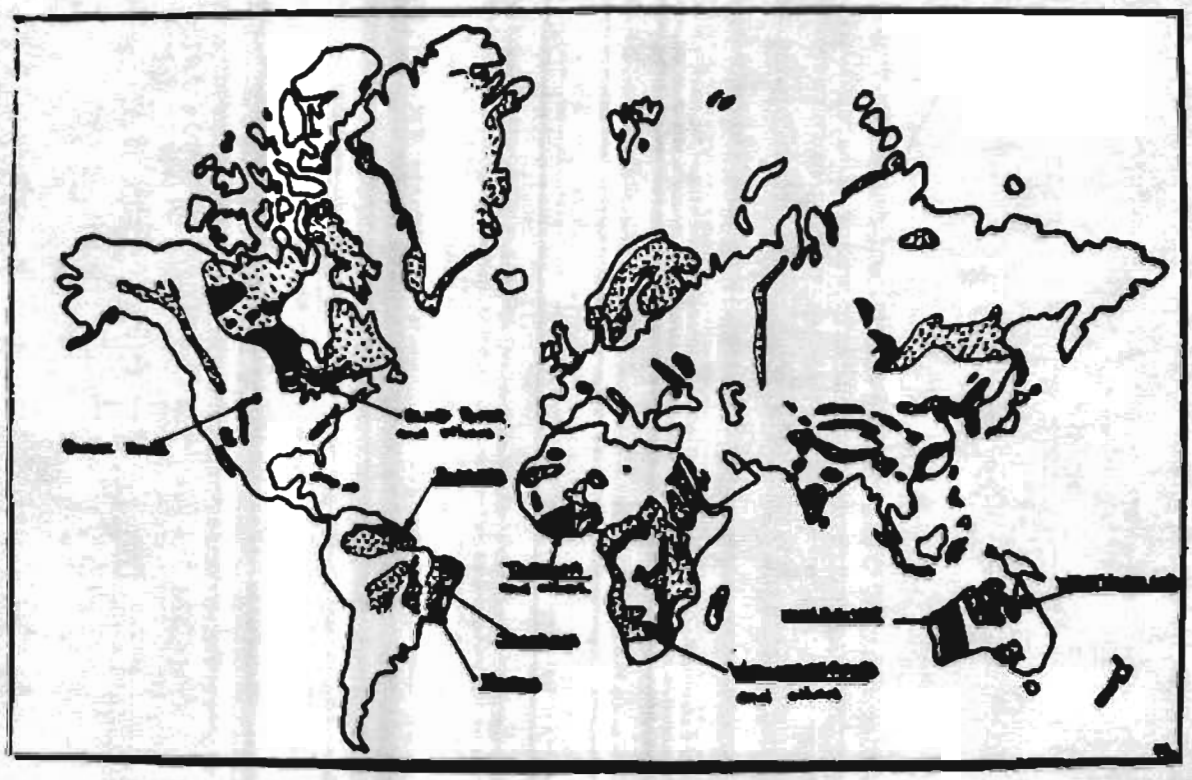
Turning to the geologic time and geographic distribution of primary lode and secondary placer and paleoplacer golds, Figure 3 depicts the relative importance of primary and secondary gold as a function of time. Note there have been two major time periods during which primary lode deposits were formed. The most important was in the Archean and early Proterozoic, characterized by greenstone belts of the developing Precambrian shield regions, followed in a much longer geologic time framework starting approximately 500 million years ago with the vein deposits and polymetallic lode deposits, characterized by the mobile belt settings. Each of these major primary associations can be likened to the chicken and the egg, the latter being the paleoplacers represented by the stippled areas.

The most important period of lode formation by far was during the Archean or early phase of crustal evolution, when significant enrichment of gold took place in rocks, referred to as greenstones. These were assemblages of fine and coarse grained clastic sediments, together with volcanic and chemical deposits, principally ironstones. The economic deposits in

these rocks, in many instances, formed as a result or consequence of subsequent processes which concentrated the gold in veins, etc.

Turning to the most important group of paleoplacers; those formed in late Archean through early Proterozoic times. The prime example is the Witwatersrand or Rand depository in South Africa.

Figure 2 depicts the distribution of primary shield gold deposits and some, but by no means all, of the documented paleoplacers derived from the primary provenance belts: these are the so called Proterozoic quartz pebble conglomerate deposits. Note the pattern of distribution with all major continents represented. The principal, but not all paleoplacer deposits,



PRECAMBRIAN GOLD AREAS Mainly older than 1.6 by.

Figure 2

are indicated in Figure 3. There is the Witwatersrand, enormously important in Southern Africa; Tarkwa in West Africa. Across the Atlantic, in Brazil, there are three occurrences; namely, Moeda, Jacobina and Roraima. In Australia, key areas are the Nullagine and Westmoreland, while in Canada there are the Blind River or Elliot Lake deposits, important for uranium. Later I will contrast this pattern with the gold deposits, associated with mobile belt settings, but first look at elephant country, the Witwatersrand basin in South Africa. Figure 4 is a sketch map of the Rand depository. The dimensions are approximately 300 miles on the long axis and more than 100 miles on the short axis. The areas around the northern rim and western rim define the districts which have been mined and are being mined, fre-

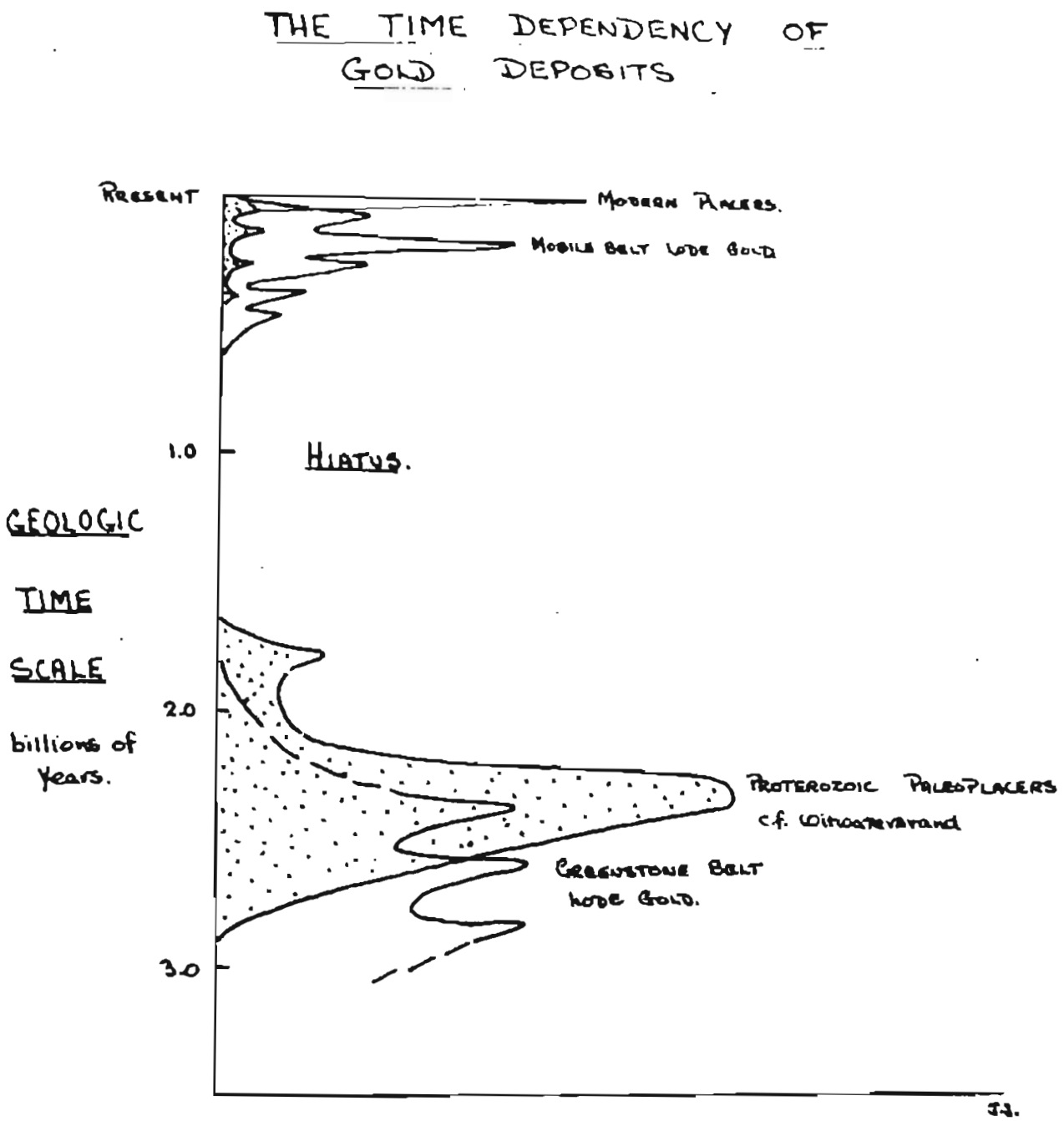

THE TIME DEPENDENCY OF GOLD DEPOSITS
PRESENT
MODERN PLACERS.
MOBILE BELT LODE GOLD
1.0
HIATUS.
GEOLOGIC TIME SCALE
billions of years.
2.0
PROTEROZOIC PALEOPLACERS
c.f. Witwatersrand
GREENSTONE BELT LODE GOLD.
3.0
RELATIVE IMPORTANCE

Figure 3.

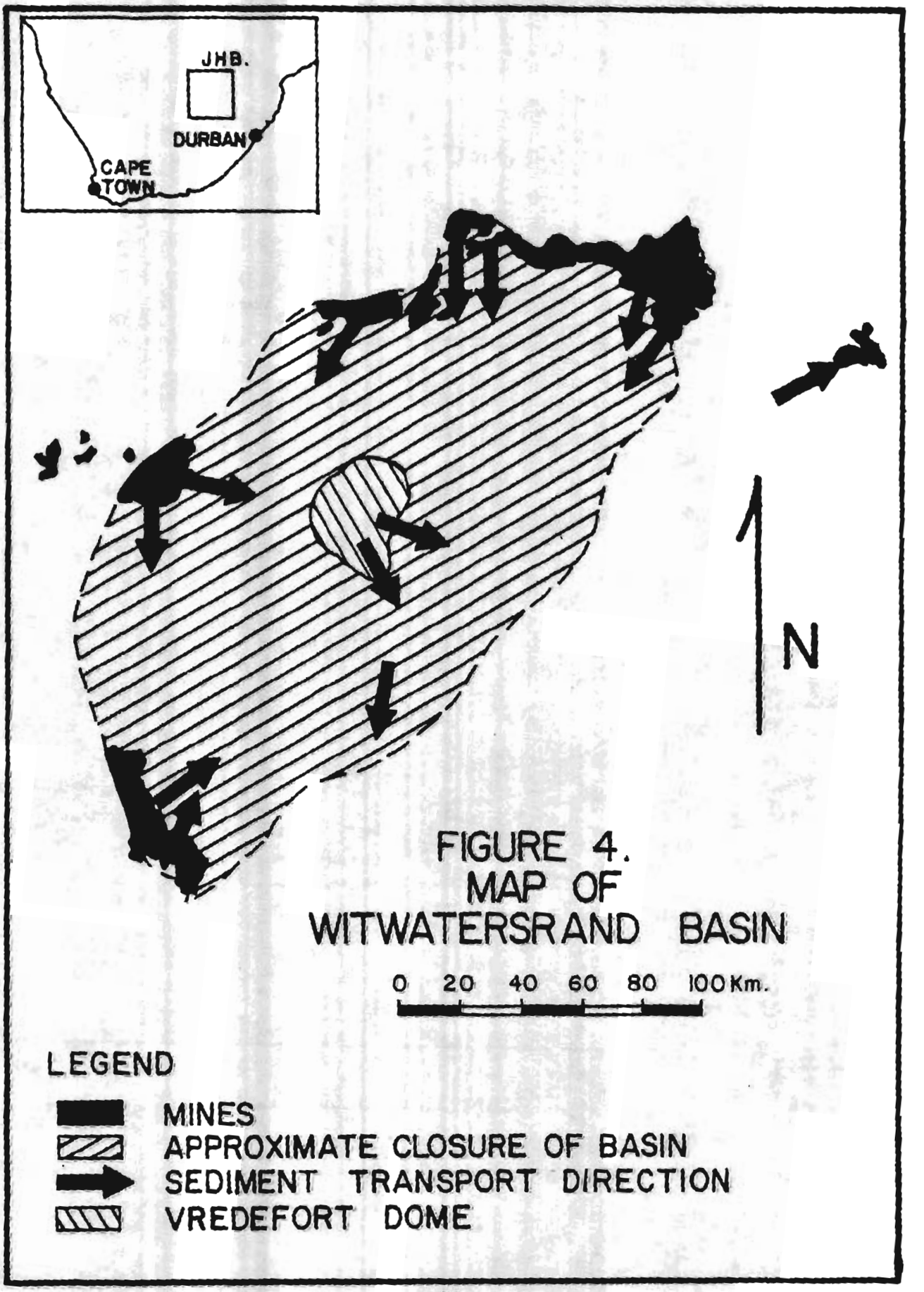


FIGURE 4.
MAP OF
WITWATERSRAND BASIN

quently described as the "Golden Arc". Quite simply, these areas along the northern and western rim represent the entry points of major river systems into this large basin. The period of time involved was several hundred million years, during which the deposits of the Rand basin accumulated. The deposits themselves resemble very large, wet, alluvial fans or deltas, over which the river distributaries discharged their gold bearing gravels. Picture a system of anastomosing laterally migrating stream channels, which eventually built up very extensive sheets of high grade gravel.

Figures 5-9 depict a typical series of specimens, such as would be encountered going from the edge of the Rand depository, in the proximal areas close to the source, further into the basin; across one of these major entry points is a major river-delta system. Figure 5 is a coarse pebble conglomerate; with a clean, sandy matrix and abundant pyrite. This is a specimen from one of the very rich South African mines, and you must take my word that this particular rock is running better than an ounce of gold to the ton.

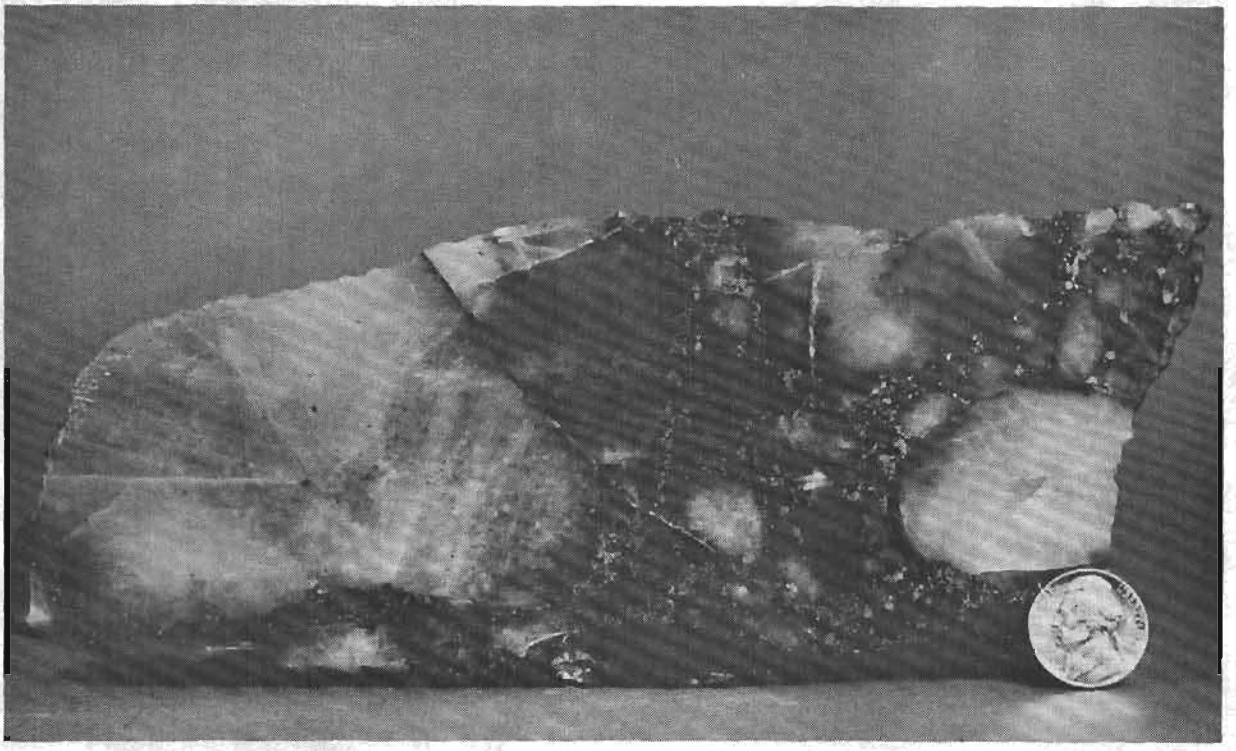


Figure 5. Coarse pebble conglomerate with pyrite in the clear sandy matrix, close to the source area.

Also present in the near-to-source areas are dirtier conglomerates (Fig. 6) which nevertheless can contain elevated quantities of gold. This is a specimen of polymictic conglomerate which, in contrast to Figure 5, consists of a variety of different clasts; including black chert, smokey quartz, white quartz, quartzite, shale and fragments of igneous rocks. The shale clasts at the time of deposition were introduced as relatively soft material. This particular unit was also yielding about one ounce to the ton.

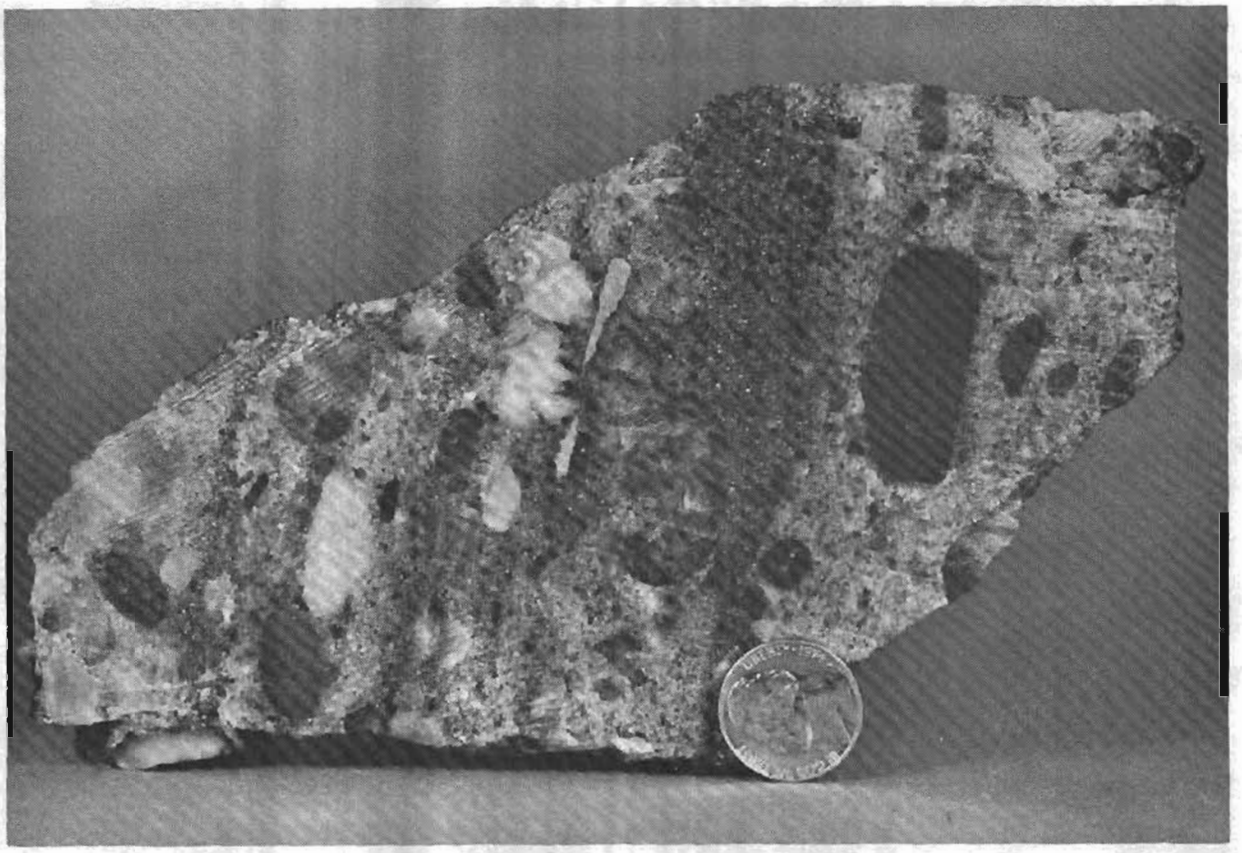


Figure 6. Conglomerate with a variety of clasts.

Further into the depository, the character of the ancient gravel or conglomerate changes and characteristically consists of smaller pebbles, quite well packed, set in a pyritic matrix (Fig. 7). Eventually, far down the depositional slope in the distal environments, perhaps 15-20 miles from the entry point, there are extensive developments of carbon seams (Fig. 8). These represent fossil remnants of algae mats which accumulated in the quieter, more distal environments of the wet fan. They most certainly represent the decay of plant material and constitute a record of early life on this planet. Figure 8 depicts a bedding surface which includes quartz pebbles distributed in a carbon seam. Often spectacular displays of visible gold mineralization are associated with carbon seams in this setting.

The speciman illustrated in Figure 9 is included to show how tantalizing the problem of dealing with paleoplacers can be. The narrow seam which looks like a pencil line is perhaps 1/50 of an inch thick. It is a seam of gold and carbon, little else. Flanking the seam above and below is clean quartzite with the occasional pebble. The values in the rock on either side of that seam are negligible, yet there is sufficient gold in the narrow seam to produce a value of something like 5 ounces to the ton, taken over a mining width of 36 inches. It is a very sobering thought, that extremely rich gold deposits can have such inconspicous appearances.

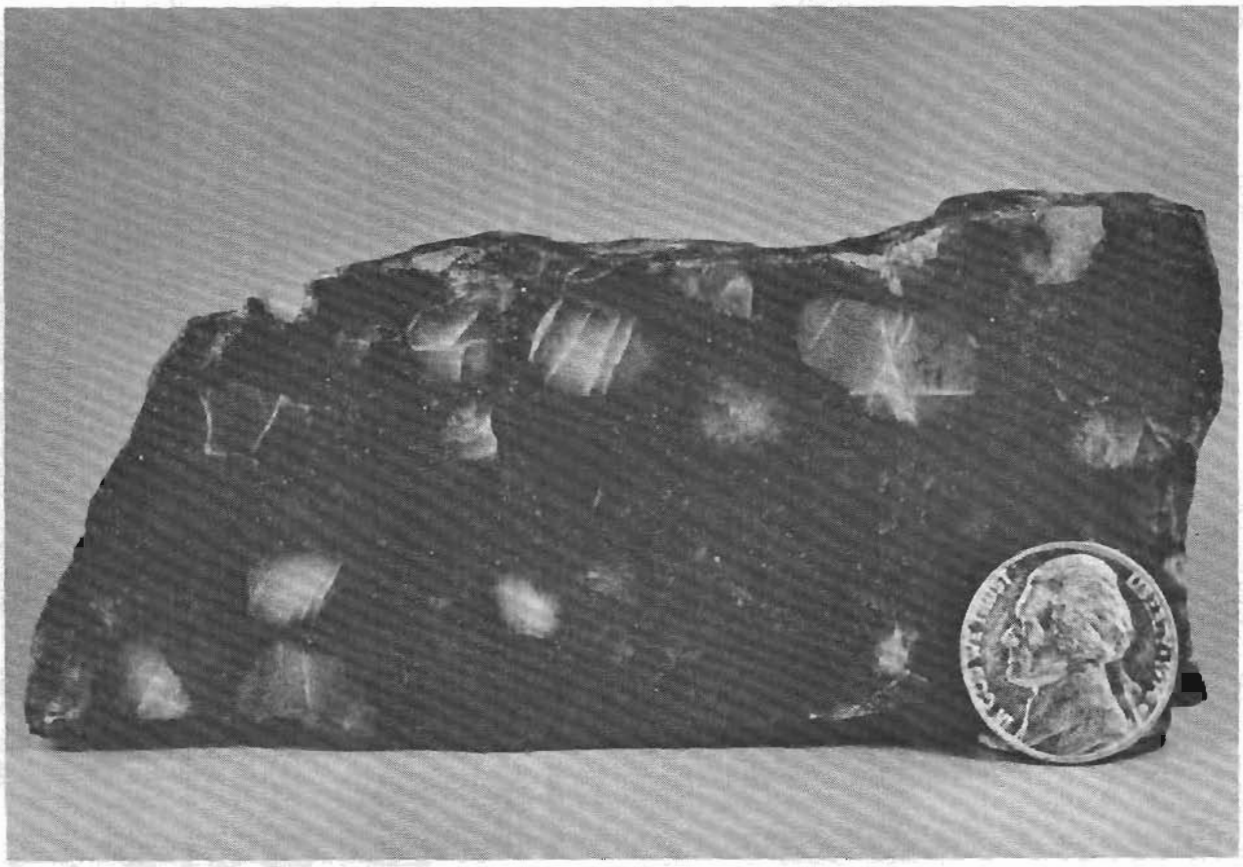


Figure 7. Smaller pebbles in a pyrite matrix further into the basin.

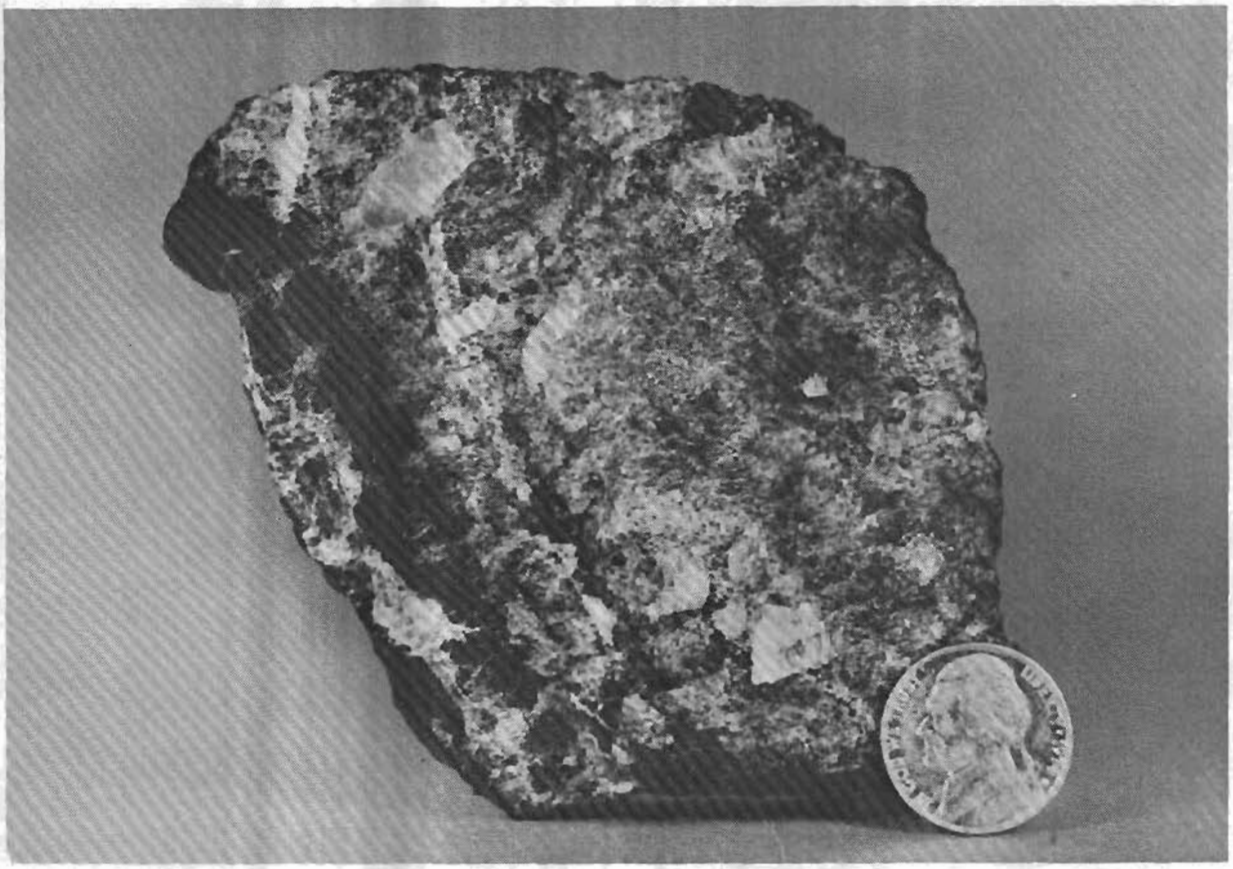


Figure 8. Quartz pebbles in a seam of organic carbon, 10-15 miles from the depositional source.

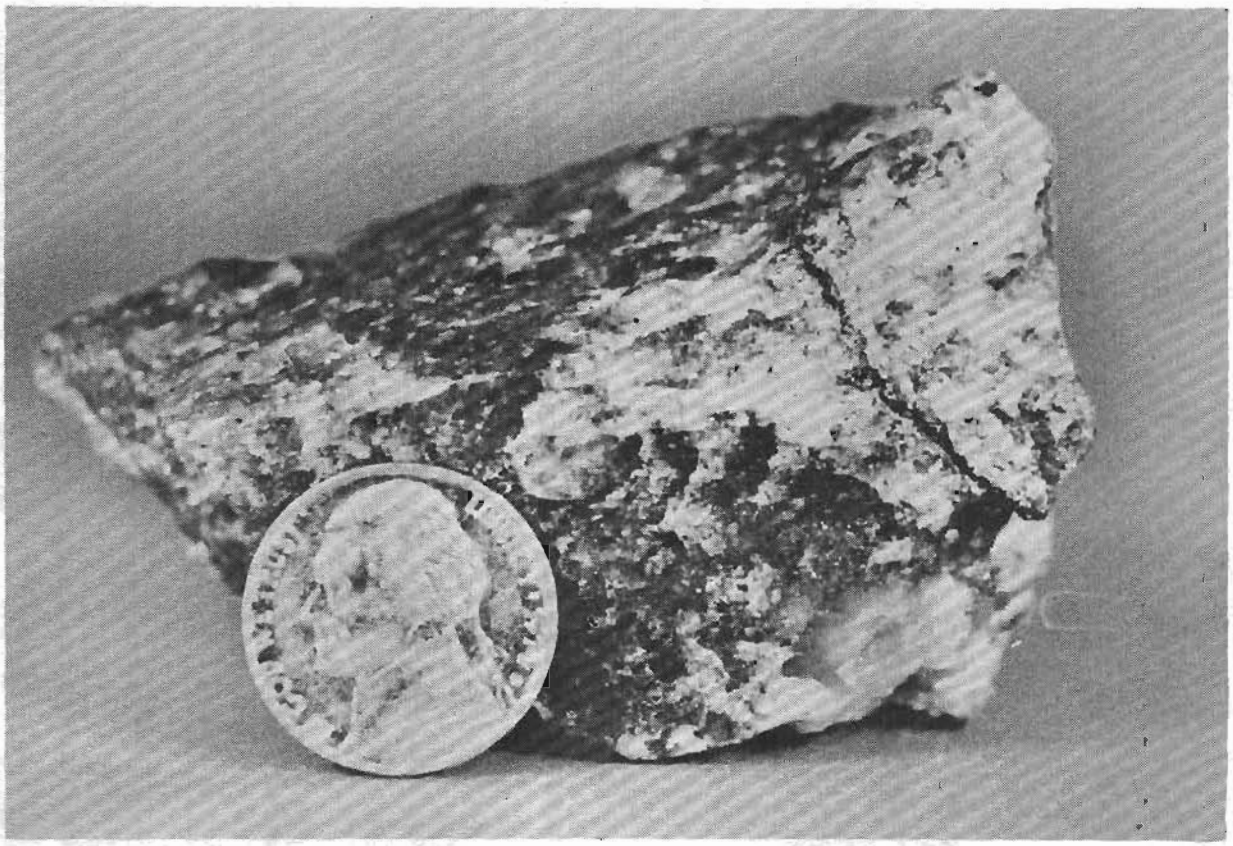


Figure 9. A narrow seam of carbon and gold in a distal conglomerate.

Elsewhere in Africa, in Ghana to be precise, there is a very interesting situation present in the Tarkwaian depository, which essentially contains both components; the chicken and the egg in the paleoplacer model. Flanking the Tarkwaian basin, which is the stippled area (Fig. 10), there are greenstone belts with several zones of primary gold mineralization. Within that greenstone terraine is the very famous Ashanti Mine which, to the best of my knowledge, is the richest lode deposit that has been continuously worked over a sustained period. Ore grades of the Ashanti, over a period of several decades, have seldom dipped below one ounce to the ton. From the primary gold belts, ancient streams, eroded distributed and deposited material, in the elongated Tawkwaian basin. There are two well-known paleoplacer districts within that basin. One is at Tarkwaian itself, and the other, some 80 odd miles away at Adowsena in the northeast. The Tarkwaian basin extends further but passes beneath a very extensive basin of younger rocks.

In terms of historic production, the banket or paleoplacer deposits of Ghana have accounted for approximately 25% or 8 million ounces of the country's production. Outside of South Africa, this important area contains some of the best exploration potential for gold anywhere. Adjacent to the Ashanti property, for instance, there is documentation of gold in paleoplacers, which to my knowledge have never been really adequately tested and examined.

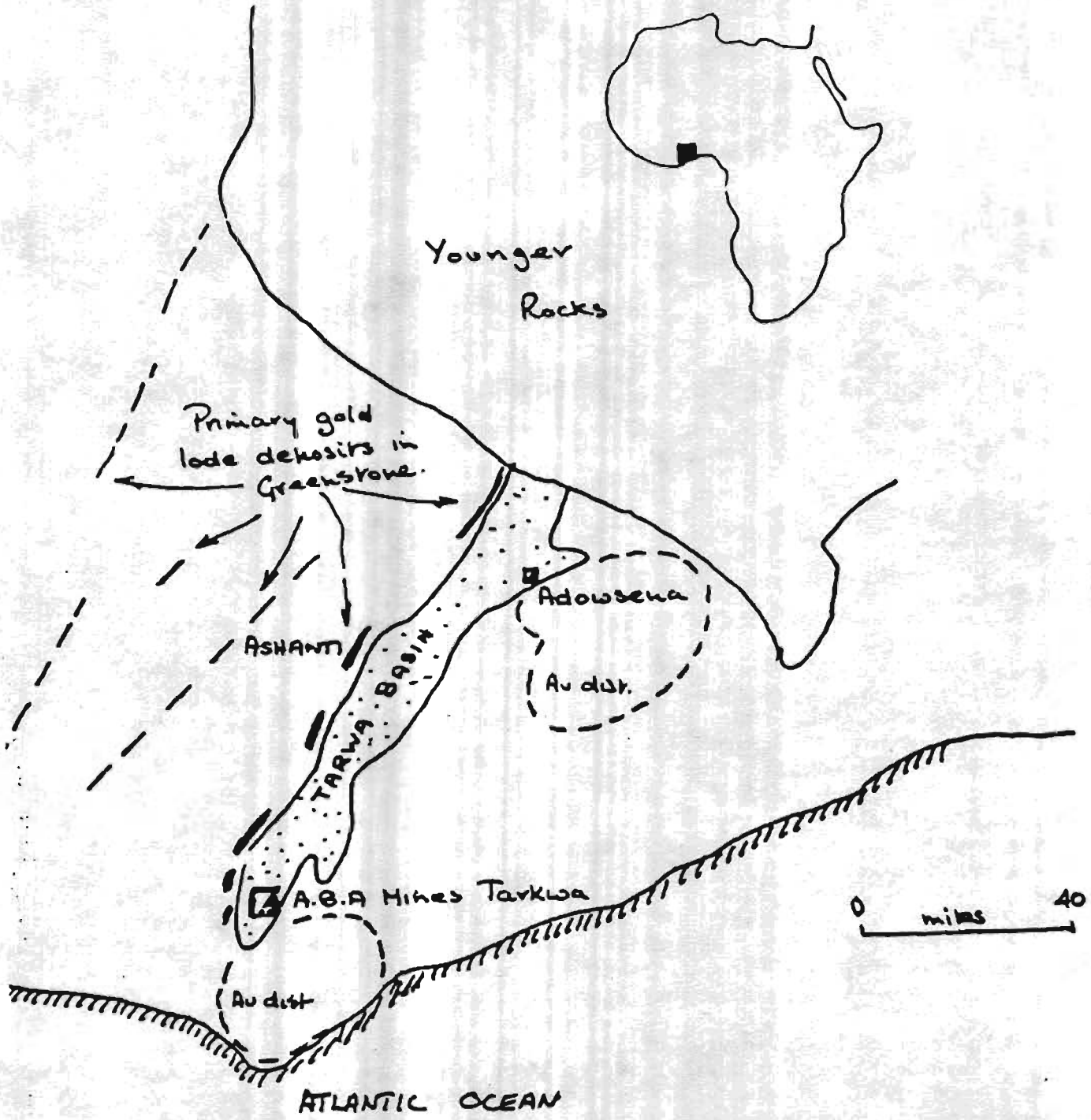


Figure 10

Primary lode and Paleoplacer gold deposits of Ghana West Africa.

In Brazil, across the South Atlantic from Africa, there are several paleoplacer occurrences of note. The Moeda conglomerates in the State of Minas Gerais covers many tens of square miles and is being investigated by the Brazilian Atomic Energy Authority for its uranium potential. Hastily, after the very early stages of a drilling program in 1972, the authorities announced that they had found a deposit, albeit prematurely, to rival that of the Blind River and Elliot Lake area of Ontario, Canada. Nevertheless, many thousands of feet of drilling later, they have accumulated a considerable inventory of information, which does indicate that there is economic potential in the Moeita Conglomerate for both uranium and gold.

Further north in Brazil, at a place called Jacobina, I managed a joint venture prospecting operation, during the period 1973 to 1977. At the end of that period a deposit had been proven containing 10 million tons of ore, grading 1/3 of an ounce of gold per ton at a cut-off grade of 1/5 of an ounce per ton, in rocks very similar to those mined in South Africa. Figure 11 depicts typical Jacobina ore in which pebbles can be seen set in a pyritic and quartzitic matrix. The Jacobina deposit has been prospected and evaluated to a higher degree of geological certainty, and is known to contain very substantial tonnages of material below the cut-off grade of 1/5 ounces per ton.

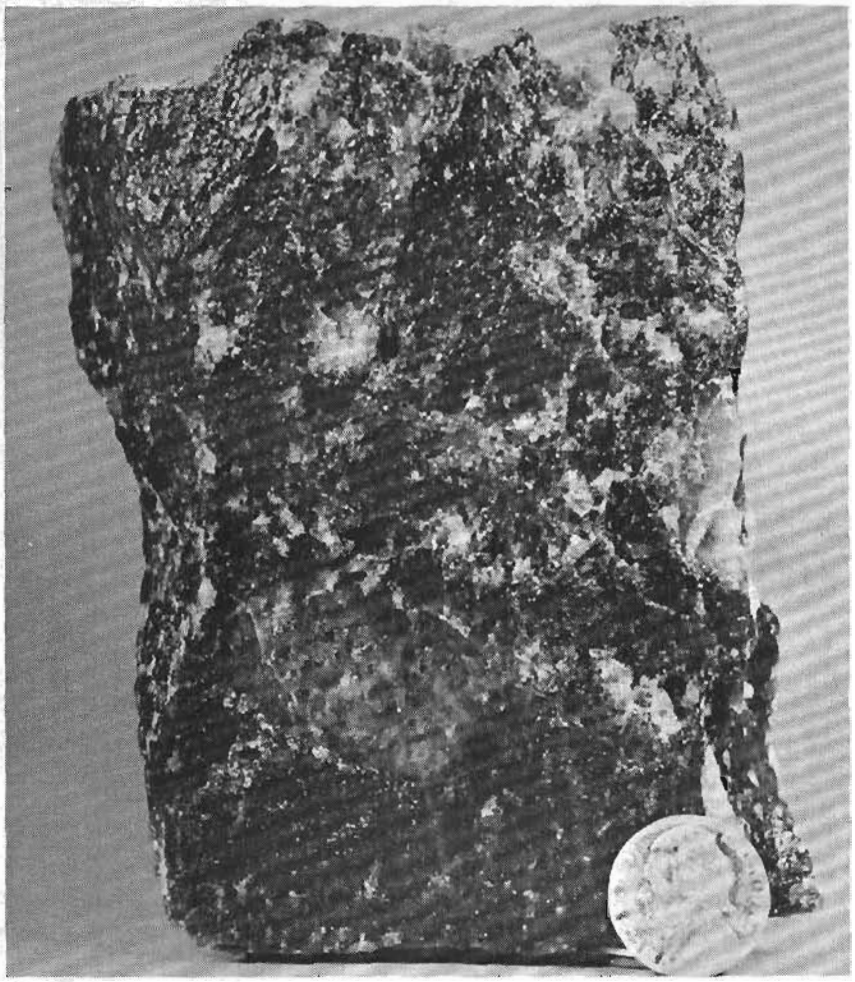


Figure 11. Jacobina ore consisting of pebbles set in a quartz and pyrite matrix.

Jacobina is not a new discovery, since the deposits have been pig-rooted and mined on a small scale for better than 200 years.

Journeying on into North America there are other famous deposits of the paleoplacer type. Figure 12 depicts a typical sample of the Blind River, or Elliot Lake ore from Ontario, Canada, which contains economic grades of uranium, associated with low almost insignificant gold values. This factor was largely attributed to provenance, or source characteristics.

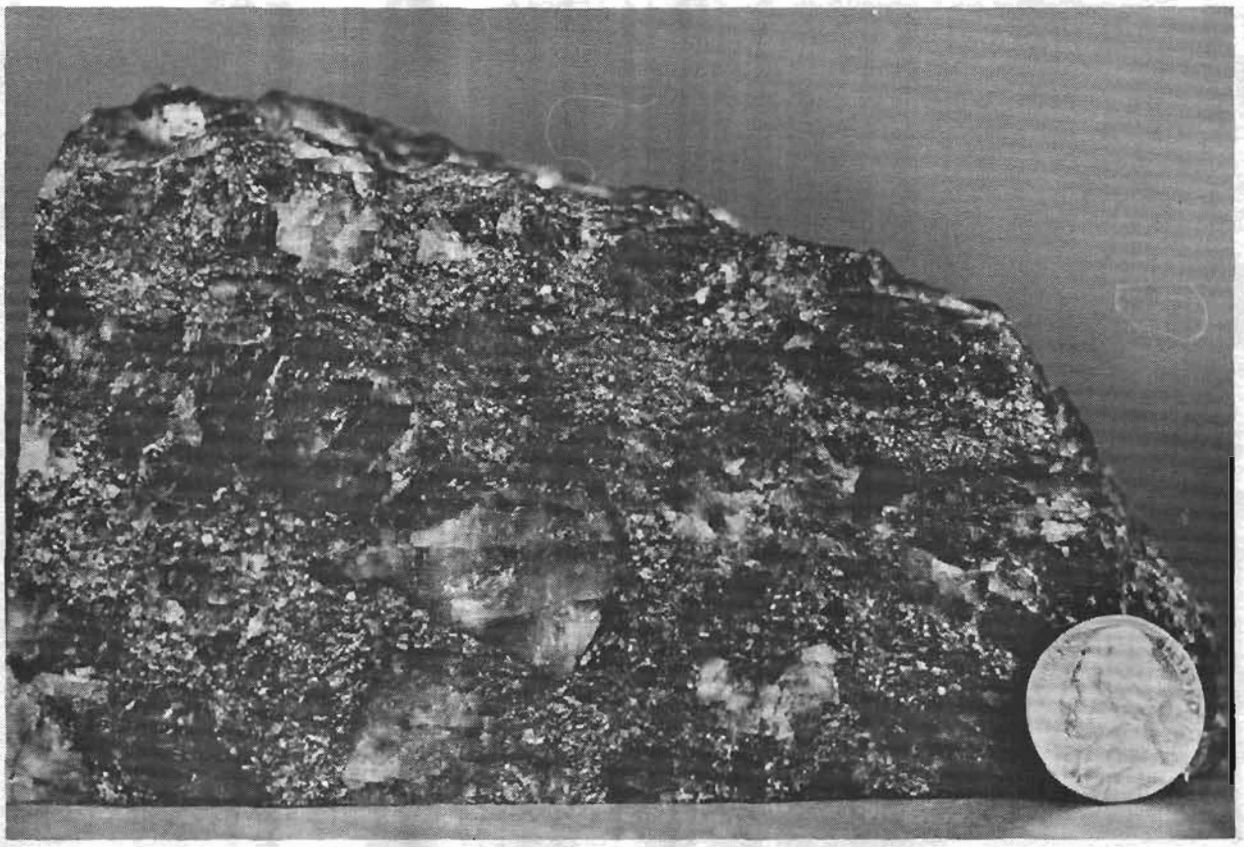


Figure 12. Blind River conglomerate with economic uranium values and minor gold values.

Recently, conglomerates or paleoplacers shown to contain gold and uranium have been prospected in the Black Region of South Dakota, not far from the Homestake mine. Gold may well have been recycled from earlier, Precambrian lode deposits such as the Homestake orebodies, by sedimentation processes.

Younger assemblages of rocks contain primary (lode) and secondary (placer and paleoplacer) deposits. This second major grouping is represented on the time chart (Fig. 13) by the period from about 500 million years ago to the present. Phanerozoic mobile belt environments differ greatly in distribution from the old Precambrian gold areas, which are confined to the period greater than 1.8 billion years.

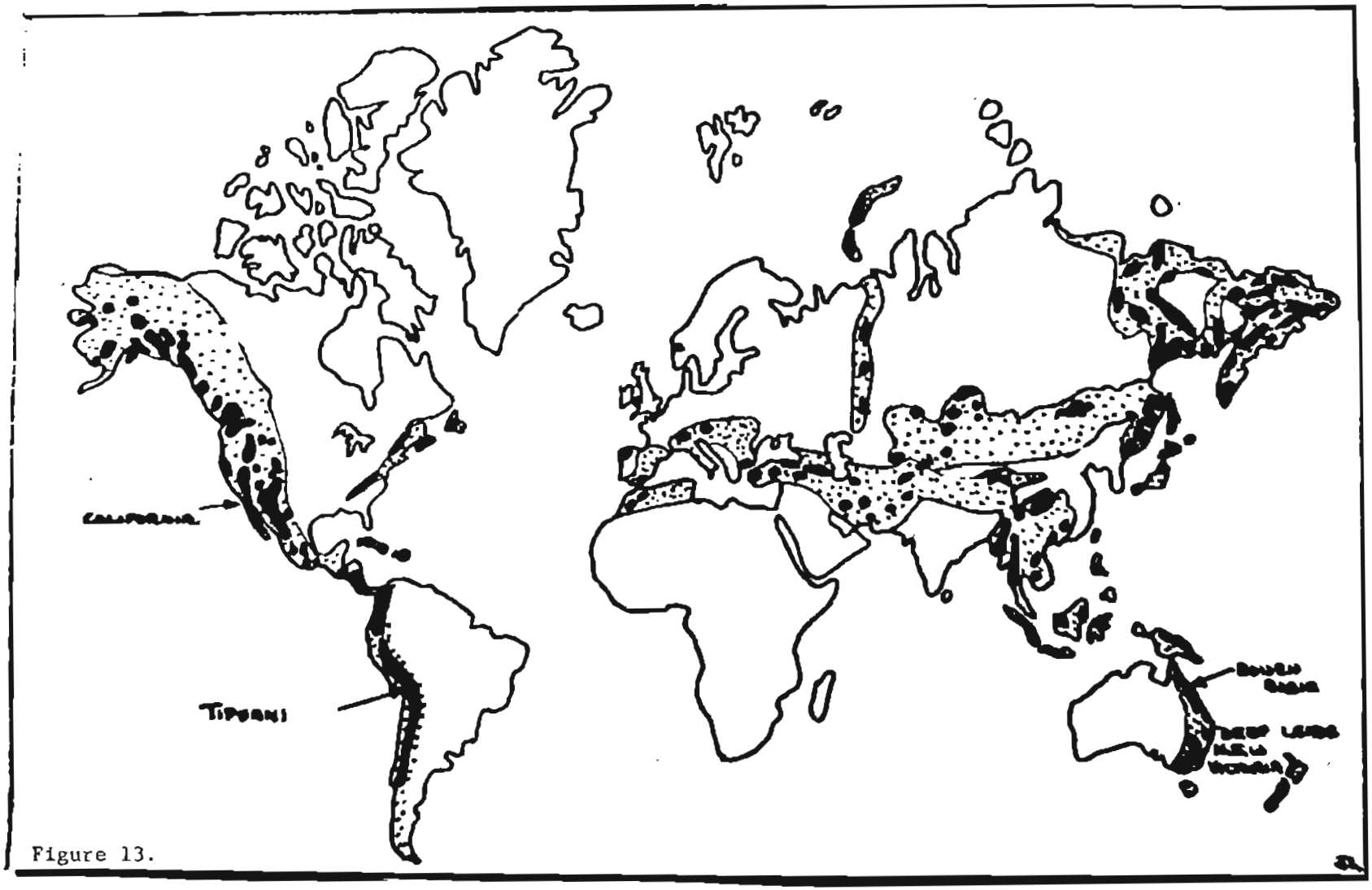


Figure 13.

PHANEROZOIC GOLD AREAS 500 my to Present

It is in this second, broad, geologic setting that the deposits of Alaska belong. Alaska lies astride part of the Circum Pacific Belt, stretching the length of the Americas, trending through Siberia, China and down through the East Indies and into Eastern Australia. A bifurcaring trend extends through Asia Minor, across into the Mediterranean and North Africa. Much of this trend, of course, is coincident with the great belts of Phanerozoic tectonic activity.

In Eastern Australia and in both South and North America, paleoplacer deposits, containing gold and other heavy minerals (notably tin) have been discovered, and in some cases, such as at Tipvani in Bolivia and in the mother lode country of California, were worked on a major scale. While uranium is apparently restricted to geologically ancient Precambrian paleoplacers, and there are compelling geologic reasons for this, there is no reason why gold should similarly be restricted, provided that essential provenance and preservation criteria can be satisfied. There are important paleoplacers in younger, mobile belt settings, such as the western part of the Americas.

One such deposit, which is in a relatively unconsolidated state, is the White Channel deposit of the Yukon. The White Channel is geologically a quite young paleoplacer, the distribution of which bears little or no relationship to the present day drainage configuration.

We should be more aggressive in our search for this type of deposit, which I believe could be more common than suspected in the past. In most cases, the paleoplacer setting equates with hardrock mining situations and therefore, mining systems vary greatly from those used in placer mining. As a consequence, cost structures are very different from those applicable to placer mining.

A word about exploration concepts for paleoplacers. It is vital in the first instance to satisfy the provenance or the source requirement. Gold placers and paleoplacers can only form from material, which itself contains gold. The search should, therefore, focus on sedimentary sequences within or proximal to known gold districts. In Alaska the effects of glaciation could drag something of a "red herring" across our identification of source districts.

The sedimentary host rocks, of course, must be younger than the age of the primary gold mineralization from which the gold has been recycled. The mineralized paleoplacer bed may have formed by fluvial-deltaic or beach processes in a relatively high energy environment. We seek to identify in nature those processes which replicate the behavior of pebbles and heavy minerals in a sluice box, allowing the heavy valuable minerals to be trapped while winnowing away the lighter, worthless fraction.

Energy criteria are frozen in the rocks in the form of pebble size characteristics, cross bedding, style and other attributes. The most favorable setting, assuming that provenance and energy requirements are satisfied, is in the basal, frequently conglomeratic, phase of a sedimentary sequence deposited on a pronounced erosion surface, following a protracted period of subaerial exposure.

Indications of the favorable attributes of a paleoplacer may be found in the high degree of rounding of pebbles, the packing density of pebbles, good sorting characteristics and the predominance of hard, durable pebble lithologies (quartz, chert and quartzite), clean, well winnowed matrix characteristics and concentrations of other heavy minerals. A common indication would be the staining or oxidation derived from sulphide species. Analysis of internal structure, such as crossbedding, would further enhance the exploration process. Bedform characteristics, such as channels, should be sought and preferentially tested.

Figure 14 illustrates some of the characteristics that should be sought. The bottom of the photograph is a conglomerate unit which is overlain by strongly crossbedded quartzite, indicative of a high energy environment; both the quartzite and the matrix of the conglomerate are relatively clean washed.

Figure 14. High energy environment with conglomerate overlain by strongly crossbedded quartzite.

Figure 15 depicts crossbedded quartzite with the angle of the foreset beds indicating a high energy environment, overlain by a conglomerate. The illustration embodies most of the characteristics that one should look for, namely, well packed conglomerate; well sorted quartz pebbles, not a sand supported fabric, but rather a well packed fabric formed by overlying and truncating the crossbeds in a high energy environment.

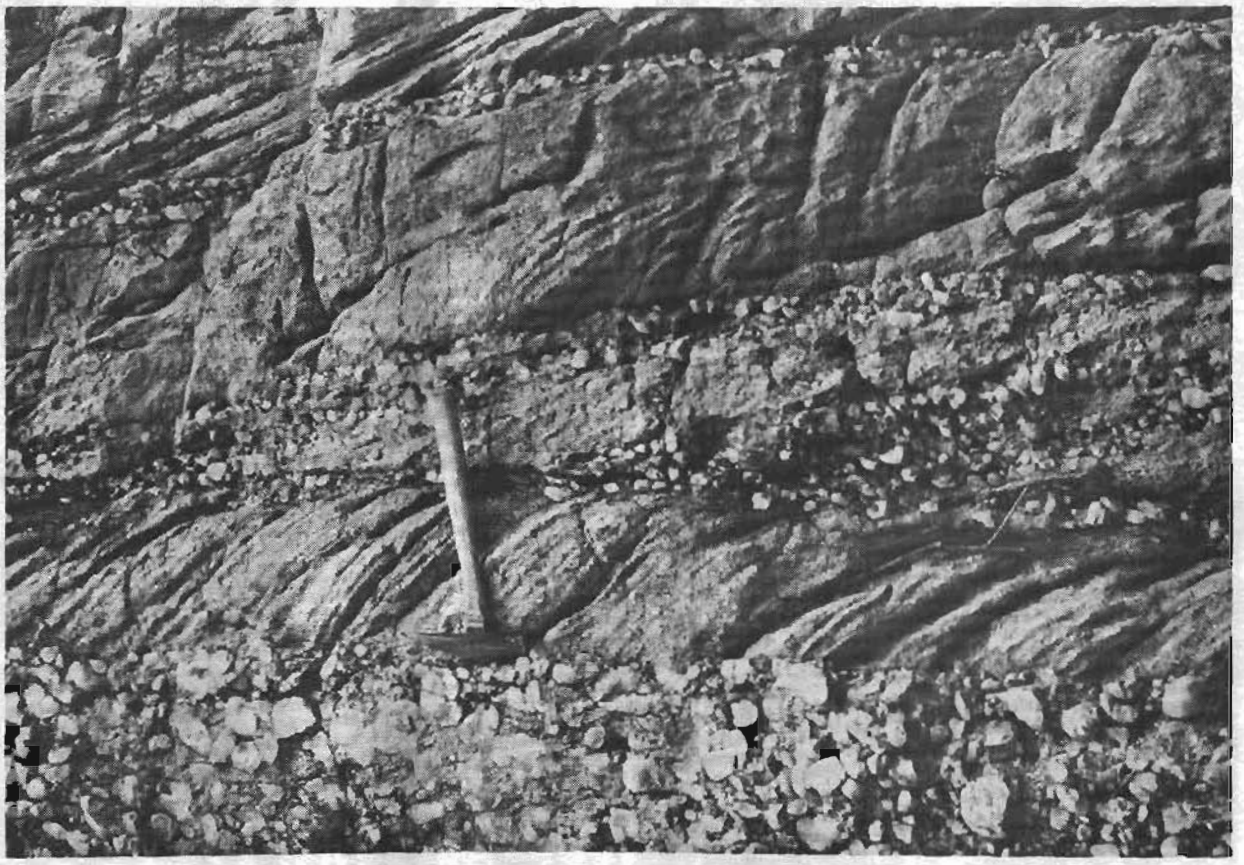


Figure 15. High energy environment with steeply crossbedded quartzite interbedded with conglomerate.

Having satisfied all the criteria which have been described in the formation of a paleoplacer deposit; the most important aspect is preservation. The situation must exist whereby the deposit, once formed, can be preserved from subsequent erosion. The preservation potential of the deposit, given the transient dynamic nature of the subaerial land surface, is not good. Special conditions of criteria are needed to cover a placer deposit once formed and protect it from erosion (Figure 16).

Such special conditions may involve:

1) Rapid inundation by volcanic rocks.

2) Rapid burial in an active tectonic environment.

3) Rapid incision of an earlier base level by rejuvenated drainage, producing elevated bench placers.

Examples of all these situations can be found in Alaska. One environment I would advocate investigating thoroughly would be the base of Tertiary coal basins, especially where proximal provenance criteria can be satisfied. With few exceptions, paleoplacers are hardrock propositions (bench and

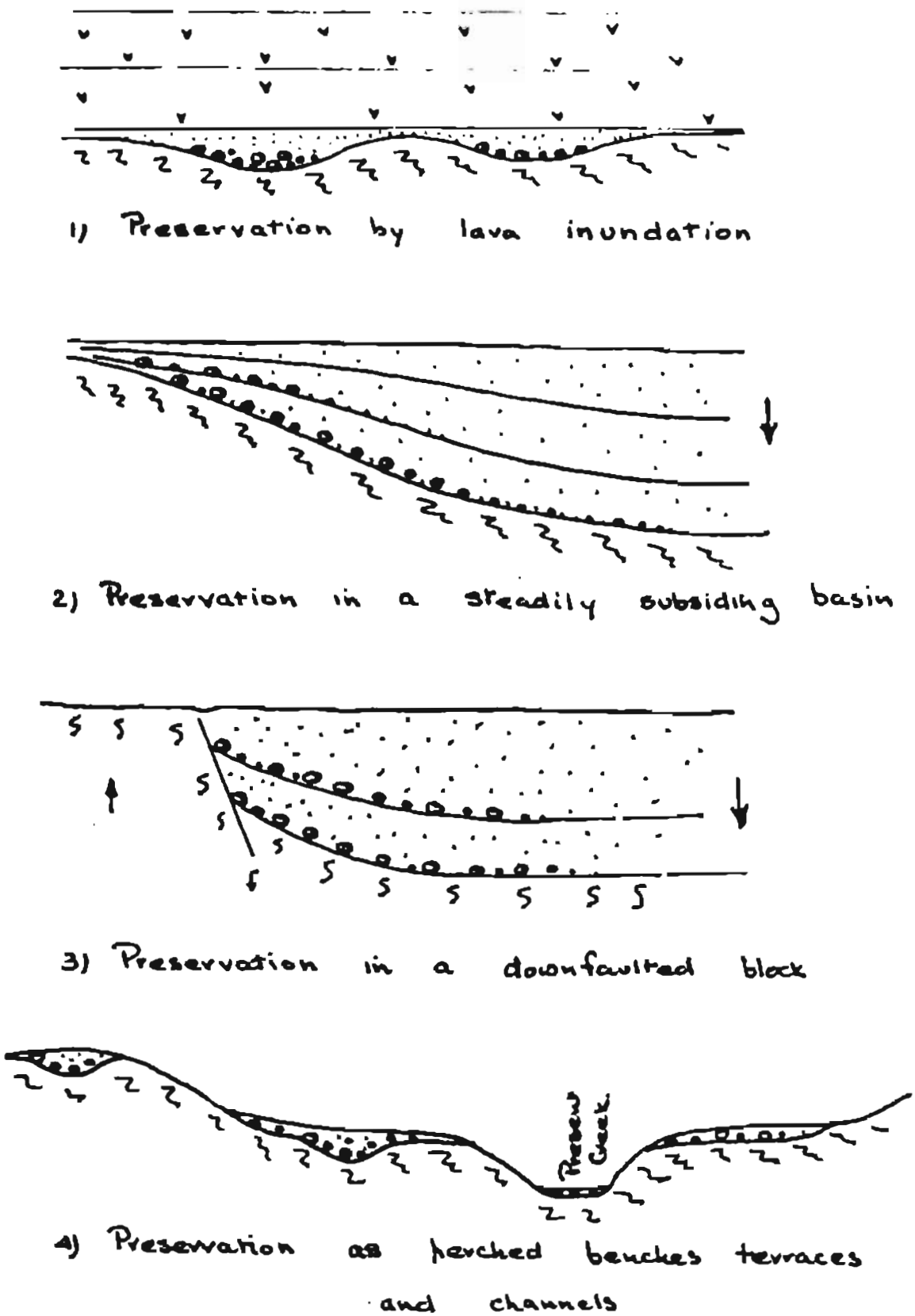


Figure 16. Preservation of a placer deposit is required before it can become a paleoplacer.

elevated channel deposits, such as the White Channel in the Yukon, are exceptions) and this is a factor that immediately equates with high mining costs. In Alaska, however, it may be easier and cheaper to effectively mine consolidated paleoplacer deposits than deeply buried frozen gravels found in drift situations. As far as paleoplacers in Alaska are concerned, I can only restate my conviction that there are many out there awaiting testing and discovery, and perhaps Nelchina will not be the last gold stampede.

AREAL DISTRIBUTION OF GOLD-SILVER RATIOS IN THE FAIRBANKS DISTRICT

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M.I.R.L.
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Gold fineness values for Alaskan placer deposits were calculated using mint return production records and the following formula for gold fineness:

$$\text{Fineness} = (Au/(Au + Ag)) \times 1000.$$

Past gold and silver production records from individuals and mining companies for the period 1900-1974 from 800 creeks in Alaska were examined and 550 creeks with production in excess of 100 troy ounces of gold were selected for data analysis. The data are summarized according to 41 mining districts and six regions.

The overall mean fineness for the 550 samples is 889, the standard deviation of the mean is 28.57, the 95% confidence interval for the mean is 880-898. The mean gold fineness values for the six regions studied are:

	Fineness	No. of Districts
Seward Peninsula	908	9
Upper Yukon-Tanana	884	11
Chandalar-Koyukuk	898	2
Lower Yukon-Kuskokwim	880	9
Copper-Susitna	886	8
Southeastern	893	3

The values for individual placers range from 567-995. One-way analysis of variance among the six regions and the 41 districts shows that the regions and districts can't be distinguished on the basis of gold fineness. The Kantishna district is anomalous and has the lowest mean value of 789, the lowest individual sample value of 567 and a coefficient of variation of 16 versus the average coefficient of variation of 4.33. The Rampart and Council districts have a mean fineness of 915, the highest mean values of the districts. Several districts, Kantishna in particular, have bimodal distributions of fineness, suggesting different sources of gold or different processes affecting deposition.

We were unable to relate the gold deposits to particular host rocks or to discern clearly the relationship of intrusive rocks to the placer deposits.

CHEMICAL ZONATION IN PLACER GOLD NUGGETS

Dr. Robert Forbes
Senior Geologic Consultant
Geophysical Institute
University of Alaska

Chemical Composition and Fineness of Placer Gold

As discussed in a previous paper at this conference, naturally occurring gold from either lode or placer deposits is not 100% pure. Although we generally think of silver as the most important alloying element in natural golds, several other elements are important constituents of unprocessed gold.

In general, placer gold is of higher purity than lode gold. This increase in fineness is related to several factors, including initial composition in the mother lode, grain size, transport time, distance from the source, the chemistry of the water and the paystreak environment.

To give you some idea of the range of fineness of placer gold, we can refer to the pioneering study of P. F. Smith of the U.S. Geological Survey, who surveyed the fineness of gold from Alaskan placers in 1937. Smith found that the fineness ranged from 970 to slightly less than 565, based on assays of 1,534 samples of placer gold from various locations in Alaska. Figure 1, a histogram, shows the distribution of fineness of Alaskan placer gold from Smith's data. As we can see from the diagram, 23% of the analyzed placer gold samples had a fineness higher than 900; 42% between 850 and 899; 26% between 800 and 849 and 9% of the gold had a fineness less than 805. Smith also recognized that metallic elements other than silver were responsible for the fineness variations in native gold, but he quite rightfully downgraded the importance of the troublesome impurities, as they merely reduced the value of the mint receipts in the old days and had no apparent positive economic significance. However, we are beginning to realize that the minor and trace element composition of both lode and placer gold carry interesting messages, which can be applied to the development of exploration and prospecting programs. Time won't permit an extended discussion of the trace element composition of native gold and all of the implications, but let's take a quick look at the essentials.

As stressed before, silver is the most important minor constituent of most native gold. Silver is succeeded in relative abundance by iron, copper, lead, bismuth, arsenic and mercury as trace constituents. Tellurium, platinum and cadmium may also be present, with a few other trace elements reported more rarely.

Silver Leaching in the Placer Environment

It has been recognized for many years that, in most placer streams, gold fineness tends to increase downstream. However, this increase in fineness is usually related to a systematic decrease in grain size in the

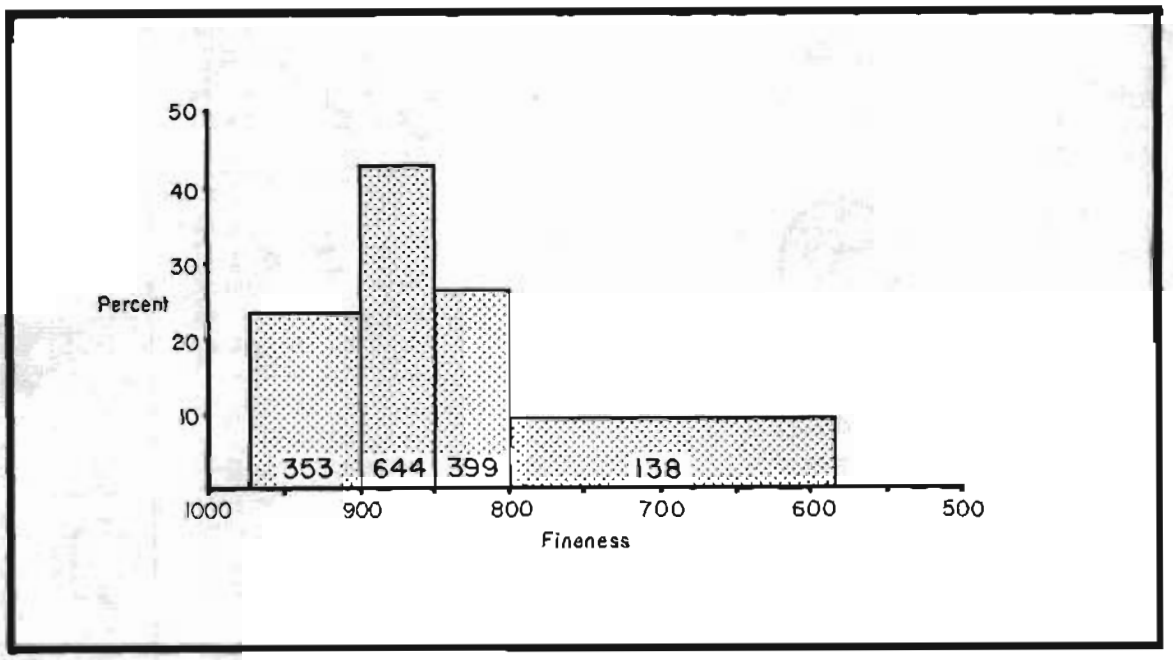

Figure 1 Histogram of the fineness of placer gold, based upon assay data from 1,534 samples from various locations in Alaska (from Smith, 1941).

lower reaches of the stream, as the grade of the channel decreases (Figure 2). Based on the work of Desborough (1970) and others, and several recent Russian papers, increasing evidence has been accumulated which indicates that silver is selectively leached from the exterior of gold nuggets and grains in the placer environment. Other trace elements may also be leached from the exterior surfaces of placer gold, but to our knowledge this possibility has not really been investigated. Equally interesting is the possibility that gold may scavenge certain elements, including mercury, in the placer environment. If the leaching of silver is related to the time that the gold has resided in the stream which deposited the paystreak, then the leached zone should be the same thickness in coarse and fine placer gold.

As Figure 2 illustrates, the smallest gold grains could be completely composed of leached gold, and therefore of very high fineness, if the total sample in each case is analyzed.

Scanning Electron Analyses of Authentic and Bogus Placer Gold

We decided to test the leaching theory by analyzing gold grains of various sizes (see Figure 3), using wave length dispersive analyses obtained with a scanning electron microscope, at the Geophysical Institute, University of Alaska. Initially, we analyzed the surface of several placer gold flakes, which were less than 1 millimeter in diameter, and were unable to detect any silver. Subsequent experiments showed that the scanning electron microscope technique can detect silver down to about 30 or 40 parts per thousand (3% to 4%). We then analyzed the surface of a small nugget from

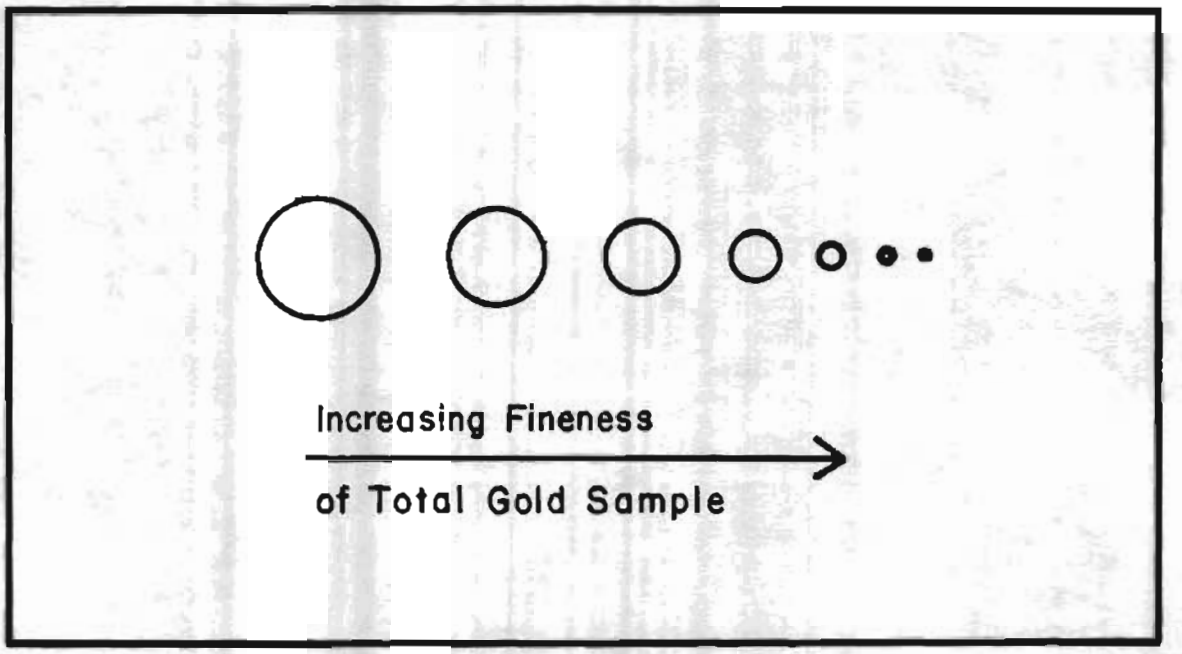

Figure 2 The grain size/surface area ratio vs fineness in leached placer gold.

the same placer cleanup that produced the fines. Two runs failed to produce detectable silver, and we concluded that the exterior of the nugget was depleted in silver. The same nugget was then polished with crocus cloth, and about .5 millimeter of gold was removed. As you can see from the assay, about 13% silver is now present, and the gold under the depletion rind has a fineness of about 870. A second polishing removed another .5 millimeter of gold, and the next scanning electron microscope analysis produced a somewhat similar gold-silver ratio. Although the silver content in this zone is apparently less than in the previous analysis, the difference between the two analyses is probably not statistically significant. We should also mention that trace amounts of iron were detected in both analyses of the polished gold surfaces.

No Grub Creek Placer Gold Analyses

(Samples provided by J. Parry)

Sample	Fines	Small Nuggets	Small Nuggets	Small Nuggets
	(1mm)	(.2 x .3 cm)	(.2 x .3 cm)	(.2 x .3 cm)
Zone	Surface	Surface	first polish	second polish
Assay Data	Silver N.D.	Silver N.D.	Gold .870 Silver .130	Gold .882 Silver .118

Figure 3 Gold/silver assay data for polished vs unpolished surfaces on a natural gold nugget.

Following these results, we were convinced that silver leaching versus grain size was a controlling factor in placer gold fineness. At the same time, another thought occurred to us. If most, if not all, placer gold has silver depletion rinds, wouldn't the presence or absence of such rinds be a definitive test for bogus versus real placer nuggets? With that in mind, we acquired a suspected bogus nugget; a confirmed bogus nugget, with a known chemical composition and another authentic placer nugget, this time from California rather than Alaska.

The results are shown in the Figures 4, 5 and 6. The assay data from the known bogus nugget seems to confirm our premise, as there does not seem to be any statistically significant difference in the gold/silver ratio between the surface and polished surface gold and silver ratio, and there was good agreement between the known composition and the assay. Based on similar evidence, the suspected nugget may indeed be a bogus nugget, as there does not seem to be any statistically significant difference in the assayed gold-silver composition of the unpolished versus polished surfaces.

The Californian nugget (Figure 6), however, is characterized by a significant difference in the gold-silver ratio determined for the natural surface versus the polished areas; which reinforces our contention that placer nuggets usually have silver depletion rinds. In this case though, I think it is interesting to note that there was detectable silver on the exterior surface of the nugget, and keeping in mind that the Californian placer environment is somewhat different than our permafrost placers here, we may have a difference in conditions that are influencing this relative effect.

The bogus nugget business seems to be thriving these days. For those who are interested, the silver depletion criteria could be useful for distinguishing authentic versus bogus placer nuggets.

Current and Future Research Topics

Before closing, however, I would like to share some additional preliminary information with you, derived from our gold investigations that are still underway. Although placer fines may be depleted in silver, the leaching process does not seem to extract trace mercury. Most placer gold contains trace mercury, regardless of grain size. Bogus nuggets composed of melted placer fines are depleted in mercury, and to a lesser extent, in some of the other volatile elements including bismuth and lead. Acid cleaning of gold, for jewelry or other purposes, will deplete silver and other trace elements from the surface areas of particulate gold (Campbell, et al., 1973). The effect is very similar to that in the placer environment, but at an accelerated rate, of course. Two-cycle placer gold appears to have a thicker silver leach zone than one-cycle gold.

There is some question as to the origin of trace mercury in placer gold as compared to lode gold. In some districts, placer gold carries greater concentrations of mercury than the adjacent lode deposits, which are believed to be the source. There is some evidence that the gold may pick up some of the mercury in the placer environment, and explorationists may find this useful.

Bogus Nugget

Zone	Surface	Known Composition	Polished Surface
Assay Data	Gold .911 Silver .090	Gold .920 Silver .080	Gold .918 Silver .082

Figure 4 Gold/silver assay data for polished vs unpolished surfaces on a bogus placer gold nugget.

Suspected Nugget

Aone	Surface	Surface	Polished
Assay Data	Gold .886 Silver .114	Gold .852 Silver .148	Gold .877 Silver .123

Figure 5 Gold/silver assay data for polished vs unpolished surfaces on a suspected bogus placer gold nugget.

California Placer Gold Nugget

Zone	Surface	Polished
Assay Data	Gold .956 Silver .044	Gold .908 Silver .092

Figure 6 Gold/silver assay data for polished vs unpolished surfaces on a California placer gold nugget.

Future studies will include x-ray microprobe analyses of nugget cross-sections, in an attempt to test the theory of in-situ growth of gold nuggets in the placer environment.

Acknowledgements

I would like to thank Jim Parry for the samples of the placer gold from No Grub Creek, and Wayne Leicht of "Kristalle", Laguna Beach, California, for the bogus and suspected bogus nuggets, and the authentic California placer nugget. SEM analyses were funded by the Mineral Industry Research Laboratory, University of Alaska, and the SEM analyses were done by Ms. Mary Ann Borchert, Geophysical Institute, University of Alaska.

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GOLD - THE ULTIMATE HEDGE

Mr. Peter A. Bushre
Deputy Commissioner of Revenue
For the State of Alaska

Gold is something very near and dear to my heart. I have a different perspective on the subject than you do. I am not a miner and I won't talk to you today about how to mine for gold, or where to find it. What I will talk about is, why gold is mined. I plan to give you the user's viewpoint, both in a general sense, and secondly, as it affects Alaska directly.

The statistics and information that we have been receiving in this morning's sessions and some of the statistics that I have personally run across in my experience connected with mining, are quite fascinating. For example: The fact that, for all of his efforts, mankind hasn't extracted very much gold from the earth. If all the gold that has ever been mined, thoughout all of recorded history in the entire world were to be melted down and fused together, it would make one great big cube, 54 feet on each side. When compared to other minerals, this isn't really that much. It is interesting to note that men have dug deeper into the earth to mine gold than any other mineral. For example: One of the major producing mines in the South African Rand is extracting ore from over 12,000 feet below the surface of the earth. At that depth, the temperatures under which men work is more than 125 degrees fahrenheit. The pressure is so great that the rock walls in the shafts can explode with the force of a cannon.

It seems to me that gold must be an extremely valuable mineral for mankind to literally go through 'hell', because I can't imagine a scenario that more closely resembles the Inferno of Hell than a picture of one of the largest producing mines of South Africa. Yet, its use is rather limited as a mineral. We all know that it has certain industrial applications. For example: It is an excellent conductor of electricity; it doesn't corrode; the space effort used gold to shield the astronauts, because gold is probably the most effective deterent to radiation; approximately 1,000 tons a year is used in jewelry (a lot of it represents recycled gold). We really can't find the true use of gold in these areas. We can't find the reason that men go through literal 'hell' to extract gold, in the industrial sector.

The real reason that mankind mines gold can be found at 33 Nassau Street, New York City, U.S.A. That is the address of the Federal Reserve Bank of New York. Eighty feet below the surface of Nassau Street, in a vault, there lies 400 million ounces of gold bullion; all of it 995 fine. That, ladies and gentlemen, is the 'real' use of gold. Its true value is a monetary value. It has come to acquire this use because, over the centuries, it has proved itself to be the only reliable non-political store of value that men have ever found. Because of that, they trust it. Consider the Mid-East, there are few sectors of the world that are in more political turmoil today than the Mid-East. It also has most of the world's wealth in the form of oil and due to the huge transfers of dollar assets from other nations to pay for this oil. Yet, we read of revolutions; we read of the hostage situation in Iran; we read of the invasion of Afghanistan, the list is almost endless. For

the forseeable future, I'm sorry to report to you that the turmoil is probably not over. Our best sources of information, which include a gentleman who is financial advisor to SAMA (the Saudia Arabia Monetary Authority) indicate that informed opinion would give the Royal Family of Saudia Arabia no more than 18 months, for Saudia Arabia may then be overthrown with a Khomeni style revolution.

Shortly following the capture of the hostages in Iran, President Carter announced that he was freezing all of the assets of the Iranian Government held in American banks. He was responding to a threat from Iran, to withdraw these assets. The best estimate, that I have heard, would place these assets at about 8 billion dollars, which is really a small amount of money in the entire world's economy. Yet this act of President Carter's sets a precedence with global impact. America became the first country to freeze the assets of another country, during peacetime, in history. And, in doing so, President Carter sent out a signal, although unspoken, to the finance ministers of every OPEC nation in the world. That message was: 'There for the grace of God go I'; what he can do to Iran he can do to me. Everytime the price of oil goes up in America, doesn't President Carter go on National Television and blame OPEC?

Perhaps what the oil ministers need to do is diversify their holdings, because most of them are in U.S. dollars; most of them are held in U.S. banks. But, where can they go? British pounds; they can do the same thing. French francs, Japanese yen; the same answer. What they needed was a non-political store of value, and they needed it fast because they were scared, and so they started buying gold like there was no tomorrow. You saw what happened. The price sky-rocketed, because that 54 foot cube represents a rather thin market.

Now, gold has become the primary reserve asset of every major industrialized nation on earth. One half of the world's gold is sitting in the vaults of Central Bank, either 80 feet below 33 Nassau Street in New York City or in other Central Banks around the world. If you'll look in your wallets, perhaps you have a $20 bill. My parents used to tell me of the days when they didn't use those $20 notes from the Federal Reserve Banks, they used to use something called a 'double eagle'. It was a gold coin and it contained approximately one ounce of gold; gold sold for $20 an ounce. Now, you could get a note from the Federal Reserve Bank, but if you had one, that said $20 on it, you could take it to the bank and get your gold coin. This $20 bill was nothing more than a warehouse receipt. Today, this $20 bill is worth approximately $4.00; that is to say in terms of what you could buy for $20 in 1933, the year before gold became illegal to own by American citizens -- You can only buy 1/5th of those goods and services today with that same $20 bill. But, if you took that $20 gold piece; that double eagle, you would find that the one ounce of gold that it containsis now selling for a little over $500 today, and it has a certain collector's value that makes it even more valuable. Therein lies the reason. It's a perfect working example of why the primary use of gold is, today and has always been, nothing. It merely serves as a store of value, the base of everything else.

The secret of this lies in the fact that the value of real goods, tangible items, other minerals, poems; everything else, do not change in relationship to one another. They change in relationship to the dollars in which they're quoted. For example: A new pair of shoes is worth about the same number of gallons of milk that it was worth in 1930, 1900, or 1950.

In the International analysis, we have a theory that we refer to as the 'new suit theory', when we're describing the value of gold. The 'new suit theory' holds that: You could buy one new suit with an ounce of gold in 1850; 1900; or 1933; and today, depending upon where you shop, you might have a little change left over. This won't last if the price of gold should fall, in terms of dollars or if the price of the suit should rise. With the inflation rates that we're all living under today, I personally would expect the latter, before I would expect the former.

However, for Alaska, I think that nowhere is the real value of gold driven home more succinctly that when it's viewed in terms of oil. Recently, oil has become the No. 1 economic base of this State. If you look at the statistical record and convert the price of oil into terms of gold, you will find that there has not been, over the last 15 years, any increase in the price of oil. Now, we all know that it has sky-rocketed in terms of dollars, but remember the price of gold has sky-rocketed, and they have sky-rocketed in tandem with each other. So, what you are left with, if you chart this action on a piece of paper, is a horizontal line. Here, we have one of the most unique ironies for this State. Here we are selling one of the most valuable assets on earth; oil. And, we're taking, in exchange, a wasting asset; cash, something that begins to depreciate as soon as you touch it. And, as treasurer, it is my job to find something to invest this 'cash' in. Ladies and Gentlemen, I can't find anything that will hold its value better than the oil, unless it's gold. Because of this, for the last year and a half, I personally have been advocating that the State of Alaska BUY GOLD AS AN INVESTMENT. Of course, we would never put all of the State's money into any one thing; gold included. Gold's store of value quality makes it stand out as far, far more valuable than any other investment we have.

To understand the reason for this is we have to go back and look at the type of investing the State is involved in. Basically, there are two types: 1) There is the social investing that you read about in the newspapers every day and which you undoubtedly will read more about in the months to come. That's not the type that I'm talking about. 2) I'm talking about 'trust investments'. We manage the two State Pension Funds and the State Permanent Fund for a total of more than a billion dollars in assets. These funds are strictly governed by what is known as the 'prudent man rule'. Let me quote to you: This rule was something developed by a Massachusetts jurist in 1830 by the name of Samuel Putnam. He was trying to find a reason to decide on a particular case, whether someone had bought a good investment or a bad investment. Just as Putnam said, and I quote, "If a judiciary shall act with the care, skill, prudence and diligence under the circumstances, then prevailing, that a prudent man, acting in a light capacity and familiar with such matters, would use, in the conduct of an enterprise of a light character with light games." Basically, this means simply: You don't take unnecessary risks, but you don't put all your eggs in one basket; and that your

first and only responsibility is to the beneficiary for whom you are investing. It further means that the term 'Prudence'; what you should do; what investment you should make is directly related to the economic conditions prevailing at the time you make the investment. Or, what is prudent today, isn't necessarily going to be prudent tomorrow, and what was prudent yesterday, isn't necessarily prudent today.

That's the position we find ourselves in. In my book, the prudent man would do everything he could to protect himself from inflation. The current law that Alaska has to invest its money under was made at a time when there wasn't any inflation to speak of.

Over the last ten years, the inflation rate of the U.S. has averaged approximately 7% to 8%. A few months ago, in headlines in both the Anchorage, Fairbanks and Juneau papers, the U.S. Department of Labor announced that the cost of living in America today, doubled between 1970 and 1980. This means, to all of us, that on average, everything we buy costs twice as much as it did 10 years ago. Today's inflation rates are considerably higher. Since the beginning of 1979 America has had double digit inflation. In every month of 1980, we have had higher than 15% inflation. In fact, this quarter's inflation rate will probably average out at 18%. The wholesale price index recently came out indicating producer prices of 19%.

Ladies and Gentlemen, at these rates, the cost of everything that we buy is going to double by 1985. And, if this rate picks up, it will double even faster. Remember, this has a compounding effect. Once it doubles; unless the inflation stops, it will double again from that base, and again and again. We all know about the energy crisis in America today. We now import more than 50% of our energy, whereas at the time that the State of Alaska developed its investment's law, inflation was less than 2%. America was energy self-sufficient and oil cost less than $2.00 a barrel. This seems ridiculous in today's world.

I think the most telling example of how far we have come in our thinking is to go back to 1971. Remember when Richard Nixon imposed the price and wage controls? Do you know what the rate of inflation was, at that time? Conditions had gotten so desperately out of hand, that drastic action had to be taken. Action that everybody had advised against, unless it was a last 'ditch' attempt to stop the effects of inflation. Ladies and Gentlemen, the rate of inflation at that time was 4½%. Now, we don't even bat an eye at 18 or 19%. As a result, the investment climate has gone to pieces. The stock market, is selling at levels below those at which it was selling in 1970. If the cost of living has doubled, it seems to me that the investment should double too, just to stay even. Instead of doubling, it dropped.

The bond market is currently going through a collapse unprecedented in American History. It is going through a collapse that is just as cataclysmic and just as significant as the crash of '29 was to the stock market. Triple A corporate bonds, selling at 30% of parr! It's unheard of! Our American dollar collapsed in 1978, and of course, the price of gold reached just unbelievable heights, as little as 6 weeks ago. So, here we are, in, what I would term 'A perfect Catch 22 situation'. The investments that the State

can buy are no good for today's conditions. The investments that are good for today's conditions, we can't buy.

I've been asked, 'Why really do you want to invest part of the State's money in gold'? It doesn't pay interest; it doesn't pay dividends; you actually have to pay a safe-keeping charge. Why would you give up all of that in order to hold an inert metal, that has absolutely no use except that everybody else holds it? Well, my answer is simply, "I'm perfectly willing to give up even an asset that doesn't appreciate in real terms (that's inflation adjusted in terms). All of us should know that gold really stays constant. It's everything else that either appreciates or depreciates. All of that is far better than having something that loses, which is what we have now.

I called my office this morning just to see how things were going. I found out that we earned 18% for overnight money. I'm sure many of you now are doing mental arithmetic, and you realize that that's 1% short of the rate of inflation. I also ran a little calculation, which really crystalizes what I'm trying to say as a potential user of gold. If we had invested 15% of the State's Pension Funds in gold bullion on April 30th, 1979, when the price was approximately $240 an ounce, and then we took a look at where we were on December 31st, 1979 when the price was a little over $500; just about what it is today, I found that the appreciation of that small stake in gold would have more than offset the depreciation of all the other investments the State has and would have given us 40 million extra dollars to boot.

Now, you see why I, as State Treasurer, would like to buy gold. But, there's also another reason, Ladies and Gentlemen. The history of our great State is really wrapped up in gold. The rest of the world knows us for the goldrush days; they don't really know us as an oil producer. They don't really know us as a strategic military base; they know us an a gold producer, and it is interesting to talk to people in other parts of the country; even other parts of the world, who don't really realize how small Alaskan gold production really is today.

I am very hopeful that someday we will find ourselves buying gold, because I think that the future of our State will be found in mining; particularly gold mining. The reason, of course, is tied to what I have just explained to you. Gold is the lynch pin of everything else; it's the ultimate foundation on which the trust that all the financial markets of the world operate on. We have the gold! We used to be a big producer, and I think we could be again. I think what we need here in Alaska are markets, and believe me Ladies and Gentlemen, they're there. The two primary producers of gold in the world are South Africa and Russia. The political future of the first is a little in doubt. The second is a user of gold. I'm not just speaking of government in this case, because the large European banks have, ever since the Second World War, recommended gold positions to their trust clients of 10% to 20%. I have contacted some of them to see what their interest would be. They've indicated to me a tremendous interest in securing a source of production in the free world, as an alternate to South Africa and Russia.

Ladies and Gentlemen, there is a great deal that we could do. The future of Alaska is really in your hands, as miners and representatives of

the mining industry. If it ever gets going again in Alaska, I'm quite confident that it will be like nothing we've ever seen before!

In conclusion, I would like to refer to a few lines of poetry. I can't remember the author, but they're very appropriate to what we're doing. We have an opportunity here, and all we have to do is grasp that opportunity. The lines of poetry are this:

> "Of all the words written by the hands of man,
> The saddest are these: IT MIGHT HAVE BEEN."

Ladies and Gentlemen, I hope and pray that those words will not apply to Alaska in a negative sense. Thank you very much.

OVERVIEW OF EXPLORATION METHODS

Ernest N. Wolff
M.I.R.L.

Gold has been discovered in Alaska using many different methods. When George Carmack and his party entered the Klondike district they discovered gold by panning the surface gravels. The Fairbanks District was discovered by Felix Pedro and his friends who came over from Circle and spent the winter of 1901-1902 on Bear Creek, which lies between Fish Creek and Fairbanks Creek. They sank shafts to bedrock, but were disappointed with the results, and they shifted to what is now called Pedro Creek. The depth was about 12 feet, probably taking them 3-4 days to dig, and they found coarse gold.

At Nome, gold mining of the streams and rivers led to the accidental discovery of beach gold.

The early discoverers spent most of their efforts traveling, usually taking a rambling route and arriving perfectly by chance at a discovery. Some however used systematic methods.

The Chandalar District, for instance, was discovered by long, hard work. Frank Yasuda and his partner, Thomas G. Carter, had entered into an agreement. Carter would first prospect one side of the Brooks Range and then the other side, while Frank Yasuda provided the grubstake and hauled it to him. They spent several years testing the shallow creeks, finally locating pay ground on Little Squaw Creek.

In Livengood the discoverers found gold first in the creek, then up on the benches after sinking 100 foot shafts.

The Juneau district was discovered by Joseph Juneau and his partner Richard Harris, probably guided by natives. They first found gold in Gold Creek, after which they found the lode deposits. They had been guided to the general area by an earlier report by John Muir.

None of these discoverers used a drill, even though drills were available in these days. They went in with what they could carry on their backs, so their equipment and methods were simple. Simple prospecting equipment includes gold pans, rocker boxes, and small sluices. Sampling methods include surface panning, ground sluicing, trenching or making a cut, sinking shafts and drilling.

The gold pan is one of the most thorough gold extracters. It is simple, light, and quick. When panning a new creek you have to get down below the surface to where the gravel has not been disturbed by running water. One usually digs a shallow drain about 2 feet deep, being careful to wash all the gravel being removed (Fig. 2). The idea is to remove the gold-bearing gravels and to concentrate all the gold contained in it at the bottom, then pan it.

Ground sluicing is another method of removing a section of ground while leaving the gold behind. A dam (Fig. 3), splash box, or ditch is constructed and running water is directed across a bench or other ground to be tested. As the gravel and fine material is washed away by the water (Fig. 4), large boulders must be tossed out by hand. The gold is then panned out of the bottom of the cut. This is a simple way of testing for gold prior to bringing in more expensive equipment (Fig. 5).

A backhoe (Fig. 6) or giant can be used for the same purpose, although the backhoe removes all the material, gold and gravel, in a cut and requires careful sampling techniques.

Gordon Hilchey will cover shaft sinking (Fig. 7) in a later paper. I might mention, in passing, that the U.S. Smelting, Refining & Mining Company actually froze sections of thawed ground and then sank shafts using conventional thaw techniques. It took them several weeks to freeze a plug down using antifreeze, pumped down through cooling lines, with a radiator on the surface. Of course this had to be done in cold weather.

In the Koyukuk area, below Wiseman, they used natural cold to freeze a thawed creek. They sank shallow shafts, and the ground between them froze by the first of the year. The six feet above bedrock remained thawed. This area was drained using a covered drain. Then they could get in and prospect or mine on down to bedrock, during the rest of the winter.

It is also possible to case through thawed ground as Mr. Hilchey will mention in his paper.

Drilling is an important prospecting tool undergoing considerable change at this time. The churn drill (Fig. 9) is the tried and proven tool for gold prospecting, but it is slow and requires a lot of skill to get accurate results. The churn drill operates by the chopping action of a bit which is raised and dropped about once a second. If the ground is thawed, a pipe (casing) is driven ahead of the bit. The gravel trapped in the center is chopped out with the churn bit. One must lift the bit before reaching the bottom of the casing, leaving a plug of ground in the bottom of the casing to prevent contamination from material being forced into the casing.

The material broken up by the churn bit is brought out of the hole and is given to the panner to recover the gold (Fig. 10). If one is using a faster drilling method one must either have a faster recovery method or store the samples and work them down at a later date. A rotary drill is faster, but it has problems in thawed ground. In frozen ground it blows material back up the hole outside the pipe, and contamination is possible. Even center return rotary drills still have problems.

A drilling program is usually designed to cover a stream with holes spaced 50 or 100 feet apart on a line across the valley, with lines spaced perhaps 500 feet apart. Accurate recording of the drill hole returns will produce estimates for the total yardage of muck, gravel and value. Each drill hole is allowed to extend its influence halfway to the next hole. There are several methods for calculating the values and weighing the results

statistically to determine the ground that can be mined profitably (see: Parks, Examination and Evaluation of Mineral Property; Addison Wesley, 4th ed, 1957).

The old churn drill is accurate, but slow. If we are going to be working lower grade ground in the future we're going to have to speed up our prospecting. The gold produced this year is only 1/10 of the gold produced in 1941, and we are capable of moving material faster than ever. I expect that within the next few years drilling technology wwill improve and we will be able to drill 30 feet in an hour, with accurate results.

Several geophysical methods apply to placer exploration. They are not evaluation tools, but can direct a drilling or backhoe program to a target area.

Seismic profiling of the depth to bedrock can determine the presence of, or map out the trend of an old, deep, channel. One would expect the best gold values on the deepest bedrock, or in channels.

In some areas the black sands which concentrate along with the gold may be chiefly magnetite. If so then a magnetometer can be used to locate channels or pockets of concentrated magnetite, hopefully with fine gold concentrated in the same places. (See MIRL special paper No. 2).

Figure 1. Modern transportation makes prospecting simpler today.

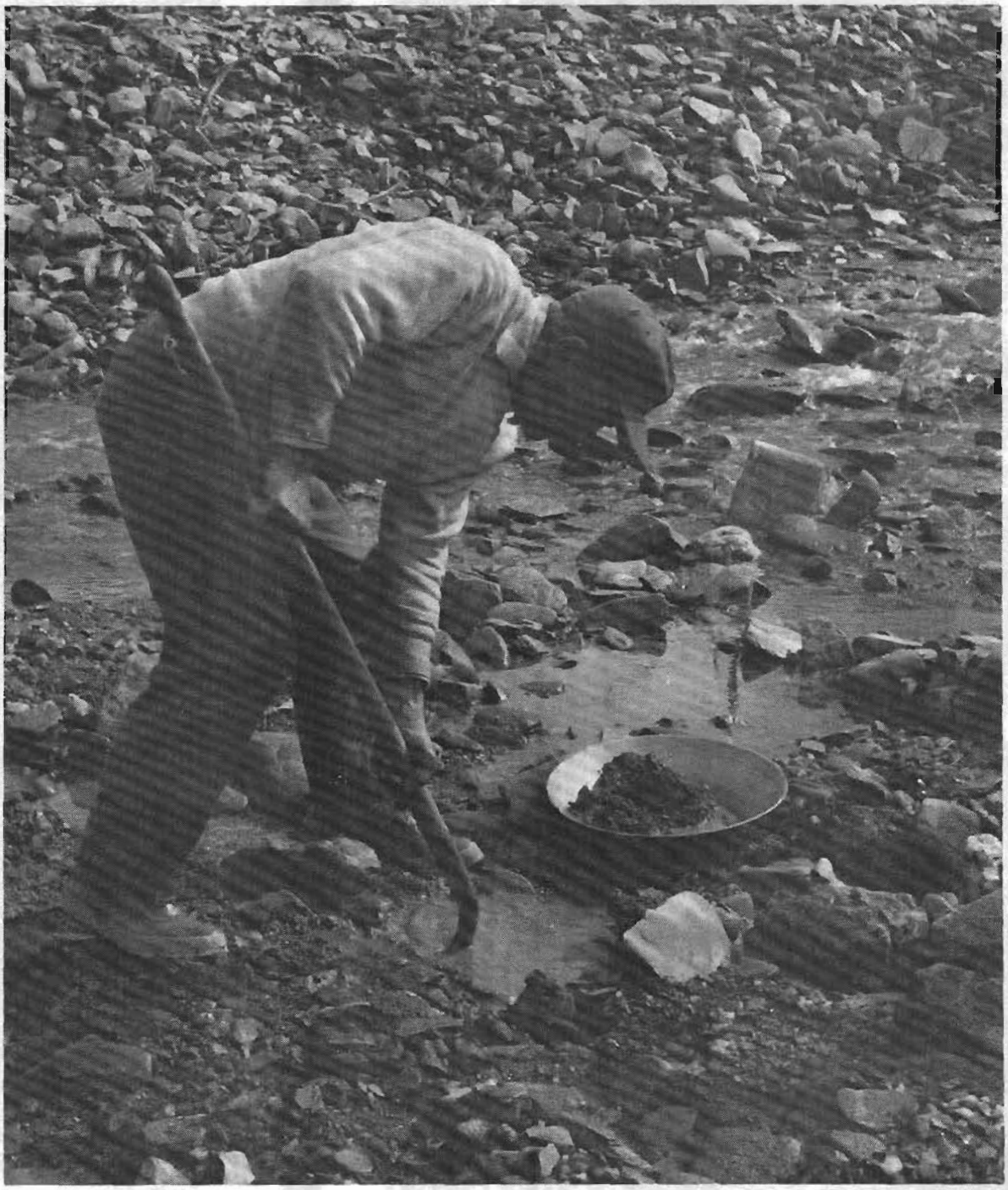

Figure 2. Panning in a shallow drain.

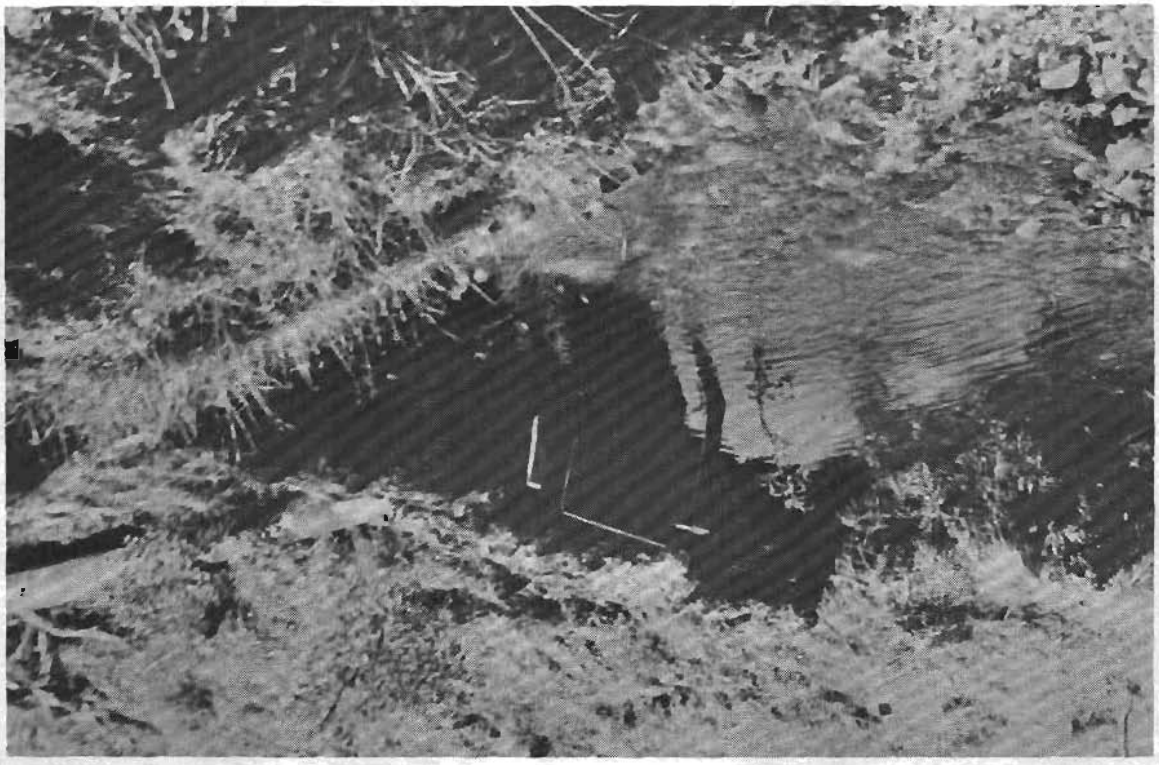

Figure 3. A small dam storing ample water for ground sluicing.

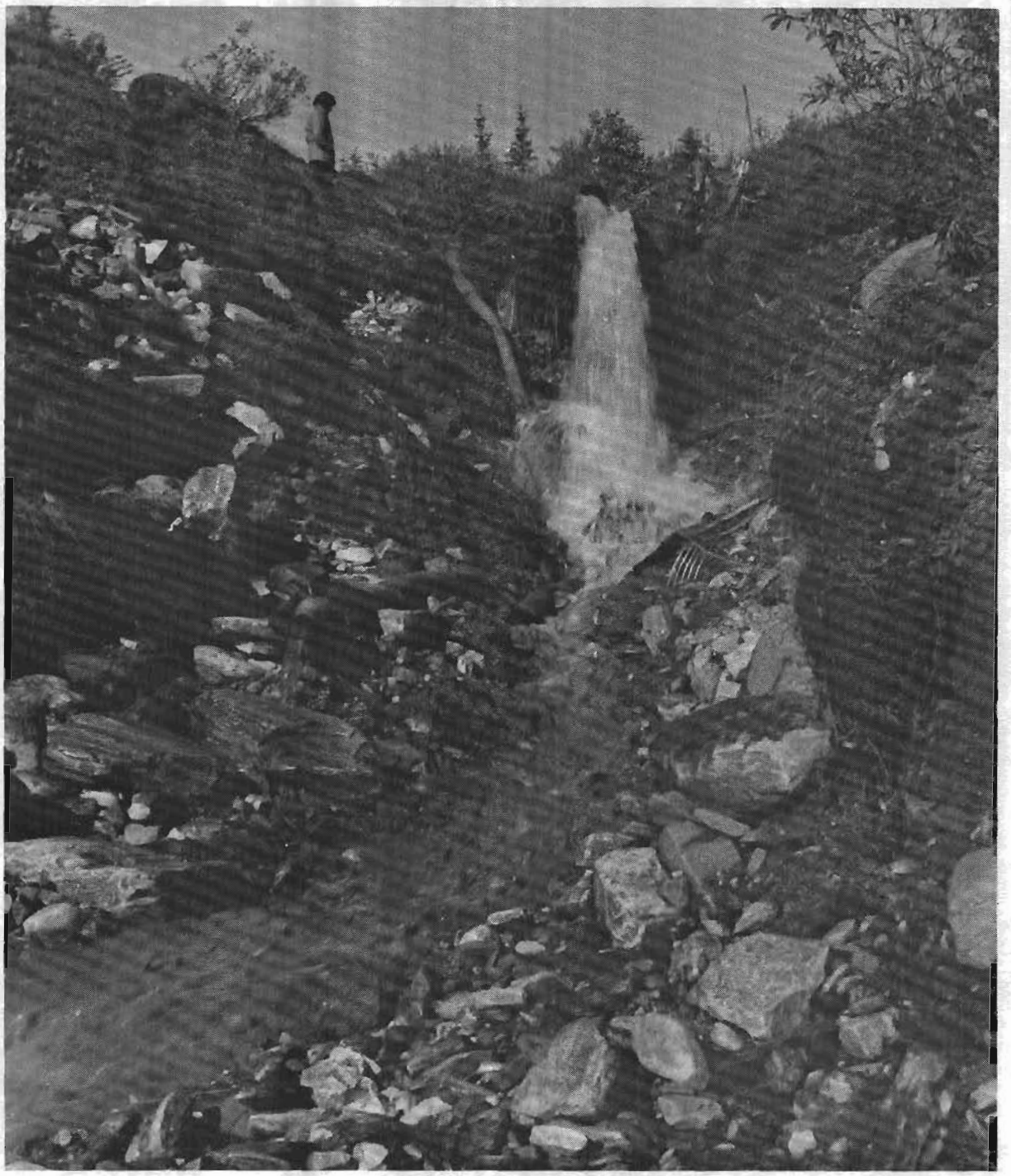

Figure 4. Ground sluicing a cut across a terrace or bench. Large boulders will be removed by hand.

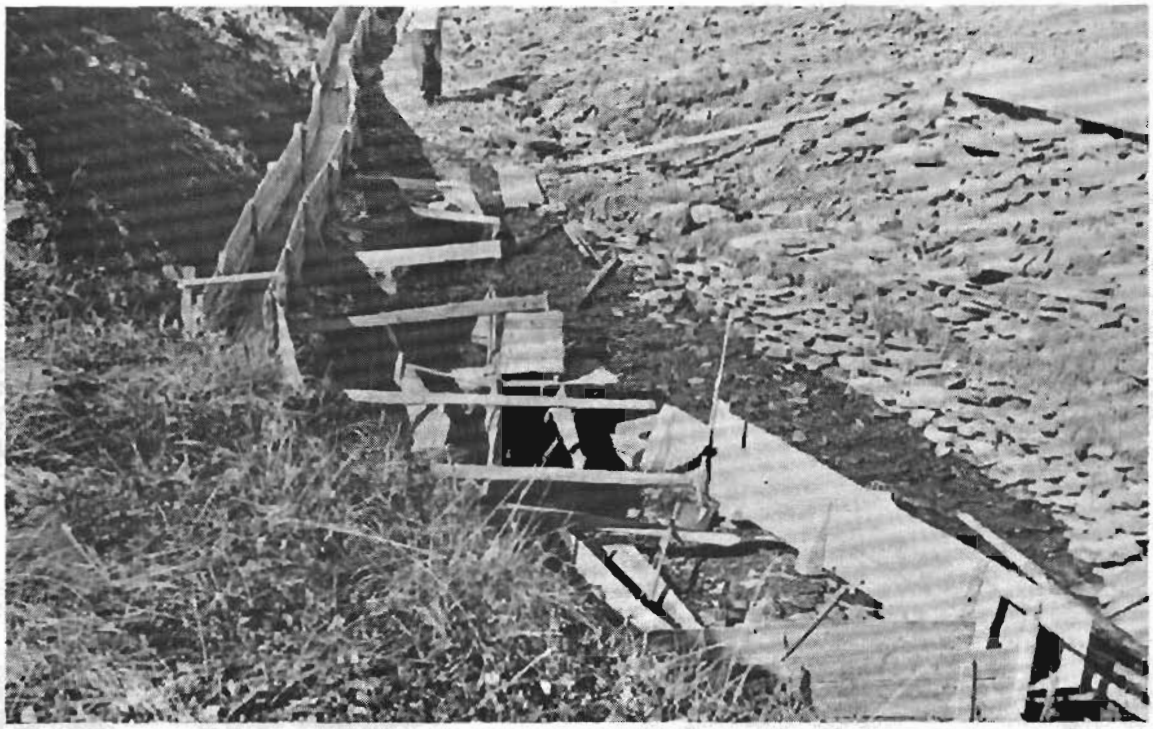

Figure 5. Ground sluicing is being used to mine this ground without more expensive heavy equipment.

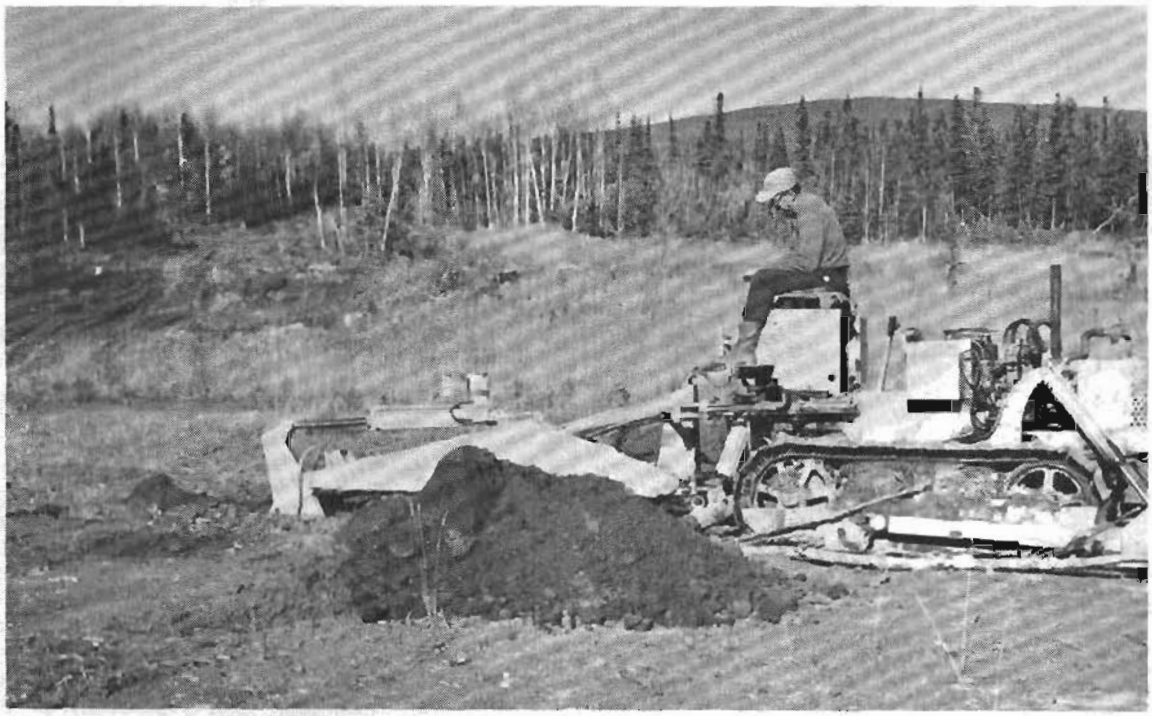

Figure 6. A backhoe is an excellent tool for testing shallow placer ground. Several models can reach 20 to 30 feet or more. Selective sampling of desired intervals, or the entire section, is possible.

Figure 7. Sinking a shaft during the winter.

Figure 8. This is one type of corner post used when staking claims.

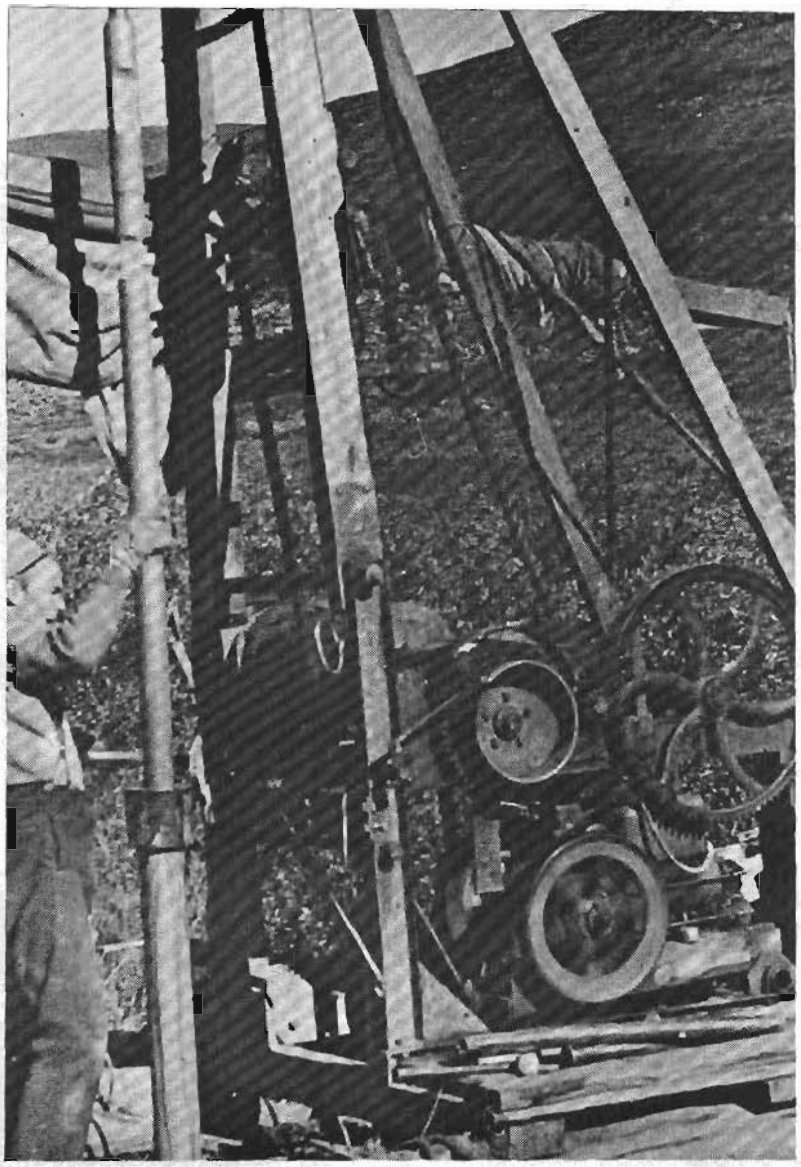

Figure 9. A Fairbanks churn drill.

Figure 10. The panner works down the cuttings as they are brought up. The volume of the return, size of the gravel, quantity and size of the gold must be recorded carefully.

Figure 11. As one old timer said: "Gold mining is not all beer and skittles."

EXPLORATION AND EVALUATION OF PLACER DEPOSITS BY SHAFTS AND PITS

Mr. Gordon Hilchey
Gordon Hilchey and Associates, Ltd.

About 50 years ago, Robert Service said, "Mining is only a gamble." As miners, we want to stack the odds in our favor, and testing is the best way to do it. We can test with a drill, or we can sink test shafts. In most placer ground a hole can be drilled in one shift. A shaft may take two to five shifts, and will cost about ten times as much as a drill hole.

Drilling

Let's assume that we have uniformly distributed gold in a paystreak six feet thick running $8.00 per cubic yard. We'll also assume fairly typical size distribution, and let $5.00, of the total $8.00 in gold per yard, be 35 mesh or finer; $2.00 will be 18 mesh gold; and $1.00 will be 10 mesh. In one cubic yard we will then have 400 pieces of 35 mesh gold, 16 pieces of 18 mesh and one piece of 10 mesh gold. If we drill a 7½" hole through this yardage, we'll get 27 out of 400 pieces of 35 mesh, 1 out of 16 pieces of 18 mesh, and .07 out of 1 piece of 10 mesh. Of course, you really don't get .07 pieces of 10 mesh, you recover one or none. In fact 37% of the time there won't be any 10 mesh gold. What is worse, however, is getting two or even three pieces- it's quite possible.

With the 27 pieces of 35 mesh gold we will be either 30% under or 40% over 95 times out of 100. A drill hole, then, can be very inaccurate. Averaging a large number of holes increases one's accuracy.

The actual recoveries of a placer operation from 1951 to 1955 will illustrate the accuracy of a drilling program. In 1951, the recovery was just under 100% of that projected by the drill program. In 1952, production was 162% of the projected recovery, a good year. In 1953, 113.8%, and in 1954, 70%. This last year was not very good but the four year average comes out to 100%.

In 1955 the production dropped to 42% of the expected return. Not only were there too few holes, but too large a percentage of the drill recovery was coarse gold. This was a year in which the miner probably lost money.

Shafts

Using the same hypothetical paystreak, let's compare the results of a 4' by 6' shaft. A 3' x 5' shaft is about the smallest one can dig, and will yield roughly half the return. Instead of 27 pieces of gold we now have 2,133, in our 4' x 6' shaft, with an accuracy of ± 5% (95 out of 100 will be within 5%). There will be 85 pieces of 18 mesh gold, and the accuracy is minus 20% to plus 30%. The 10 mesh gold will average 5 pieces with an accuracy of plus 110% to minus 35% Instead of $1.00 we could get $2.10 or we

could get 65 cents. This is a degree of accuracy that we can live with, especially considering the 95% accuracy on the bulk of this gold.

When you are recovering less than 20% of the gold in any size fraction you have very little accuracy, and real problems. Drilling is not necessarily a bad way to go. Obviously, the Fairbanks Exploration Company drilled, and made money. Yukon Consolidated and Schmidt and Franklin also drilled. They drilled a lot of holes and the average gave them a better evaluation of the ground. As a matter of reference the long term average for drilling is 105%, but any one year can be pretty inaccurate.

Testing is a form of insurance. If your risk is small, don't test; take out a cut and see what you get. If your risk is high you can't afford not to test. In a month or two one can put in a lot of drill holes. If only a few holes are possible, a shaft or test pit is much better. If you can't afford a bad year then test.

Testing Equipment

The size of the sluice or rocker box, etc., used to work down a sample should have a capacity that will match the speed with which a sample is collected. Furthermore, the type of ground will determine the rate and method of sampling. A gold pan will not keep up with a drill that is running at 20' per hour.

In thawed ground, that is not too deep nor too wet, one can use a backhoe. To match the backhoe I have used a screening plant built on the chassis of an old bus, and a 20" sluice box. This particular sluice box was set at about a 2' in 12' grade, and recovered some very fine gold. The sluice utilized 1 inch angle in the top half with expanded metal over turf in the bottom half. We also tried covering the water with a plastic sheet to break the surface tension and thereby prevent thin flakes of gold from floating down the box, but our results were inconclusive.

In frozen ground one will need a boiler to dig a shaft. Packaged boilers may be purchased for $3,000 to $5,000. They may be oil fired or wood. Wood, of course, requires extra labor. It is also necessary to mount the boiler so that it may be transported.

An oil drum boiler is easier to move and easier to obtain. It can be set on a simple frame with a fire underneath. One should be able to steam all day on one drum of water, and one can check the water level by lifting or tilting the drum. The drum should be run with 30 to 40 pounds of pressure, certainly less than 50. I install a quick opening cork near the pressure gauge, that can be opened immediately if the pressure gets too high. One does not want to spend minutes cranking open a valve, one wants to leave the rig immediately.

Two steam points get much more steam into the ground than one. I used 40 lbs. of pressure, but, if your steam lines and boiler are in good condition, 60 to 70 lbs. is preferred by some. When driving shafts, 6 foot points

are the most convenient length, as one can still reach the top of them to drive them into the ground.

A windlass is set up over the shaft at a convenient height for the workers turning the winch handle. Ten gallon buckets work well for hoist buckets. Safety is very important; the winching hardware must be checked every day. Dropping 125-150 pounds of gravel on someone can be fatal.

To match our shaft sinking operation we used a small spring box with a 3/4" screen to separate the gravel. The 3/4" and smaller material was washed directly into the dump box of a small sluice. One can clean up after a days work or after the entire shaft.

When steaming through frozen ground, I stop and remove 5-6' of muck at a time, as we have little interest in this material. In gravel I stop and muck out every 2' or so. On clay bedrock, 4" is sufficient if care is used not to push gravel and gold into the clay underfoot. On soft schist bedrock a foot or so is needed, though one wants to mine as little of this as possible. Hard, rocky bedrock may require up to 12 feet of digging.

Logging

If you are going to put down a shaft, you need to keep records. Records may be for yourself when mining begins, or for that number one son who inherits the ground years later. Each hole needs to be numbered and it's location recorded, along with the date started and completed. Keep a log or other written record that includes the time of day, size of shaft, amount of material removed, and a description of the material. Knowing how long it took to dig a shaft is very useful if one ever returns to the area. Not only the thickness of the muck, but also its composition is worth recording. Are there layers of sand in it? Moss or roots? Thawed horizons, trees, etc., this information will help determine the method used to strip the muck off. If it is clean, a sprinkle will work very quickly, if it is loaded with debris then a bulldozer may be the best way to strip it.

One also needs to record the depth to bedrock, thickness of the gravels, thickness of the gold bearing gravels, size and quantity of boulders, type of bedrock and of course, the amount of gold recovered and its fineness. Don't forget to record the price of gold you used to value the ground, and state whether you are using U.S. or Canadian dollars. Also record the number of pieces of gold in the coarser mesh sizes that you can easily count. Fewer pieces reduces the accuracy.

In the course of your work you will pick up a lot of valuable information. Keep good records for if this information is lost, it is often gone forever.

References and Recommended Reading:

Sample size and Meaningful Gold Analysis, USSG paper G25C. A technical report with the mathematical reasons behind the sampling process.

Hester, Brian, 1970; Geology and the Evaluation of Placer Gold Deposits in the Klondike Area, Yukon Territory; in the Transactions of the Royal Institute of Mining and Metallurgy, London.

Wolff, Ernest, N., The Handbook for the Alaskan Prospector, M.I.R.L. Out of print, but a practical explanation of the sampling process. (Now in print and available at M.I.R.L., Univ. of Alaska, ed.).

Let's look at some of the basic provisions of the act. Section I of the 1872 Mining Law says: All valuable Mineral Deposits in lands belonging to the United States, surveyed or non-surveyed, are declared to be free and open to exploration and purchase. This basic statutory right provides for the utilization of public lands for mining.

Section II of the Act states: That no location of a mininig claim shall be made until the discovery of a vein or lode within the limits of the claim located. Later Legislation and Court Decisions have also stated that this discovery requirement applies to placer gold claims as well as vein and lode discoveries, as written into the law.

I want to point out that the location of a mining claim, prior to making a mineral discovery, does carry with it some rights; possessory

Figure 5 - A Comparison of the Averages of Various Suites of X-ray Fluorescence Results and Corresponding Chip Sample Assays Obtained During Test Work on Various

Tables 1 and 2 show a comparison of results obtained. Table 1 is a comparison of the effective sample volumes in various hole sizes; looking at 9 1/2 inch, 7 1/2 inch, 6 1/2 inch and 5 1/2 inch holes expressed as volumes per vertical foot of hole. If churn drilling or some other system recovered the material from the hole for assay or for analysis, these are the volumes in terms of cubic inches which would be generated per foot of hole.

If we had a down-the-hole system which had the penetration characteristics of the hand-held probe, which is two inches, we would effectively be looking at volumes significantly greater than the volume of sample material generated by the churn drill. Of course, if we make this comparison in hardrock with diamond drill cores, we have a much more spectacular favorability (Table 2).

TABLE 1 - A Comparison of Effective Sample Volumes in Various Hole Sizes

Sample volumes relate to 12" of borehole depth

Hole Characteristics	Sample volume (cubic inches) in churn drill hole	Sample volume (cubic inches) represented by fluorescent sample sleeve
9 1/2" outside diam. 8" casing	850.6	867.1
7 1/2" outside diam. 6" casing	530.1	716.3
6 1/2" outside diam. 5" casing	398.2	640.9
5 1/2" outside diam. 4" casing	285.1	565.4

TABLE 2 - Comparison of Effective Sample Volumes in B and N Size Diamond Drill Holes.

Sample volumes relate to 12" of borehole depth

Hole Characteristics	Core size	Sample volume represented by split core	Sample volume represented by fluorescent sample sleeve
B	BX(W)	12.9	328.7
	BQ	9.7	
N	NX(W)	21.9	375.5
	NQ	16.6	

Q designates wire line core sizes
X(W) designates conventional core sizes

O.D. of hole in both cases is the same.

In hardrock it is conventional for assayers to split the sample and retain one half for future reference purposes, and use the other half for assay purposes. Table 2 depicts the volumes, in terms of cubic inches, which a split cone sample would represent per foot of hole; compared to the sample volume of a sleeve of material around the periphery of the hole, which would be scanned by the insitu probe method.

What I've tried to demonstrate is the advantage obtained by down-the-hole probes with respect to relatively large sample volumes. What is really needed is a realistic research and development program to study the application of this technology here in Alaska. This could take the form of some sort of joint venture arrangement between a system manufacturer and one of the agencies keen on promoting the mineral industry in Alaska. The research facilities here at the University could be utilized in this regard.

There are many unknowns which need to be examined, including improved sensitivities, nugget effects, the effects of casing, permafrost and water on resolution, to name but a few.

This is far removed from the old blackbox technologies of the past and could constitute a very significant breakthrough in terms of future gold and other precious metal valuation practices.

Attached to this report is a report from EG & G Ortec on their portable gold analyzer. The portable analyzer produced by EG & G Ortec is only capable of measuring 20g/ton of gold (2/3 oz per ton). This is very rich ground; 2/3 oz per ton is almost 1 oz per yard, or $460 per yard (with $500 per oz gold).

EG&G ORTEC
TECHNICAL DATA

Portable Gold Analyzer

Introduction

A fully portable source excited x-ray fluorescence analyzer has been developed to detect and quantify trace concentrations of gold *in situ* at the working face.[1] The technique utilizes the 88 keV gamma-ray of ^{109}Cd to excite gold K_β x rays which are detected and analyzed by the instrument. The instrument must meet two very tough criteria in addition to the normal laboratory specifications of a precision spectrometer. First, it must be able to withstand the rugged environment of a mine including high temperature, high humidity, dust, and bumps. Second, it must be fully portable and capable of being carried easily by an operator into this environment without impairing his/her ability to move around and work.

The requirement for a rugged, reliable, portable x-ray spectrometer for underground use required the development of new sophistication in nuclear instrumentation. Devices and circuits which work well in the laboratory must be adapted to work in very hostile environments while not adding a significant burden to the operator using the instrument.

The analyzer consists of a hand-held probe assembly, a chest pack assembly, and a support module. The probe and chest pack are designed for use underground, while the support module is a laboratory environment unit.

The portable x-ray fluorescence analyzer uses the 88 keV gamma-ray from ^{109}Cd to fluoresce the $K_{\beta 1}$ and $K_{\beta 2}$ x rays of gold. The gold x rays are detected and processed so that a peak-to-background ratio can be determined. By keeping the Compton backscatter rate approximately constant during a measurement, an accurate valuation of the gold can be obtained from the peak-to-background ratio even if the measured surface is rough and nonhomogeneous.

Instrument Requirements

In order to make these measurements accurately and reliably in very hostile environmental conditions by an operator with minimum training, a high performance gamma spectrometer had to be designed that was rugged, lightweight, and simple to operate. This task involved the development of ruggedized detectors, lightweight cryostats, and low power electronics, as well as the packaging of these components.

The following general specifications were placed on the instrument:

1. Ability to detect gold in a mine face at a concentration of about 20 g/ton.
2. Sufficient liquid nitrogen and battery power for a shift operation of six to seven hours.
3. Lightweight and easy to carry in a stope.
4. Operate at a temperature of 20° C to 50° C.
5. Operate at 100% relative humidity with water splashing on the instrument.
6. With the probe turned in any direction, the liquid nitrogen must not spill out.
7. Survive continuous exposure to quartzite grit.
8. Be shock resistant.
9. Be intrinsically safe for use in methane atmosphere.
10. Safe and easy to operate.

The chest pack also contains the battery supply and control panel. The Ni-Cd batteries are protected by barrier circuits to insure intrinsic safety. The control panel has the few operating adjustments and switches required for instrument calibration. The panel and all switches are O-ring sealed. The total chest pack weight is 7 kg.

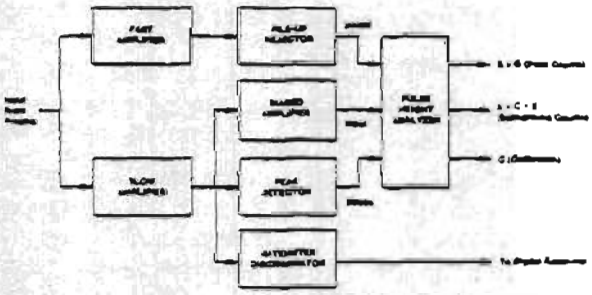

Fig. 5. Analog Pulse Processing and Pulse Height Analyzer.

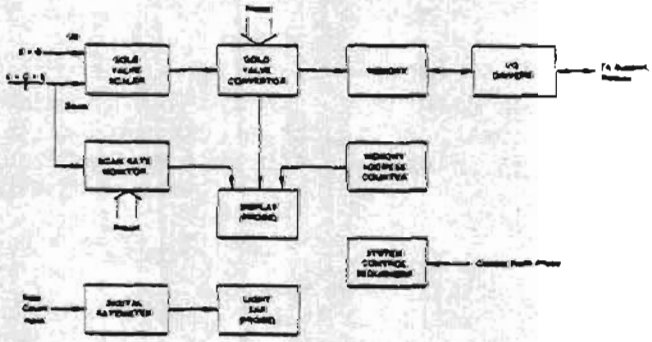

Fig. 6. Digital Data Processing and Memory.

Test Results

An extensive amount of testing has been completed using a number of instruments for several years. The results have shown that the instrument gives a spot assay result which is unbiased compared to chip sampling. When scanned along a mine face the results provide a significantly more accurate valuation of the face (about 2 to 2-1/2 times more precise). This will permit much more accurate location of regions below cut-off grade.

The minimum detectable concentration of gold is about 20 g/ton in the volume of rock assayed. Thus the instrument has clear application in mines with narrow vein deposits containing gold at these levels or greater.

These tests have proved that a high performance gamma spectrometer system can be built that is lightweight enough and rugged enough to give consistent assay data while being carried around in a very harsh environment.

In the evaluation of prototype instruments, four probes have been temperature cycled hundreds of times (sometimes with the high voltage on) without a single failure of an FET and without degradation of performance of the high purity germanium detector system.

Benefits of the Instrument

Fast Assays – Better Sampling

The gold analyzer is intended to improve the quality of mine sampling by providing data on more volume of the mine face with less labor required. With the immediate availability of gold value, the instrument becomes very valuable for high speed automated mining techniques. The instrument is also extremely valuable for the geologist, allowing him/her to find and value ore deposits quickly.

This instrument was developed with the support of the Chamber of Mines of South Africa, Metallurgy Laboratory.[1,2,3]

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[2]D. A. Roberts and P. J. D. Lloyd, Report on Underground Testing of the First Prototype of an Instrument for Determining Gold Values *In Situ* in the Reef. *Chamber of Mines of South Africa*, Research Report No. 38/77, September 1977.

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PROBLEMS OF DEPRECIATION AND DEPLETION

Eugene G. Yurkovich
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Main Hurdman and Cranstoun

As an accountant, I am going to talk about the problems of, and reasons for, depreciation and depletion. What is depreciation? What is depletion? How do they apply to the mining industry? First let's look at the mining industry.

About 85% of the mining establishments in the U.S. employ less than 20 people. Most of these are unable to plan future equipment purchases and expansion in a systematic way. Related to this, of course, is financing. It is common in mining firms to sell common stock and enter into a joint venture, to form partnerships and borrow from local banks. Investors have to be realistic in their approach and see good planning of their projections. The tax benefit is one incentive which interests the investors. This incentive or benefit has brought depletion into existence.

Depletion is an exception for minerals or ore. It's a hypothetical proposition, in most cases, and we have to establish a formula to compute this. Depletion permits a tax deduction for miners, to compensate for the wasting away of their product, their land and their gold.

Early in 1900, a group of miners challenged the first tax system, called the franchise tax, on the grounds that they needed to recover their investments in mining properties. In 1913 the first provision that provided for depletion was passed, this was a flat 5% of all mining properties, the gross income for all types of minerals produced.

Many changes occurred throughout the years, and finally in the revenue acts of 1921 and 1924, Congress limited some of the tax loopholes and provided the limitation that we know today. A depletion is limited to 50% of your net income. That still stands today as a restriction on depletion.

There are three justifications for depletion, the incentive for a risk capital. Eliminating depletion would leave industry starved for capital, and investors would cause many mineral shortages and, of course, more dependency on foreign suppliers or foreign investments. This was not the intent of the mining depletion law.

Some consider depletion a government subsidy. History shows that the mining industry's return on net worth is far less than that of other industries. The return of capital is the original concept of early depletion. The intent of the legislation was for a unique kind of depreciation, covering actual property acquisition costs, exploring and drilling costs, etc. This is the only sound or logical basis for the defense of mineral depletion. The depletion allowance function reduces the firm's income tax liability. It is a non-cash expense and represents no physical transaction.

There are two types of depletion: cost depletion and percentage depletion. In figuring your income tax returns you must compare these and use the largest amount for that year.

Basically, cost depletion, based on units (tons, oz, yards of reserves, etc.), involves a system of prorating the amount capitalized against the number of units mined. Property acquisition costs, added to exploration and other development costs, divided by total estimated production (determined by survey or drilling) gives the total cost per unit. This figure multiplied by units mined in the current year gives the depletion expense. Unit cost depletion seldom results in a higher tax deduction than percentage depletion. The unit method limits deductions to the capitalized expenditures. If the estimated units of production increase (if an upward adjustment is made in your reserves) then the unit cost is less, and deduction decreases.

Percentage depletion is more common. A percentage of the total reserves can be deducted each year. This percentage is determined by an IRS code rate which, for gold, is 15%. Just in case the percentage of total reserves exceeds the annual income, there is a limitation. The deduction is limited to 50% of your pre-tax income from mining. If you have a $10,000 net profit from mining, your maximum depletion allowance is $5,000.

Cost depletion is intended to return to the taxpayer the cost of the property, tax-free. Percentage depletion is entirely unrelated to the cost of the property, and may continue as long as the property produces income. Tax deductions from the percentage method may exceed the initial cost of a property. To get depletion you have to have an economic interest or ownership in the property.

Planning depreciation is important and is related to the planning for equipment purchasing and the projection of your cash flow. Depreciation usually starts with an asset when it is placed in service, and ends when the asset is retired. A proper deduction must be taken into account, each year. Failure to take a deduction in one year does not allow a taxpayer to take a large deduction in a later year. He must go back and amend the prior year in which there has been a change.

Generally, most tax payers seek to maximize the greatest possible deduction in depreciation, in the least amount of time. This is called declining balance method or accelerated method of depreciation. In later years, the deduction is less. Some prefer the constant depreciation method; that would be your typical straight line method of an equal amount each year.

Depreciation is based on some factors: the first is the basis of the cost, or your acquired basis in that property. That's your basis for determining how much can be written off. The method of depreciation has limitations also. It depends on the type of property; the classification; its life and so on. The depreciation period is used for life. The last thing that must be taken into account is any remaining salvage value. This is particularly important in equipment, because equipment does seem to have a salvage value, and IRS is looking at that, you cannot depreciate the lowest salvage value.

You, as a taxpayer, have a choice, the first year that you file your return, and need to plan around your cash flow and your requirements in your mining.

Property must be used in the trade or business, or held for business purposes to qualify for a depreciation. Property used solely for personal use is not depreciable; where you use property for personal and business a deduction is allowed for the prorated business portion.

Other factors that small operators should consider include an office at home deduction. Again, you have to prorate that and there are some restrictions. A conversion of personal assets to business assets is acceptable and qualifies for depreciation. You have to determine the fair value at that time, or cost, whichever is less. If you are building your own assets; assuming you are building a building or bunkhouse on the mining property and use your own equipment, you must capitalize the depreciation on that equipment while you're constructing your own assets.

Methods used in depreciation must be reasonable, with some restrictions. Usually where business is growing and new assets are being purchased, a fast write-off and short lifes are used. Most of the time we use three basic methods in depreciation; a declining balance method, sum of the digits and the straight line rate. You must decide which method to use when filing a return for the first year that you acquire assets. Your choice is based on your personal planning of cash flow and future plans. The declining balance is an accelerated method. The 200% method is twice the straight line rate. 150% would be 1 1/2 times the straight line rate.

Assets are prequalified for the type of rate; the 200% rate is generally available for new, tangible, personal property, or new residential property. The 200% declining balance method cannot be applied to used property or used equipment. The life of the item is also required to be 3 years or more. The 150% rate is available for new or used personal property, but only on new real property. Again, for a 3 year or longer life. The 125% rate is available on new or used personal property and all new, real property and some used residential real property, with a 20 year life or more. In other words, older buildings can qualify for an accelerated depreciation of 125%.

Salvage has to be taken into account, but under the declining balance method, salvage is only taken into account at the end of the period, or before the action is fully depreciated.

The sum of the years digit's method utilizes a fraction of the life of an asset. To consume the 5 year life of an asset, simply add 1 through 5 to get a denominator of 15 (1+2+3+4+5=15) then the first year you would have a 5/15 deduction; second year 4/15 year; third year 3/15, etc. That's one method that qualifies depreciation. It gives you a faster depreciation expense in the beginning years and declines later on.

The simple and basic rate is, of course, the straight line. For these last two rates you must also consider salvage value before you can depreciate the assets.

GOLD: CARATS, TROY WEIGHT AND FINENESS

Merl Thomas
Alaska Gold Sales

There are 5 different weight systems in use in the City of Fairbanks today. The apothecares' weight system is used in the pharmacy, although younger pharmacists are using the metric system. The metric system is in general use in most of the non-English speaking countries of the world. In the United States, the metric system is largely restricted to scientific work. The most common system here is the avoirdupois system. Avoirdupois comes from the French word meaning "to have weight". When you go to the butcher shop and buy your meat, or the hardware store to buy your nails, this is the weight system that they will use. Next, there is the metric carat. The word carat has an ancient origin. It originated from the Arabic word qirat, back in the Middle Ages. A qirat is a seed out of a coral tree. These seeds have been used from time immemorial in the East, for the weighing of gold, pearls and precious stones. When dried out these seeds maintain their weight. The word "troy" comes from the French town Troyes. Troyes was famous for its carnival. At these carnivals, the qirat seed was used to weigh out precious stones and gold.

The word carat, spelled with a "c", refers to the metric carat; and is the basic unit used in the weighing of diamonds. One carat equals 200 milligrams, or about 3 grains of troy weight. This unit has been adopted almost universally around the world. Prior to the adoption of the metric carat, the International Carat was used. They are slightly different in weight. Neither of these carats have any relationship to gold.

The carat that refers to gold, with the same spelling, is a measure of the purity of gold. When one refers to 24 carat gold, he is talking about pure gold, anything less than 24 carats is not 100% gold.

The United States, in view of the confusion among the various weights of trade, found it necessary to legalize a particular weight for use by the mint. They legalized the troy ounce in the act of May, 1928. It is interesting to note that the English made the troy pound illegal, though the troy ounce is still a legal termination there. That's one explanation for your not hearing about the troy pound. The precious metals are referred to in troy ounces, or in the larger weights, they use the metric system.

The grain is a division of the apothecaries' weights. It is also a division of the avoirdupois system and the troy system. A grain weighs the same in all three systems. But, you have to remember that there are 7,000 grains in an avoirdupois pound, and only 5,760 grains in a troy pound. So, the avoirdupois pound is actually heavier in mass than the troy pound. But, the troy ounce is equal to 1.907 avoirdupois ounces, making the troy ounce heavier than the mass of the avoirdupois ounce.

I thought it would be nice to tell you how to weigh your cleanup on the bathroom scale, and have it come out in troy ounces. If the bathroom scale

that you happen to have is the one that your wife uses, it probably weighs a little on the light side anyway, so you have a safety margin. For example, if we have 2 pounds 8 ounces on your bathroom scale this equals 40 ounces avoirdupois. Multiply that by .911 to get troy ounces. 40 ounces avoirdupois multiplied by .911 equals aproximately 36 ounces troy. It puts you in the ball park until you can get to a more accurate scale.

When one is talking about gold and fineness, a thousand fine is 100% gold. Anything less than a thousand would have some kind of alloy or impurity.

Gold is almost always used in the form of alloys, whether it's found in nature or processed for use by man. It is not a pure metal, unless it's made pure, purposely.

Gold is almost always used in the form of alloys, not as a pure metal. It is much too soft for most industrial purposes, as well as too expensive. The properties of these alloys, however, are still those of the precious metal, so that they have come to be regarded, not as alloys, but as different grades of gold.

The quality of gold in an alloy is not ordinarily expressed as a percentage, as with other metals, but in terms of fineness or on a carat basis. I believe that fineness is the term used by people in the trade; such as metallurgists, assayers, engineers and the like. Carat is used by people in the jewelry business. Gold is hardened by the addition of both silver and copper, except in coinage, where copper alone is used. White gold is properly an alloy of gold. Efforts have been made to alloy gold with lighter metals, but to my knowledge, without success.

One of the common things that you'll run across in jewelry is the gold coated base metal. The gold coated base metal is commonly used in 24 carat (pure gold). Anything less than 24 carat can be expressed in fineness by dividing the carat value by 24. Thus, if you have 18 carat gold, you divide 18 by 24, which equals 750. It can be expressed both ways; 18 carats or 750 fine actually mean the same thing. If you have a fineness figure, and want to convert to carats, you can multiply the fineness figures of percentage by 24. Thus, 850 fine times 24 is equal to approximately 20 carat.

Gold-filled is something else again. It refers to the soldering, brazing, welding or other mechanical method of attaching a layer of carat gold to one, or both sides of a base metal. This composite is rolled or drawn to thinner dimensions. You then have, in effect, a sandwich, with the base metal in-between the carat gold. The most generally used material is 12 carat gold.

An item that's marked 1/10th 12 carat gold-filled consists of a base metal covered by one or more layers of gold. The gold alloy comprises 1/10th of the weight of the entire article and that gold is going to be 12 carat gold.

When you send gold to a refiner they will send you a return that gives

you a fineness figure of your gold. They take the product that you send them and melt it accompanied by a flux. Then flux off as many impurities as they can. Then they reweigh the remainder (a bar of gold). This alloy is assayed right at their depot; if you want to have umpire assays you can have that done too. They will assay your gold and remelt that bar and pour it into water to make shot. They will take that shot and put it in aqua regia, a combination of nitric and hydrochloric acid, which dissolves almost everything. The silver, gold and other precious metals go into solution, except about one percent. This one percent is filtered, washed and retreated in the same manner, returning it to the original solution of aqua regia with the dissolved gold and the silver. It is then precipitated by one of several different additives. The silver stays in the solution and the gold precipitates. The resulting residue will be cleaned up by another bath. This will be melted with a little flux and a bar poured.

Some refiners give you a fineness figure after an initial melt has been made and impurities slagged off. Others will give you a return as a percentage recovery. Those people that give you a percentage recovery do not melt, to start with, so you don't have that initial shrinkage factor involved. Such a refiner goes directly to the parting process. In order for those people to treat your product, they have to treat your product individually. If you have the gold assayed it is made up into shot and then, after 20 or 30 customers, the end product comes out of the vat, or is precipitated out, and they divide that gold up, according to the assay made prior to the parting process.

The people that deal in gold tell me that the industrial buyers that they've have as customers for years aren't buying gold at the present time. The people who are buying gold are the speculators. They aren't having any trouble. That's probably one of the reasons that the market is jumping around so badly; the speculators are able to speculate on tomorrow's price.

BANQUET SPEECH

Lt. Governor Terry Miller

I am delighted to be here. I am not going to speak to you with any formal text. Instead, I am going to speak to you straight from the shoulder (as opposed to shooting from the hip) about a few things that I think are pretty important to all of us. I'm going to talk about three separate and distinct things that I think are politically important.

I want to discuss with you the involvement of State Government in promoting the future of mining in Alaska. I'd like to talk to you about what I call "new economics" and how it pertains to Alaska. Then I would like to talk to you about Alaska's image in the rest of the United States and what we can do about it.

Beginning with the question of Alaska's mining future, let me say that I think that it ought to be an affirmative State policy to try to diversify Alaska's economic base into as many different areas as possible. The State of Alaska ought to be the catalyst for that diversification; mining and mineral extraction has an important role to play as a key component of the mix in that economic diversification.

All too often we see, in Juneau, a heavy bias for what I call, "the renewable resource development". I submit to you that it's right and proper that we place an emphasis on renewable resource development. There is little question that this type of development will be encouraged in the next few years as we decide what we're going to do with the "oil money".

Renewable resource development ought not to come at the expense of such development as mining and mineral extraction. In fact, this industry played a major role in the development of early Alaska and has a key role to play in its future development. The United States, indeed, needs our precious and strategic minerals.

This is one of the reasons that I have spent approximately 40% of my time, since taking office, not in Alaska but in Washington, D.C. and traveling throughout the West Coast; hunting for friends.

One of the key decisions that will determine the future of mining in Alaska, and indeed the future of Alaska's economic base, is going to be made in the Congress of the United States, in the very near future. Obviously, I'm talking about the Alaska Land Bill. In a resource base state like Alaska, whoever controls Alaska's land, controls Alaska. I'm telling you that it ought to be Alaskans. We ought to be making those decisions. That's why I've spent 40% of my time Outside, before the Bill comes to the Senate floor. I intend to go back.

The Congress of the United States is about to make one of the most important resource trade-off decisions ever made in the history of the Congress of the United States; ever made. That's what the Lands Bill deci-

sion is; a resource trade-off decision. How do the people of the United States want the rich bounty of Alaska used? Are they going to honor their commitment, under the Statehood Act, to the people of this State? In part, that will decide the future of mining and the future of many other things in Alaska.

This is one of the reasons that I've been so active in the western coalition. I just want to very briefly impart that notion to you. It doesn't give much currency yet, here at home, but it will. I must confess that, as a result of the Lands Bill, I have become somewhat radicalized. I sit here watching the Congress (in this case the House) with 435 members charged by the Constitution, sworn to act in the best interest of the American people, make a terrible decision on behalf of not only Alaska, but their constituency. I recognized that we couldn't go it alone; we had to find friends. The friends that we could find are friends who are in the same boat we are. These include the other 12 western states, where 60% of the land is owned by the Federal Government. If we, in fact, could parley that strength through a coalition of mutual grievances, that would pay dividends (not just now, in terms of the Lands Bill) although that ought to be the first installment, but down the road in terms of other major Federal-State interface decisions.

The State investment policy ought to encourage the proper investment of our oil and gas resources by diversifying the State's economy, to include mining and mineral extraction.

We need to become rational regulators of the State's economy. I don't think I have to tell you the sad tales regarding the State's poor record in comprehending the real problems the Alaska mining community has with regulations. The agreement, which was recently signed, between the Department of Natural Resources, the Department of Environmental Conservation and the Department of Fish and Game to process permits with a single application, is a small step, but I submit to you an important first step, for these three major departments to recognize the need to rationalize that process. It's got to go beyond that and become much more a partnership cooperative agreement. I submit to you, that given the need of this Country for the precious and strategic minerals which Alaska contains, we should put the same emphasis (in terms of our State Government) acting as a catalyst for development in mining and mineral extraction, that we do in bottom-fishing and that we do in timber. These are very important efforts, but we ought to move in the area of mining as well.

The next thing I would like to talk to you about is what I call "the new economics" (when I get into this people think: "Miller, you really have been on a plane too long"). I think there is a "new day-a-coming" in this Country. In that new day, Alaska has a very important role to play, if we act prudently and wisely. Assuming (it's a big assumption) that we're able to get a rational Lands decision out of Congress, or if not out of Congress, out of the Court, to allow Alaska's land to be used rationally in the manifold of purposes that it ought to be, we then have one of the major factors for production; land. We now have, or will soon have, the next important factor for production; CAPITAL. We have, for the first time in the history

of Alaska, indigenous risk capital, in the quantities the likes of which you've never heard.

The latest revenue projection from the Department of Revenue, and the Department of Revenue is always terribly conservative in their revenue projection, is that we will have a general fund balance of approximately 165 billion dollars in 20 years. We're talking about an amount of risk capital that literally boggles the imagination. We, here in Alaska, happen to be sitting on top of abundant quantities of the most rapidly appreciating product in the history of mankind; oil and gas. Oil and gas that we can make available to the people of the United States to feed the American industrial plant.

Assuming that those of us in government and those who follow us in government make rational decisions when investing your money; I think we're going to create a whole new era of economics in Alaska, never before dreamed. Diversifying the economy is a little bit like the weather; everybody talks about it, and nobody has ever done anything. But I submit to you, because we now have the second factor of production, that will change.

This Legislature and perhaps the next one are going to be making "water shed decisions" about several key issues. Last week they passed the Permanent Fund Bill; a Permanent Fund Bill that's not written in stone. Succeeding Legislatures can perfect it, by making the initial decision that we're going to invest, rather than spend. We're going to postpone present consumption in favor of future investment.

I think the investment decisions ought to include the "trust fund" concept that the Governor talks about. We need our rainy day account; safely managed money. However, what is conventional, orthodox money management in a 4% inflation economy, is horrible management in a 14% inflation economy. Mr. Bushre, who is charged with the management of our liquidity, is urging the State to invest in gold. Who would have believed a few years back that we'd be doing that? Yet, look at what private industry is doing. Some of the major corporations in the United States;Exxon, IBM and most of the major oil companies, have larger amounts of liquidity cash as a proportion of their total assets than they've ever had in history. This is an indication of the instability and the uncertainties of our economy. We ought to be acting as the private sector does, instead of trying to go "social engineering" with the people's money.

Let's get away from orthodox money management. The "rainy day account" is not seriously questioned by anyone. But I think we need to step out. I'm talking about this now because these decisions are being made in the next few weeks in the State Legislature. If you don't agree with what I'm talking about; if you don't agree with what they're talking about, this is the time to let us know.

I think that the next building block ought to be what I call "public infrastructure investments". I think, for example, we ought to make a major commitment (a billion dollar-plus commitment) to hydro-power Development. I think we ought to take our fossil fuel energy consumption and convert it to

a renewable energy capability. Who are the largest hydro-power developers in the world today, bar none? Bar none? The Arabs. They are also the only ones in the world who are sitting on more oil than we are. We ought to take a page from their book and explore other alternate energy sources. I think it's a practical matter, because the technology is in place, and because we have an abundance of sites. We also need, as part of the public infrastructure building block, basic, sound public facilities that will encourage other kinds of economic development. A lengthened runway would, perhaps, permit a different generation of aircraft to come to this State. A continental land link by railroad. But first let's spend what needs to be spent on a cost benefit analysis, to see if that makes sense. Perhaps another form of transportation would be better. I think that we can put these investments into fair, analytical objective tests; like cost benefit ratios. We're talking about investing, rather than spending.

A good building block would be a Home Loan Program, so that Alaskan's can have affordable housing. This is one way to upgrade everybody's standard of living, without a lot of government. We could also develop business and industrial loans.

Another step ought to be what I call R & D money. We should invest in technology. We're seeing a little bit of it at Delta Junction, where the State is in the process of spending $25-30 million of your money on an agriculture for export experiment. That's what it is; an experiment. I don't pretend to tell you, today, that that money will be recouped. We may not be successful in creating a product that can be exported; in this case barley and rape seed. Perhaps the economics of it won't work because of the unsolved transportation difficulties. Maybe the market will fall through, although when I was in Tokyo, the Japanese businessmen said that they were willing to buy it, if we can give them large quantities at world class prices with good quality. This is a $30 million experiment. If we're successful, we will have created what we've talked about in Alaska ever since the Matanuska Valley colony. If we're not successful and we lose $30 million, this amount, expressed as a percentage of the total oil wealth of this State, is not even a fraction of 1%. I submit to you that this is a good investment, the kind of thing we ought to be doing.

The last suggestion is more nebulous. I call it the so-called "social-capital investment". It is certainly subject to more interpretation. It plows money back into the third factor of production; education and training, to increase the productivity of the people of Alaska. That too, if done correctly, is an investment.

When I say "investments", I don't mean for the State to do it, I mean for the State to make that risk capital available for you to do it; for the people of Alaska to do it. We don't have to bring in outside firms; we don't have to have the absentee ownership that's attended this State. With the energy situation in the United States, we're going to go back to more efficient forms of transportation. Water base transportation is going to be favored over aircraft transportation; even though they're making a new generation of aircraft. Rail will probably become preferred to wheel based transportation.

Alaska is situated next to the West Coast of the United States, with a population of about 60 million of the most affluent people in the entire world. Our other coast is a market of 600 million Asians, some of whom we already have good trade relations with.

We should diversify our energy supply. We should not just consume our fossil fuel energy, but export some of it other than what we need for our own purposes. Let's take the wealth of that and put it in other forms of energy that will be with us when it's all said and done. If we can, for example, identify production processes where energy is a major component, and match that with the minerals that we have in the State, we can then have manufacturing in Alaska; we can require in-State processing. That was never before dreamed of. It all depends on whether the right decisions are made by those of us privileged to represent you in government.

The third thing that I would like to talk about is every bit as important as the first two. The third thing may well determine the first two. That is: Alaska's image elsewhere, particularly in the rest of the country. One of the things that I have discovered is that we are vulnerable, if you will, to mischaracterization. By our own Federal Government and also by our own press. We have been characterized as the "blue eyed Arabs", the rapacious developers; people who are out for the quick "buck"; people who want to sell just to foreigners; as people who don't care about the rest of the country. I have heard it on the floor of the United States House of Representatives. For example, when Morris Udall, a very skilled debater by the way, said, "Why do we want to worry about jobs in Southeastern Alaska? The State of Alaska wants to create a pulp bank to guarantee that the existing job base remains in place, but they sell half of their stuff to the Japanese anyway". The Congressman from Arizona said this on the floor of the House, and he said it very effectively. He must have. He beat us.

It occurs to me that we ought to take a small portion of our oil wealth; maybe 10, 15, 20 million bucks a year for the next 10 or 15 years and start selling Alaska to the American people on the tube, in the papers and on the radio; the same way Idaho sells potatoes and Florida sells Sunshine Orange Juice. We need to reframe the issue, so that the person sitting in Toledo, Ohio, when he hears of Alaska, will have a different conception from that which he now has. We need to tell them why it makes sense to utilize the manifold potential of Alaska. We ought to tell them, for example, that the largest State Park any place under the American flag is in Alaska, created by Alaskans; that we do care about conservation. We ought to tell them, for example, that Alaska's fishery has the protein potential to serve half of the United States, if they're willing to tap it. We ought to tell them that as long as the American people want to buy Toyotas and Sony T.V.s, they'd better let Alaska sell some of its products to the Orient. We're the only one in the United States that has a 7 to 1 favorable trade balance with Japan--"7 to 1". We need to let them know that we're performing a patriotic function by doing that. We're bucking up the American dollar, when it's slipping every place else.

They need our precious and strategic minerals; they need our oil and gas resources; and yes, they need our pristine wilderness, the likes of which cannot be duplicated any place on the American flag. We would want to preserve that too, but it can be done in balance; it can be done rationally; and it can be done best, if they let Alaskans, who know more about Alaska, (to paraphrase an airline ad) than anybody else. If they want rational decisions, it ought to start here. We have more at stake than anybody.

Most responsible economists and a lot of us now in politics are telling the American people, "you've got to start to lower your expectations; to tighten your belt. We've been living too long on an energy binge and too long on a false economy. They're really saying: "The standard of living in the United States is going to continue to decline." Last year it declined by 7%; 7% loss of purchasing power. That's a decline in the standard of living. You can package it any way you want, but that is what it is. I submit to you that that decline will continue until the American people decide they want to start allocating resources more wisely. The reason that that is important to us here in Alaska is twofold: 1) If it continues to decline, as I think it will, and I think as most of us think it will; absent a reversal in policy, they're going to say, "Well, look at Alaska; look at how rich Alaska is. Let's redistribute that wealth". And you say, "What are you talking about Miller?" Well, they attempted to include our royalty oil under the Windfall Profits tax. What's the significance of that? It means that for the first time the Federal Government was going to tax a State Government, just like private industry. I don't know that much about the State Constitution or the Federal Constitution, but I don't think that was contemplated when they wrote it. The national government was going to tax away about 50% of the economic rent for the oil fields. That's the next step to expropriating the oil itself. One way that we can give ourselves insurance from that is to go out and communicate our side of the issue to the American public.

The second thing that the campaign might do is to tell the American people that the standard of living doesn't have to decline, and that Alaska has a manifold potential to contribute to the national economy and to maintain America's standard of living and strength, just let us do it.

This State is terribly divided; whether it's the Capital move or D2 or fishing or the regionalized economy that we have. All too often, many in Alaska worry first of all about "how is it going to affect my portion?" We're very fragmented in this State. Maybe in the process of educating the American people about Alaska's manifold potential; maybe in the process of showing others what we're like, we'll see ourselves differently, too. That we are a national State; a rich sub-continent; we do have a meaningful, significant contribution to make and we have a terribly bright future.

I went to graduate school in Boston. One of my classmates is now a counterpart in state government in an eastern state. We occasionally sit down and compare notes. The frame of reference for his state government includes questions such as: How do we stretch a little more out of an overworked property tax, to keep the education establishment going? What are we going to do in 10 years to meet the unfunded pension liability for

public employees? They are facing up-against-the-wall issues. What are they going to do about pollution? Terrible problems! We, here in Alaska (I try to be careful when I talk to him about it) have to decide how to spend an incomprehensible surplus of money. We have all the advantages. What a difference. How lucky we are!

ROUNDUP OF GOLD RECOVERY SYSTEMS AND DEVICES

Cleland Conwell
ADGGS

This presentation was based upon W.J. Mildren's paper "Resume of High Capacity Gravity Separation Equipment for Placer Gold Recovery". Jim Mildren was unable to attend the conference, as planned. His paper has been reproduced separately and is available in the M.I.R.L. office. A brief outline follows:

I. High capacity gravity separation equipment:

A. Jigs are one of the most efficient separators with coarse material between 1" and 100 mesh. Adjustments of flow rates and finely classified material is needed for effective operation.

B. The Reichert Cone operates on the pinched sluice principle wherein an ore slurry is crowded into a progressively narrowing channel with the heavy minerals migrating to the bottom. A constant feed density of 60% is required with a maximum feed size of about 10 mesh. Recovery is very good in the minus 30 to plus 270 or 325 mesh size range. Feed has to be controlled carefully, and the slurry should contain less than 5% clay. The Reichert Cone has no moving parts, very low operating costs, long equipment life, and uses much less water than jigs or sluices.

C. Spiral concentrators utilize a maximum feed of No. 4 mesh and will effectively recover minus 10 to plus 200 mesh concentrates. The slurry density must be 25 to 35% solids by weight.

D. The sluice box with riffles is an effective separator for medium to coarse gold, but has never effectively recovered fine gold. Turbulent water is required to recover fine gold in the quick-sand trap formed by the riffles. As the riffle angle increases the turbulence and water velocity increases also, but the quick-sand bed is also washed out. Perforated 1"-1 1/2" riffles set at a 15° angle, over astroturf improves recovery, and a long narrow box increases the chance that a particle of gold will enter the trap. The slope is usually 1 1/8" to 1 3/4" per foot.

E. The Wright impact tray is another pinched sluice type of separator designed to operate over a wide range of feed water and tolerate trash and oversize in the feed with the ability to reject it to the tailings. It is a new device that should not be overlooked.

II. Medium capacity gravity separation equipment described by Mildren include:

A. Ainlay and Knudson bowel concentrators.

B. The Bartles - Mozley table is a new invention which recovers particles in the 5 to 10 micron range, possibly 1 micron. A film flows across a spinning table with a 1° to 3° angle from horizontal. When the table becomes charged with heavy particles remaining behind, the table tilts and the heavy particles are washed into a collector.

C. The Johnson type cylindrical concentrator was first introduced in 1926 in South Africa. It is a slowly revolving cylinder with spiraled rubber riffles on the interior. The feed (usually minus 10 mesh is washed upon entering the upper end. The rotation of the cylinder carries the concentrate up the riffles and out the top of the cylinder, while the tails are washed down out the bottom.

This concept is being used by Mines, Metals, Management of Fairbanks for their final concentration.

D. The plane table concentrator is a sloped steel table with longitudinal rubber riffles about 3 1/2' wide and 14' long. The concentrates settle into the slower moving film in the rubber riffles and are separated out as the lighter material goes across a gap at each step in the table.

E. The riffled belt concentrator is a slow moving conveyor belt 5' wide and 24' long moving at a rate of 1 1/4' per minute up a 10° to 12° slope.

F. Heavy media separation is an old technique used to upgrade coal deposits and remove lighter material from gravel.

G. The hydrocyclone ore concentrator is normally used for size classification, but can also be used for heavy metal concentration.

III. A reference list for low capacity gravity concentrators is also included in Mildren's paper.

PIPE AND PUMP HYDRAULICS FOR THE PLACER MINE

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Water is viewed by hydraulic engineers as energy. Generally they partition this energy into three types: pressure, velocity and elevation, expressing the pressure either in pounds per square inches or feet. Probably the best way to illustrate this is to look at a simple system, wherein you have a water reservoir and a pipe (with a valve) discharging the water.

First of all, let's close the valve. We now have elevation energy containing the water. You want to tap the water at a high elevation and convert it to pressure where you're going to use it. The elevation of the water reservoir is the amount of energy that we have available, and as the pipe drops down, we convert some of this elevation energy, which gets less and less, into pressure energy. Of course, if the valve's shut, there's no water flowing and, essentially, we have all the energy at the bottom as pressure energy.

The next situation, which is just slightly simpler and slightly more complex, is to open the valve, but look at a system where you have a very large pipe or where you have no friction of the water. The reservoir is elevation energy; in the pipe the elevation energy is being converted to pressure energy and, at the same time, we are producing velocity energy, which takes up some of the pressure. Depending on what we want to do with the water at the bottom end, we may want to use this by putting it through a nozzle and sluicing it out on the ground over some distance. It would constrict the nozzle somewhat and come out with even more velocity as the pressure energy drops off to zero, because it's out in the atmosphere.

First, we do not gain any energy in the pipe system, we only lose it. Second, if you're going to have water moving, you have to have velocity energy; and if you have a very small pipe, that amount can be quite large. If, for some reason, you had your pipe go up over a hill, then compared to the amount of energy you started out with, you would have a small amount of negative pressure. This is usually called a siphon. But, if you have a very large area of pipe, under negative pressure to the extent that it is below the atmospheric pressure, air can leak into the pipe. The air can accumulate and it can become trapped at the top and actually break the flow. That's a problem to be avoided for a very long length of pipe.

Let's look again at a situation with water flowing in the pipe from a reservoir and discharging out into the atmosphere. If you have a very small pipe with a large flow, the energy that you lose due to friction can be very large. If you have a large pipe with a very small flow, the frictional loss will also be large.

Let's look at a real situation where we have frictional loss. Friction does a couple of things to you. First, it immediately steals energy

out of the pipe. The further you go down the pipe, the more you lose to friction. It's to one's advantage to keep the loss due to friction as small as possible so that you have either more pressure to work with or more velocity. Friction is a function of turbulence in the water. It is usually caused by roughness in the pipe. If you're designing a city water main you want to choose a pipe that will have a very low roughness and last for a long period of time with little corrosion. In a mining operation, I imagine you're moving pipe around quite a bit, and you're probably limited by the materials you already have. You probably have to move it around, store it and have a chance to clean it out. That's probably not too large a problem.

There's an equation which says that the amount of friction energy you have is equal to a constant times the discharge squared divided by the diameter to the fifth power. Now, I want to try and concentrate a little bit on this diameter to the fifth power. That means, as you increase the diameter by a little bit, you can decrease your friction loss by an awful lot in a hurry.

If we increase the flow we'll have more friction loss. It will go up quite rapidly too, because friction loss depends on the square of the flow. The important thing is that as you increase the diameters the friction loss goes down very, very fast. If you have an opportunity to choose the size of pipe or the amount of flow you want to put through a pipe, you can certainly contain the frictional loss; if you consider this before you design your system, it may come out better. Once in a while, it may be to your advantage to put a couple of pipes along side each other, especially if you have only one kind of pipe to work with, to keep down the flow as much as possible, ending up with a larger pressure and more velocity depth.

If, in a pipe 1,000 feet long and 6 inches in diameter, we pump 1,000 gallons a minute, we then have nearly 80 feet of friction loss. This means that if you have an elevation or a reservoir 80 feet up on the side of a hill, by the time you get to the bottom you'll have no pressure left; you'll just use it all up. You simply have to tolerate that loss. But an increase in the diameter by only a little bit--this is the fifth power working for you now--the friction loss drops all the way down to 20 feet, and by doubling the diameter from 6 inches to 12 inches, the loss drops all the way down to 3 inches. Then, after that, there's very little additional increase that you obtain from 3 feet, 4/10, 1/10. So if you had to move 1,000 gallons of water a minute through 1,000 feet of pipe, it would probably pay for you to consider a 12 inch pipe, but you wouldn't gain much by going to an 18" or 24" pipe. You couldn't tolerate trying to put 4,000 gallons a minute through a 6 inch pipe. Even 12 inch pipe has too much frictional loss. You'd need an 18 inch pipe before the loss would be tolerable. You want to start with a clean pipe. If it's going to be installed for a long time, it should be something that won't corrode. You want the pipe to be as large as possible, but not too large. It may be cheaper, if you need to expand your system, to actually put in additional pipe, rather than invest in a larger size pipe. To haul a bunch of pipe that's too small back in a remote site just may not do the job for you. You may end up having to put in a lot more parallel pipe to move the water, than if you had taken in a slightly larger pipe to begin with.

I want to point out one other thing with pipe flow. It would be nice if we could just put things through pipes, but unfortunately, you have to hook the pipe up to something. You have to take it out of the reservoir; you have to put it through a strainer; you have to put a valve in and a number of other things. Hydraulic engineers call these minor losses. Sometimes, however, they're not so minor; sometimes they can be a major loss. Let's compare this to the equivalent feet of pipe that you would have to get the equivalent frictional loss. As an example, I've listed the number of feet of 8 inch pipe that would match the amount of frictional loss you have going through several simple devices. A strainer with a foot valve, such as you use on a pump to strain out leaves, sticks and stuff, has a frictional loss equivalent to 266 feet of pipe. Although it may seem like you're getting the pump very close to your intake point to cut down on the suction of the pump; putting the strainer on actually increases your friction loss and is equivalent to being 260 feet from the reservoir.

A simple swing check valve; wide open, is equivalent to the loss of 266 feet of pipe. An entrance going into a reservoir, just shoving a pipe into the reservoir and letting the water go into it, is equivalent to 13 feet of pipe. A simple 90 degree elbow in an 8 inch pipe is equivalent to 29 feet of pipe.

A gate valve is fairly efficient, if it's wide open; only 4 feet. Globe valves are horrendous for chewing up friction. They're more like a strainer with a foot valve, at about 250 feet. In a globe valve you actually draw the valve back and force the water to take a tortuous path through the valve. A gate valve is pretty direct; it's a good device to use. You can look in a handbook of some kind to find other kinds of friction losses.

A pump does the opposite of a pipe; it adds energy to the flow. We think of this as the pump adding pressure to the flow. It's important to remember that you still have friction involved, and that you have friction on both sides of the pump. If you have a pipe hooked up to your reservoir, there is actually some loss there. You have to account for that. The pump gives you flow from the pump up to an upper reservoir. When you're sizing a pump that you have to use, the manufacturer or somebody says that it will pump a certain head. You have to remember the friction loss and you can't just buy a pump that will pump water up to its head, because it won't pump as much as you thought it would.

It's extremely important that you keep a pump as close to the reservoir as possible, with as big a pipe as you can tolerate. You can tolerate a big pipe, but you should not buy such a large length of it. You have to be careful about the number of strainers and foot valves and stuff that you put in the pump. You have to have some, but it is usually best to keep the upstream side clear of valves. It's very important to keep the pressure at the suction side of the pump as high as possible.

One of the things that the manufacturer will tell you about a pump is its discharge curve. That usually comes as a graph. It starts out with the shut-off head (no flow) and it begins to drop off because there's a lot of frictional loss inside the pump (as the pump operates, it actually puts out

less head than at the shut-off head). On the other hand, when you start your pipe system, and as the flow is shut off, you have a lot of static head that you have to overcome. Also, as you begin the pump, you have to overcome some kind of friction. At the operating point (say at 1,000 gallons a minute) you've now lost some head in the pump and you've gained some head in the friction; this is the place where the two should meet. You have to buy a pump and make sure that you have excess head to begin with. Sometimes pumps are purchased so small that they don't even have enough to overcome the static head; they just sit there and spin. Water may even start flowing back through them, even though the pump's turning. That's a disastrous situation.

Every pump has what you call a characteristic point or operating point or operating characteristic. That pump is designed to operate at that flow and at that energy head and will put just so much pressure on the water. To sum up pumps then: First of all, you have to have enough head to overcome the shut-off head, or the static head. The operating head has to be less than the shut-off head and it also has to overcome the frictional loss.

For suction dredges, the suction pressure is important. It has to be above a certain amount of pressure. It it's not, the pump won't operate properly, and it cavitates. In cavitation the pressure becomes so low, at certain points in the pump, that the water boils. It boils at a cold temperature, because it's at a very low pressure. If a pump is cavitating, the cavitation will usually get worse. If you've had this experience with a pump, the impeller looks like a chewed up piece of Swiss cheese. Actually, the water pressure is expanding in little vapor bubbles and banging back on the impeller repeatedly on the same spot. Eventually, it flicks off a piece of metal.

It's important that you talk to the pump dealer; look in his specification book and try and find out what suction pressure a particular pump is designed to operate at. When you get into the field, put the pump as low as possible, with respect to your reservoir, or dig a pit if you can. If you can't dig a pit, keep your intake pipe as large as possible. Don't put valves in between your pump and your reservoir. Try to avoid as many strainers and other things as possible. Everything you put in between the pump and the reservoir adds to the frictional loss and drops the pressure at the pump.

Finally, a word about suction dredges. As I understand the principal of operation, you have a pipe or a hose of some kind, going from the bottom of the stream to a sluicing device on the boat or raft. Then you have a pump. The pump doesn't actually pump water through the pipe, since you want to pump not only water, but also material. A very effective device that has been devised to provide the pumping action without actually passing the material is called a momemtum jet pump. This pump takes water out of the stream (it has energy above the stream) which goes down through another pipe and shoves a high velocity jet into the secondary flow. This acts like a pump bed. It speeds up the secondary flow and adds energy to it. Because the secondary flow is unrestricted, it pulls material up and into the pipe. The more material per unit of water the heavier this material gets. If you

have too much material, the momemtum jet doesn't have enough energy and it will just clog up. It probably clogs up very tight.

If you have too long a run, the heavier materials will bounce along and, when other heavier material gets behind it, it will clog up. Once it clogs up, the energy drops off very rapidly, and the whole thing just shuts down. I suspect that, if you do this right, you can fill it up real tight and spend some time trying to dig it out again.

One nice feature about most suction dredges is the constriction at the end, thus the size of the material that can pass through the end (which you of course can knock off) will hopefully pass through the rest of the pipe. That's good. If you clog up material at the bottom it will shut off the flow very quickly. Of course, the material in the pipe is depending on flow to lift it up to the dredge, and if you clog up the material at the end of the pipe things will again clog up very rapidly.

CYANIDATION

Mr. William McClintock
Mining Services and Properties

Cyanidiation is a busy thing, in the lower '48. I believe it may have an application to Alaskan placers, and it certainly has an application to our hardrock mining.

There are two possibilities for the cyanidation of placers. One which Cleland Conwell will cover is the cyanidation of concentrates. Many of you treat your sluice concentrates with Mercury, it's possible that you are losing a significant amount of gold that is still locked in the concentrate. In my analytical work with concentrates, I have discovered that many placer concentrates still have ½ to one or more ounces of gold tied up in the concentrate.

A second possibility for the cyanidation process is the cyanidation of placers in place. Prior work on this utilization of cyanidation has been published in the Bureau of Mine's Report: Investigation 7559. One places the cyanide in the upper end of a placer deposit. Hopefully, it flows downstream along bedrock dissolving the gold and you pick it up at the bottom. There are a number of drawbacks to this. You have to be careful that the cracks are all cyanide. The cyanide will only take care of fine gold; it will dissolve coarse gold only with a great deal of time.

I concluded a number of years ago that cyanide was the coming way for the gold industry in the United States. There was very little cyanidation 7 or 8 years ago. People were afraid of it. But, cyanide is nothing but a combination of Carbon and Nitrogen. There ought to be a way to handle it effectively; especially when it dissolves gold so effectively. I have been working to develop methods for the cyanidation process.

Heating Bleaching Operation

A storage sluicing tank contains your cyanide and lime (Calcium Oxide and Sodium Cyanide). You pump it over the ore heap. This ore heap is sitting on an impervious pad; usually asphalt. You want to be sure that it's impervious to prevent cyanide from perculating through to the settling pond.

In order for cyanide to dissolve gold, you have to have Oxygen. When you sprinkle the solution over the ore heap it picks up the needed Oxygen. After it perculates through the ore heap; it is collected in a settling pond. It is now called a 'pregnant solution', pregnant with gold.

The second new innovation in gold cyanidation, is called Carbon Absorption. You pump the pregnant solution up through columns containing charcoal. For some reason coconut hulls make the best charcoal, also the most expensive. After passing through the charcoal, the solution no longer has any gold. It goes back into the makeup tank. Then you take the loaded Carbon to a desorption unit, which will dissolve the gold in the Carbon. The

The Counter Current Decantation is profitable at about .1 ounces per ton. The capital cost is a great deal more in this process. I talked to a number of metallurgists in the process, and they concluded that the best solution might be a Counter Current DeCantation with a Carbon Absorption. The Carbon Absorption system is a great deal cheaper and simpler than the Merrill Crowe zinc process.

ANNOUNCEMENT FROM THE WASHINGTON CONCENTRATES OF
THE AMERICAN MINING CONGRESS

Ron Sheardown
Vice-Chairman of the Anchorage Branch of
the Alaska Miners' Association

This is a short announcement from the Washington Concentrates of the American Mining Congress. It is something that we're all interested in. There seems to have been a change of heart on Mr. Udall's part regarding his non-fuel mineral policy.

Mr. Udall has stated that the President (Carter) should take several steps to avoid a crisis in non-fuel mineral supply. Udall, Chairman of the House Interior Committee, has made 5 specific recommendations to the President. 1) Direct the Interior Secretary to review lands believed to have high mineral potential and to open those lands appropriate for mining as soon as possible. 2) Ask the Secretaries of Agriculture in the Interior to cooperate and prepare uniform guidelines and plans designed to help incorporate mineral activity into Land-Use plans and decisions. 3) Review Federal regulations and policies, designed to protect the environment and the health and safety of workers and general public, to insure that regulation of the mining industry is carried out economically and without unnecessary burden to those regulated. 4) Establish a government wide coordinating system among the Federal Agencies, with responsibilities in non-fuel, minerals' policy. 5) Ask the State Commerce Defense Departments and the CIA to work with Interior to establish an advance warning system to monitor trends and forecast events that may affect the availability of minerals in the U.S.

My comment: This is the cause; quoting the cure.

GOLD RECOVERY FROM PLACER CONCENTRATES BY CYANIDATION

By Cleland N. Conwell, DGGS mining engineer

You may have thought you recovered all the gold from your sluice-box concentrate, but you probably left either flakes of gold that were not separated or gold that was not liberated from the quartz. This hard-to-recover gold might be dissolved in a weak cyanide solution, and then precipitated by zinc dust or absorbed by an ion-exchange resin or activated carbon (charcoal), thus adding to the overall profit of your operation.

Recovery by absorption and subsequent oxidation of the charcoal appears to be the preferred method.

Introduction

In a recent study initiated at the request of three placer-mine operators in the Circle Mining District, DGGS experimented with recovering gold from cleaned placer concentrates. The operators, from different subdistricts, provided the samples. Each miner first screened the concentrate and recovered gold by gravity methods, and one operator went a step further and used mercury to amalgamate the gold.

In the gravity separation of gold from the gravels and gold from the concentrate, two principles, specific gravity and particle size and shape, oppose each other. This makes the final cleanup difficult by gravity methods alone. Adding mercury to amalgamate the gold flakes increases recovery, but three conditions must be present: a) the gold particle must have a clean surface, b) the mercury must be in contact with the gold, and c) the gold must be liberated from the matrix or at least have enough surface exposed to adhere to the mercury. A weak solution of less than 500 parts per million cyanide will dissolve gold.

The primary requirement for solution is a clean surface on the gold particle. The chemical reaction is:

$$4\ Au + 8\ CN^- + O_2 + 2H_2O = 4\ Au\ (CN)^-2 + 4OH^-$$

In treating these placer concentrates, interfacing ions such as zinc or copper were present in concentrations of less than 110 ppm; they did not appear to consume cyanide.

In addition to the cyanide (CN^-), oxygen (O_2) is required and the solution must be basic. In practice, the solution is buffered with CaO to hold a pH of 10 or better.

Acknowledgements

The author gratefully acknowledges the assistance of Fred Wilkinson, Joe Vogler, and E. N. Wolff for providing samples, P. D. Rao and Wolff for their suggestions, and the laboratory section of the DGGS for the analyses. D. R. Stein performed the assays.

Procedure

In these experiments, the procedure outlined by Dorr and Bosqui (1950) was followed.

Each sample was separated into the basic particle-size fractions and visually examined for gold and mineral content. The samples were then amalgamated with mercury. Six cyanide tests were completed, with and without grinding. Gold was precipitated by zinc dust, activated carbon, and Dowex 21K.

Samples Submitted by Vogler

Nearly all the quartz and rock had been removed in the samples, and 99.9 percent of the material had a specific gravity of over 2.88 (bromoform heavy-liquid separation). If magnetite was originally present, it had been removed and the remaining material was mostly wolframite, a tungsten mineral with a specific gravity of 7 to 7.5, and cassiterite, a tin mineral with a specific gravity of 6.8 to 7. The specific gravity of the sample was 7.0.

Sample JV-1 was separated into size fractions and examined for gold flakes as indicated in Table 1.

Table 1. Sieve analyses of sample JV-1.

Mesh size	Weight (g)	Percent of total	Percent passing	Percent retained	Remarks
+16	0		100.00	0	No visible gold
-16 + 32	2.88	0.72	99.28	0.72	Visible gold
-32 + 60	40.44	10.11	89.17	10.83	Visible gold
-60 + 120	342.24	85.56	3.61	96.39	Visible gold
-120	14.44	3.61	0	100.00	No visible gold
Total	400.00	100.00			

A 400 gram sample was then amalgamated for 2 hours with 1 gram of mercury. The mercury was recovered by panning and dissolved in nitric acid. The residue contained 60.62 mg of gold, or the equivalent of 4.42 oz. of placer gold per ton (this includes the silver alloy with the gold). The

sample was then treated in a solution containing 500 ppm potassium cyanide and buffered with 0.90 grams of calcium oxide to keep the pH of the solution above 11.0. The solution was sampled for gold after 3 and 5 hours of agitation. The assay of the solution was constant at the equivalent of 8.28 ppm, or equal to 8.28 mg of gold. The tails assayed 1.06 ppm (0.424 mg) gold. The test is summarized in Table 2.

Table 2. Gold recovery from sample JV-1.

Gold	Weight (mg)	Percent of total
Recovered by amalgamation	60.62*	87.45
Recovered by cyanidation	8.28	11.94
Remaining in tails	0.42	0.61
Total	69.32	100.00

Computed assay of head - - - - - - - - - - - - - 5.05 oz/ton
Assay of tails - - - - - - - - - - - - - - - - - - 0.03 oz/ton
Total recovery of gold - - - - - - - - - - - - - 99.39 percent

*Including silver

A second Vogler sample of slightly coarser similar material (Table 3), was dissolved in cyanide without removal of gold by amalgamation (Table 4). It took 72 hours to dissolve the gold.

Table 3. Sieve analyses of sample JV-2.

Mesh size	Weight in (g)	Percent of total	Percent passing	Percent retained	Remarks
+8	0	0	100.00	0	
-8 +16	0.84	0.21	99.79	0.21	Visible gold
-16 +32	93.16	23.05	76.74	23.26	Visible gold
-32 +60	306.00	75.70	1.04	98.95	Visible gold
-60 +120	3.40	0.84	0.20	99.80	Several colors
-120	0.84	0.21	0	100.00	
Total	404.24	100.01			

Table 4. Gold recovery from sample JV-2.

Gold	Weight (mg)	Percent of total
Recovered by cyanidation	159.06	99.80
Remaining in tails	0.32	0.20
	159.38	
Computed assay of head- - - - - -	11.62 oz/ton	
Assay of tail - - - - - - - - - - -	0.02 oz/ton	
Total recovery of gold- - - - - -	99.80 percent	

Samples Submitted by Wolff

Ernest N. Wolff provided two samples from Coal Creek. These samples consisted of about 87 percent almandine, 8 percent spessartine, and 3 percent andradite garnet. Less than 0.5 percent of the sample was floated in a heavy-liquid (specific gravity, 2.88) separation. The grain-size analyses of sample EW-1 is indicated in Table 5.

Table 5. Sieve analyses Coal Creek sample EW-1.

Mesh size	Weight (g)	Percent of total	Percent retained	Percent passing	Remarks
+10	1.36	0.34	0.34	99.66	Visible gold
-10 +16	27.24	6.81	7.15	92.85	Visible gold
-16 +35	197.16	49.29	56.44	43.56	Visible gold
-35 +60	145.68	36.42	92.86	7.15	Visible gold
-60	28.60	7.15	100.00	0.00	Visible gold
Total	400.04	100.01			

Gold was visible in all size fractions and observation under a 30-power binocular microscope revealed that it had not been liberated from the quartz grains. The sample was then amalgamated with 1 gram of mercury for 1.5 hours. Quartz grains containing gold adhered to the mercury. The mercury was dissolved by acid and then the quartz dissolved with hydrofluoric acid; 643.4 mg of placer gold was recovered from the 400.0 gram of sample. This is the equivalent of 46.91 oz of placer gold per ton. Assuming a fineness of 905 (Smith, 1937), then 643.4 x 0.905 = 582.28 mg of gold, or 42.22 oz/ton (46.91 x 0.905).

The sample was then ground to -100 mesh and treated with cyanide. There was no increase in gold in the cyanide solution after 8 hours. The solution contained 19.6 mg of gold; 1.8 mg remained in the tails (Table 6).

Table 6. Gold recovery, Coal Creek sample EW-1.

Gold	Weight (mg)	Percent of total
Recovered by amalgamation	582.28	96.01
Recovered by cyanidation	19.60	3.23
Remaining in tails	4.60	0.76
Total	606.48	100.00

Computed assay of heads- - -	43.99 oz/ton
Assay of tails - - - - - - - -	0.14 oz/ton
Recovery - - - - - - - - - - -	99.24 percent

A sample of slightly coarser material (EW-2) from Coal Creek was tested (Tables 7 and 8). The 400-gram sample was treated in a cyanide solution for 48 hours.

Table 7. Sieve analyses, Coal Creek sample EW-2

Mesh size	Weight (g)	Percent of total	Percent retained	Percent passing	Remarks
+10	0.84	0.21	0.21	99.79	
-10 +16	31.96	7.99	8.20	91.80	Visible gold
-16 +35	231.92	58.00	66.20	33.80	Visible gold
-35 +60	106.71	26.69	92.89	7.10	Visible gold
-60	28.40	7.10	100.00	0.00	Visible gold
Total	399.83	99.99			

Table 8. Gold recovery, sample EW-2.

Gold	Weight (g)	Percent of total
Recovered by cyanidation	41.42	83.19
Remaining in tails	8.39	16.81
Total	49.81	100.00

Computed assay of heads- - - -	3.029 oz/ton
Assay of tails - - - - - - - -	0.612 oz/ton
Recovery - - - - - - - - - - -	83.19 percent

Sample submitted by Wilkinson

The sample submitted by Fred Wilkinson had been amalgamated, and no gold was noted by casual visual observation. A preliminary assay indicated 0.80 oz of gold per ton. The screen analysis indicated the material was not as well sorted as the Vogler and Wolff samples (Table 9).

Table 9. Sieve analyses of sample FW-1.

Mesh size	Weight (g)	Total percent	Percent passing	Percent retained
+10	0.32	0.08	99.92	0.08
-10 +18	62.72	15.71	84.21	15.79
-18 +32	113.04	28.31	55.90	44.10
-32 +60	138.96	34.80	21.10	78.90
-60 +120	70.84	17.74	3.36	96.64
-120 +250	11.16	2.79	0.57	99.43
Pan	2.28	0.57		
Total	399.32			

In this sample 44 percent of the material was lighter than 2.88 specific gravity. The light fraction was composed primarily of metamorphic rock fragments and mica grains. The heavy fraction (56 percent) contained a variety of minerals, including cassiterite, garnet, scheelite, ilmenite, magnetite, zircon, tourmaline, pyrite, arsenopyrite, and galena. The sample assayed 6.45 percent tin and 3.68 percent tungsten.

The sample was first subjected to a cyanide test without grinding (Table 10); the recovery is indicated in Table 11. The gold was effectively dissolved in 5 hours.

Table 10. Gold recovered without grinding, sample FW-1.

Gold	Weight (mg)	Percent of total
Recovered by cyanidation	7.22	73.30
Remaining in tails	2.63	26.70
Total	9.85	100.00
Computed assay of heads- - - -	0.72 oz/ton	
Assay of tails - - - - - - - - -	0.18 on/ton	
Recovery - - - - - - - - - - - -	73.30 percent	

Gilmore (1967) describes a resin in pulp ion-exchange method. In the laboratory, 3.8 l of solution assaying 4.46 ppm was stripped with 10 gram of Dowex 21K. The gold was recovered by slow oxidation of the resin (Table 15).

Table 15. Recovery of gold by resin, Dowex 21K.

Solution	Gold (mg)
Pregnant	16.95
Stripped	0.65
Recovery	96.31 percent

Adamson (1973) suggests that gold be stripped by a liquid ion exchange but laboratory tests were inconclusive.

In our experiments, stripping with activated carbon and subsequent oxidation of the charcoal appeared to be the best methods for a small operation. After dissolving the zinc dust in hydrocloric acid to recover the gold, the gold dust adhered to the beaker. The gold remained as delicate spheres after the Dowex 21K was oxidized; if the fumes were properly vented, this could be the second choice to charcoal. Figure 1 shows the flow of the cyanide solution through the concentrate and stripping of the gold from the pregnant solution by charcoal.

Gold Recovery Summarized

This procedure is recommended for the recovery of gold from placer concentrates:

1) Screen and size the concentrate.
2) Recover as much of the gold as possible by gravity methods.
3) Recover particulate gold by amalgamation. This step may require cleaning of the gold particles by chemical action or attrition. Many operators use either an amalgamation rotating drum or cement mixer to provide the contact of of gold with the mercury and the agitation necessary to clean the gold.
4) Recovery of the balance of the gold from the concentrate by cyanidation, which is a chemical process requiring careful solution control. Both the pH and strength of the solution must be carefully controlled, and the solution should be assayed to determine when the reaction has reached completion. The stripping of the solution requires careful control. The concentrate must be analyzed to determine if the gold is free or, like the Coal Creek samples, in quartz, so that grinding is required for liberation. If the proper procedures are followed, additional gold can be recovered by cyanidation. Figure 1 is a flow diagram of gold recovery by using cyanide and carbon.

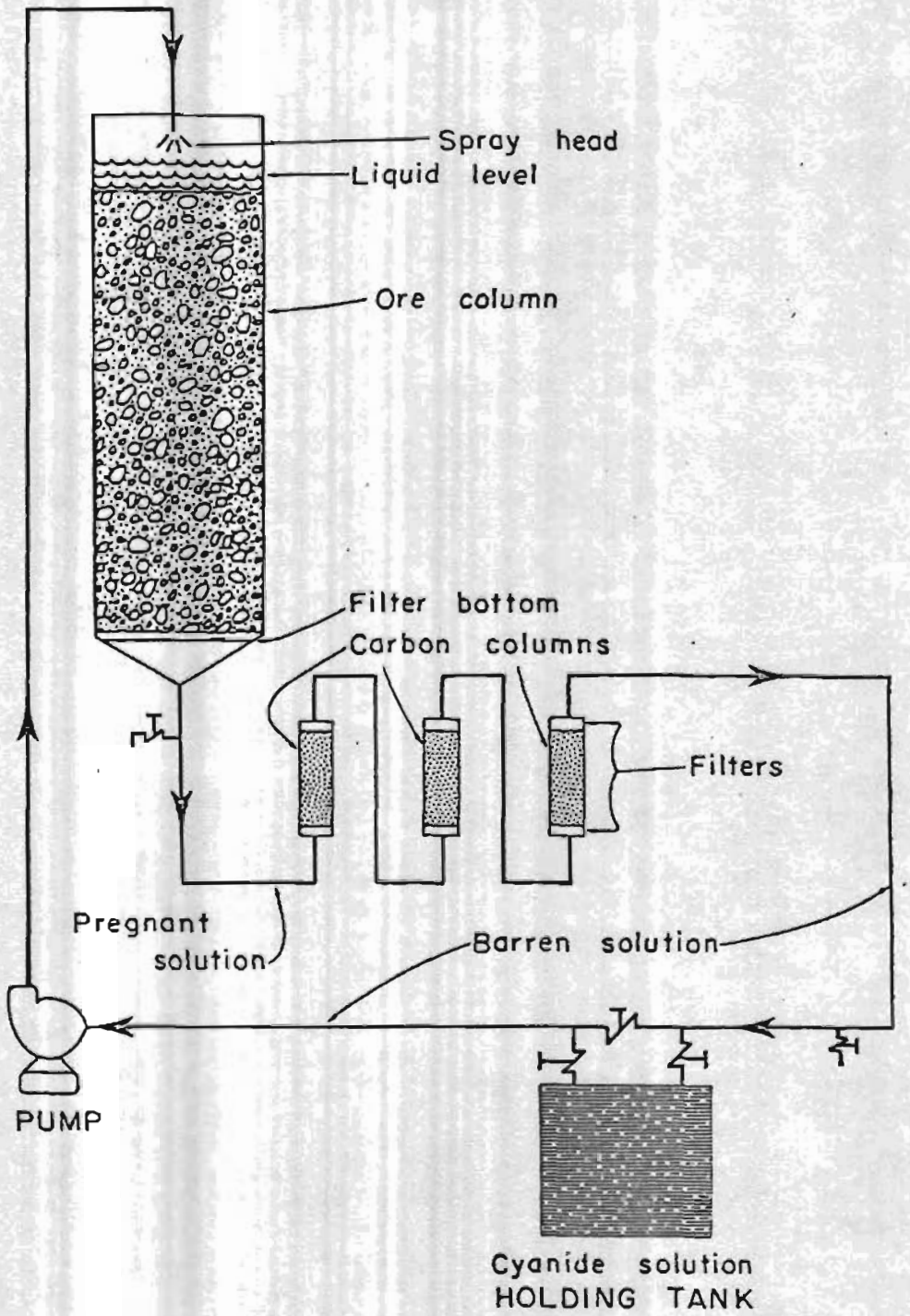

Figure 1. Flow diagram of gold recovery from placer mining concentrates by cyanide solution and activated carbon.

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PLACER RESEARCH AT THE SCHOOL OF MINERAL INDUSTRY UNIVERSITY OF ALASKA, FAIRBANKS

Ernest N. Wolff
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Early London gold was $518; at mid-day it was $528 and late London gold $535.

The Mineral Industry Research Laboratory is a part of the School of Mineral Industry. It works very closely with the academic part of the School. We have students working in the Lab, and people from the Lab are teaching. We think it works out very well that way. This laboratory was established by an Act of the Federal Legislature in 1963. They appropriated the money to set up the laboratory. It was to be administered by the school as the College of Earth Sciences and Mineral Industry, which we now call the School of Mineral Industry. Its duty is to perform basic and applied research and to work with both Industry and Governmental agencies. We've always looked upon it as our chief charge to conduct research which would help establish a mineral industry for Alaska.

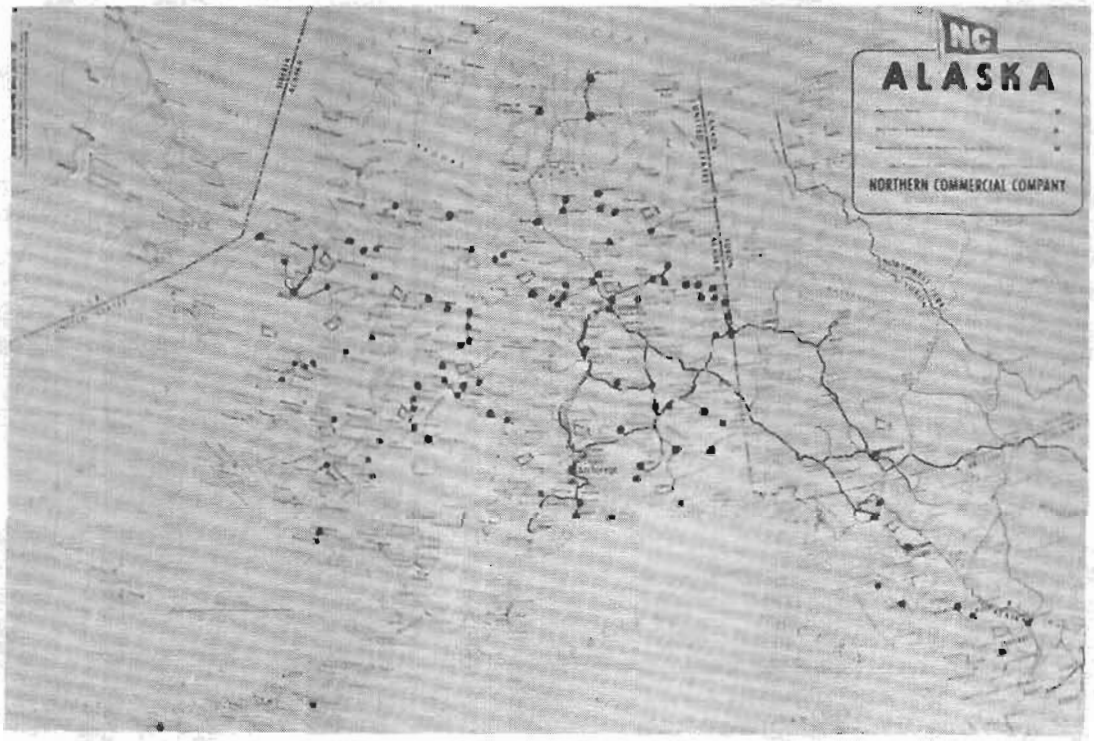
The Usibelli Coal Laboratory is a very important part of this lab. Dr. Rao is our coal specialist. There is a great deal of coal research going on. We also do geological research; regional studies of geology and ore deposits; law; economics; marketing and mineral preparation. In past years we've done placer research, and with the increased interest in placers we are looking at that again.

This rather simple, almost crude map on a Northern Commercial Company base isn't just thrown in there to have a map of Alaska. Each one of those dots represents a community started by the Mineral Industry. Prudhoe Bay, of course, through oil, but most, including the main towns of Alaska, were started either through placer or lode mining. Mining has been an important aspect of Alaskan history, economics and culture.

Two early works on placer mining in Alaska stand out. U.S. Geological Survey Bulletin 263 by C.W. Tarrington; Methods and Costs of Placer Mining and Gravel Mining in Alaska, published in 1905. The Geological Survey once had people in here who were very interested in placer mining methods. This publication contains comprehensive and detailed descriptions of placer mining as practiced during the early gold rushes. It is a fascinating bulletin available at the University Library. It describes all the camps and about half of the mining districts with the methods used in each.

Another important work was the U.S. Bureau of Mines Bulletin 259 by Norman L. Wimler; Placer Mining Methods and Costs in Alaska, 1927. This brought up to date the state of the art of placer mining in Alaska.

In the mid-1950's, the School of Mines at the University of Alaska conducted another survey of post World War II Alaskan placer mining. The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results were published in U.S. Bureau of Mines Information Circular 7926, by Thomas Cook and Walter Kearnes. This work, entitled; Methods and Costs of Operations, Using Hydraulic and Mechanical Excavation Equipment and Washing Plants, was published in 1969.

Gold mining, even at that time, was in a period of economic stagnation. There has been little interest in placer mining research for the past 15 years. With the end of government control of the gold price, the price began to move up in real terms. Interest in placer mining has revised and the time has again come when the state of the art should be described as a prelude to active research and development.

During July, August and September of 1979, a team from the Mineral Industry Research Lab visited a number of placer mining districts that could be reached by automobile; hence at a reasonable cost for transportation. These districts yielded varying amounts of information that will be of value to the industry. The districts visited were: 1) Fairbanks 2) Circle or Birch Creek 3) Livengood or Tolovana 4) Manley Hot Springs 5) Forty-Mile 6) Klondike 7) Kantishna and 8) Ietna.

Before beginning a visit to a district, an attempt was made to contact at least one miner or roadhouse keeper who could tell the miners that the team was coming. In a previous study of this kind, during the '50's, a questionnaire was used, but during this one, no fixed format was followed. A mining student was attached to the party and it was his duty to make sketches and take notes, while other members were talking to the operator. The results of the field work were embodied in notes, sketches and photographs.

It's my opinion that the greatest advances made in the last few years have been in recovery systems. We intend to publish descriptions of the mining operations and the recovery systems used today. Improvements have been made in sluice boxes and riffling material; the use of one inch astroturf is a good example.

We also noticed, as we went through the districts, that an idea would soon become fairly common. For example, in the Circle District sloping grizzlies are very common. Many are using shaking screens. In the Forty-Mile, the grades are much steeper. Of course we know that Loren Ross, when designing his Ross Box, went to a 3 inch grade, unheard of just a few years ago.

We have 3 publications describing Alaskan placer mining in the past, and this will be the fourth, 20 to 25 years after the last one, which I worked on also.

I want to tell you about some of the other placer mining research that's been done here in the past. Dr. Cook of the School of Mineral Industry (around 1952) carried out the only quantitative experiments on sluice boxes, that I know of. In a 12 foot wooden box, with a window in the side, he took pictures of the turbulent action and the movement of gold underground. As I remember it, with grades above 18 inches (1 1/2 inches to the

foot) he found that he started to lose some of the gold. Perhaps, if you used more water, you could keep the turbulence up. Research is needed on the two or three inch grades that are being used now.

A few graduate students have worked on placer mining research. For example, about 6 or 7 years ago, Art came in from a very large mining company that operates in South, Central and North America. They were operating in a place in South America where they were only recovering 10% of the total gold by panning. A pan is one of the most efficient gravitational concentrating devices yet. It was pretty clear that their dredge must have been losing 90% also. They tried centrifugal amalgamation. Once screened, the material is whirled with amalgam, increasing the efficiency of the recovery many fold. You can force the fine gold into the mercury by centrifugal action. At least two theses were written, describing the results of this research.

The publication, put out several years ago, by Dr. Cook and Dr. Rao, describes the size distribution of some of our Alaskan gold and the shape factors. By knowing ahead of time the size distribution and the shapes of the gold in an area, you can predict whether or not ordinary gravitational methods in a sluice box are going to work, or whether a jig is needed.

Water studies have been funded by people who are more interested in environmental questions than recovery questions. It's up to us to work on both the environmental problems and improve recovery. Three theses have been written, two of which are quite descriptive. Water from placer mines has been analyzed to find out about the distribution of the material size and the chemicals dissolved in the water. One of these theses used a cyclone to clean up the water. It was a very thorough study of what can be done with a hydrocyclone to clean up placer discharges. He found that you can make a separation at 16 microns, which is pretty small but not as small as we'd like, without adding flocculants. This removes the saliable solids. The EPA requires you to remove the saliable solids with a settling pond, but then you've still got the turbidity remaining. The turbidity is going to do everybody in. If we can't change the requirements for turbidity, we must find a way to clean up. This study found that flocculants in a hydrocyclone were successful, but it does get pretty expensive. He concluded that the use of a hydrocyclone on muddy water, followed by a placifier, made it possible to clean it well enough to recirculate the same water indefinitely. This leads right away to water saving devices that increase the efficiency of mining. It isn't just a matter of cleaning up the water. If you can recirculate water continuously you can continue mining while the other fellow is shut down, waiting for the water to build up in his reservoir.

Research in drilling is vitally needed because the old "tried and true" method of the churn drill is too slow to drill large blocks of ground. This big boom that we're experiencing now is based on less than 10% of the gold that was produced in the high year of 1941. Now, with the price of gold 15 times as high, we may be looking at infinitesimal amounts of gold to be detected with our sampling methods. We're going to have to drill a lot more holes to evaluate a particular block of ground. We need to find a faster drill.

There are a number of things that, if the price of gold holds up, will need to be investigated to make Alaska's placer industry viable and able to contribute to the economy as it should.

DRIFT MINING

Carl Heflinger
Heflinger Mining Company

The economic conditions prevailing in Alaska, prior to World War II required that all men earn their own livelihood. In interior Alaska, placer mining and fur trapping were the basic industries. Many operators and claim owners mined frozen gravel with underground methods during the winter. This was called drift mining or "taking out a winter dump". The winter dump was thawed and sluiced as soon as water would run in the spring. Merchants usually financed the drift mining operations by extending credit to the miners. It was very important to get your dump sluiced and get the money back to those merchants as early in the spring as possible.

Prospecting a creek was the first requirement for developing a drift mine. A series of prospect holes were sunk across the valley about 100' apart. At times, tunnels were driven from the prospect holes, crosscutting the valley. As a rule of thumb, the deeper the ground, the more tunnelling a prospector would do. Ideal drifting ground was deeper than 40'. Shallow ground was usually mined by windlass dump process or open cutting.

A drift mine required construction of a cook house, bunk house, boiler house, an 8' by 8' or 10' by 10' working shaft, a gin pole, sluice boxes, 100 or more cords of wood for fuel, a horse barn and a dog team or other form of transportation to get the mail and supplies as needed.

When prospecting unknown ground, I would sink a hole along one edge of the valley in what I thought might be the shallowest ground. When I got to bedrock, if the gravel looked promising at all, I would run thaws in opposite directions, probably 20' long. Even though there were no colors, I would check for concentrates and heavy material. The direction in which I found the heaviest concentrates would be the direction I would sink the next hole. I would progressively follow the concentrates until I found gold, or didn't find it.

After a block of pay gravel has been located, a mining plant is installed. Following is a sketch of the mining plant used commonly from 1900 until 1940. A plant includes a boiler and hoist house. You usually had a single drum hoist and a gin pole which was between 50' and 70' high. Of course, there's the winter dump. A trip cable which went to the bottom of the hole and was anchored solid.

This of course is the shaft. This part is what we call the gallow frame; the high line we always called the trolley line. The sluice boxes were placed under the dump before you started mining in the fall. Before you started mining, you placed the sluice boxes and cribbed them up with the bulkhead. I'll show you a picture of that a little later. But, they were set, usually, on the grade of one inch to the foot. You already had your water supply prepared, so that you were ready for water the first thing in the spring.

Now, this is a little more detailed, showing the trolley line, the hole and the gin pole. The trolley line was deadmanned or anchored on both ends, and there was a large turnbuckle on it so that the proper tension could be kept on the trolley line. As the bucket went down in the hole, the trolley line was equipped with an automatic carriage allowing the bucket to go up and down the hole, come up to the carriage and catch in an eccentric on the carriage. On its way up to the dump, the trip line would engage a piece of wood anchored in position to cause the bucket to dunk.

The temperature of the underground shaft was usually between 30° and 32°F, except when steaming. It was necessary to timber the shaft and tunnels in the deeper mines both to keep the heat down and to prevent sloughing. Steam lines were insulated and installed with a swing joint to compensate for expansion in minus 20 to minus 30 degree weather. If the boiler house was 100' from the shaft, and you put steam through the line, it could travel 8 or 9 inches due to the expansion from the extreme heat to the extreme cold.

It was important to have a good sump hole in every drift mine. We usually sank the shaft as deep as possible into bedrock to get drainage both ways from the drift. As a rule, one couldn't move downstream as far as one could upstream, because the grade of the creek prevented one from draining back to the shaft.

A 2-cylinder horizontal steam pump was used both to expell excess water from the shaft and to drive the points in dry gravels. Where very little water was trapped in the gravel, hot water circulated from the sump hole by the steam pump was the best method to drive the points. If you tried to drive the points in dry gravel, the steam would blow back and cause excessive sloughing in the rooms behind you.

Points were made from drill steel. When using water, four to five points were driven at a time. They were driven about 18 inches off the bedrock and 3 feet apart. It was preferred to drive them 10' deep, but the points keep getting shorter when you sharpen them or break off the ends. When driving the points, you sometimes encounter larger rocks that require you to pound pretty hard on the points. It was undesirable to change the location of the points from the original 3 foot spacing, as it was necessary to thaw this ground evenly so the wheelers could operate the mucking easily. Even point spacing was important to get all the pay out. After driving the steam points with water (approximately 4 or 5 is all that a horizontal steam pump can handle) we'd pull the points and place what we call sweaters (made of 3/8 water pipe) in the hole. Live steam was injected as fast as the ground would condense the steam. Not all ground will take steam at the same rate. The more water trapped in the ground, the more steam it will take. There isn't any textbook that can say that a certain size boiler will take care of so many points. When gravel had a high water content, sweaters could be driven directly with steam, and water was not needed. Steaming time depended on the amount of moisture in the gravel. The drier the gravel the longer it took to steam. It could range from 6 hours in wet gravel to 36 hours in dry gravel.

Figure 1 is a picture of a drift mine. In this mine we used a 30 horse wood fired, Pennsylvania Boiler. The boiler house also contained a forge for sharpening picks; a very important process in drift mining.

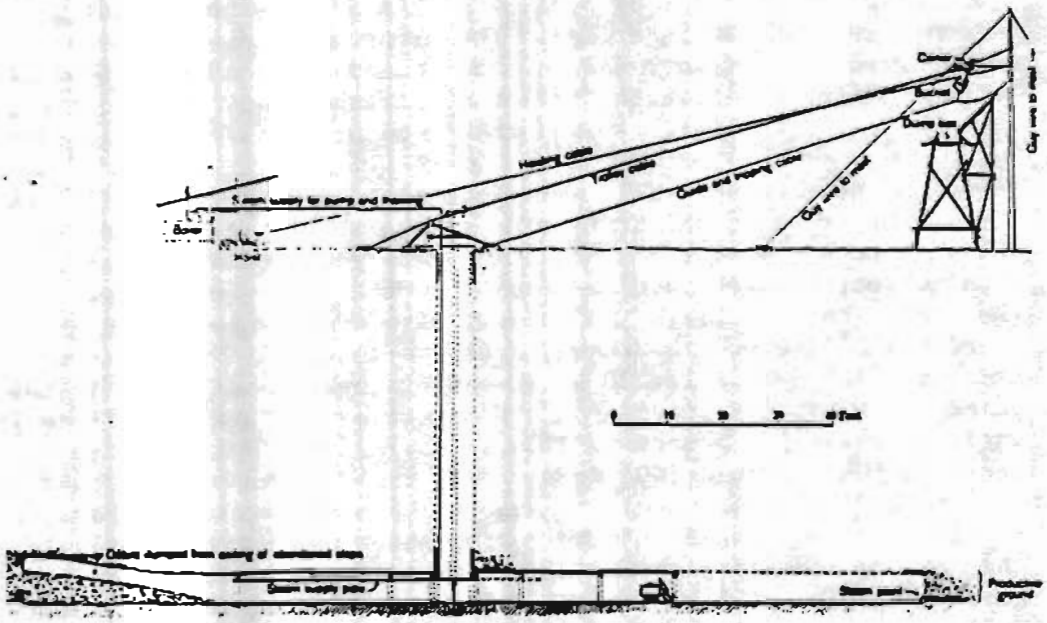
On the downstream side of an average drift mine, the shaft is sunk as deeply as possible into the bedrock. A good sump hole was dug off to one side of the shaft or on the side of the tunnel. You drove your tunnel as far downstream as you could and still have drainage to the sump, then you dug crosscuts. You did the same going upstream. The cross-cuts were very seldom more than 200 feet long. The paystreaks were not usually that wide. One hundred feet on each side of your tunnel made a good sized drift mine. In the smaller mines, with smaller paystreaks, they wheeled the gravel to the shaft. On the larger mines they used ore cars.

When developing a drift mine one started expanding as far back as one could. Never widen the drift mine at the shaft. Always drive your tunnels and work back toward the shaft. Insulate your steam line to prevent heat loss to your cross-head. Each point on the cross-head has a valve to control the steam individually. The points, of course, were placed about 3 feet apart and 10' deep. The thawed area was about 30' wide on your cross-bed and about 12' deep. The 30 horse boiler could handle from 15 to 30 steam points at a time; depending on the nature of the gravel. Steam pressure varied between 105 pounds to 140 pounds. If the boiler house is 100' away from the shaft with a 100' deep shaft, and you pumped the steam an extra 100' to 200' up the tunnel, through all of the necessary hoses, with 50 pound steam, you wouldn't have anything but condensed water. One hundred to one hundred and fifty pounds of steam was needed. If you open the valve good, hot steam will be just blue for about 3 feet, then it will fan out into sort of a fall. It is also necessary to carry over 100 pounds of pressure when using injectors to put the water in the boilers; an injector will slobber and quit at about 90 pounds of steam pressure. In the plant that I ran, I had a steam siphon down to a spring. I would siphon the water up to the boiler, to a reservoir, and then inject it into the boiler.

The haulage of paydirt was usually done by a man and wheelbarrow. One hundred to 150 wheelbarrows per man were needed. Candles were used along the haulage ways along with carbide light lamps. A candle would burn 5 hours if not in a draft. Sometimes the wheelers would run so fast they would make a draft for the candles, allowing them to burn longer.

We used No. 2 shovels. Fifteen shovelfulls filled a wheelbarrow, roughly 2 1/2 cubic feet of gravel.

The paydirt was hauled to the surface with a steam hoist and stockpiled to be sluiced in the spring. There was quite a difference in the height of the paystreak in various mines. The Dawson area was famous for bedrock pay. Bedrock pay ranged from 6 inches thick to 5 or 6 feet of pay. In thick paystreaks, you could thaw about 4 1/2 feet high, and then each time that you made another thaw, the heat of the thawing would slough more down behind you. You would pick up your sloughings and newly thawed ground and get by a little cheaper on your wood pile and steam.



Section of drift mine.

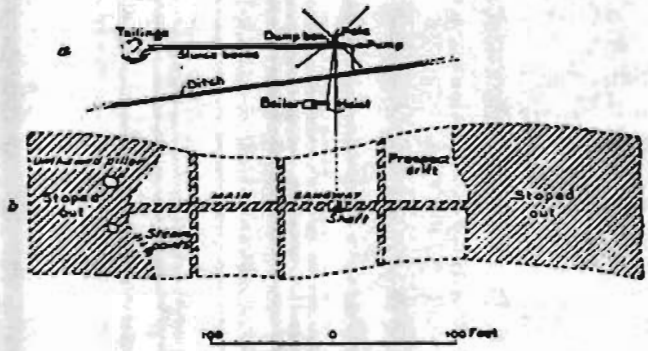


Diagram showing arrangement of a drift mine. a) Plan on surface; b) plan on bedrock.

(from U.S. Geological Survey Bulletin 525)

It takes experience for a man to properly steam ground. It was necessary to listen to the steam going through the points. After you were experienced you could tell by the amount of steam that was going through the points how fast the ground or the gravel was accepting that steam. If a point died while you were gone, you wouldn't get an even steam. After a certain period of steaming, we pulled the points half-way back; otherwise, you would get an uneven roof. If a point or two died, you'd have to leave them in longer, after they were restarted. Some spots might take more steam than others. The man who took care of the steam points and did the thawing wasn't very well thought of if he had uneven thaws and didn't get the bedrock out. He had to do his job, and do it properly.

Of course, summer operations were also common. The tail is then hoisted into a hopper and sluiced each day. Large operations had rail cars and tracks to the main tunnels. In summer operations, they would just hoist and sluice the dirt up each day.

The sluice boxes were placed on grade so that the winter dump could be hoisted over them. There were 10" by 12" telescopic sluice boxes protected by polled bulkhead. The lumber company cut special box bottoms for us. They were 10" by 12" and could be telescoped together with a piece of gunny sack between each one of them.

Prior to sluicing the dump in the spring we'd thaw out the dump. We'd feed the boxes just as much material as the water could take away. The piles would fall into the boxes by gravity with a little extra shoveling. We'd make a clean-up as soon as possible to get it to the merchants and give them a little money. In those days, the First National Bank, which was the only bank that we had in town, would buy the gold from you. They charged a small fee, depending on the volume of gold that you were selling to them. If it was only a small amount, they'd charge you 2%; if it was more they'd charge 1%. They had their own assay office here in town, where they did their melting and assaying, and then sent the gold to the U.S. Mint.

After sluicing the dump, we would, if possible, use a hydraulic system. All of the rocks over 6 inches or more were scaped down in the drift and thrown back. They didn't lift any large rocks out of the mine.

I will give you a few suggestions of what I think about modern day drift mining. I would suggest that we drive a 45 degree slope to bedrock and use mine cars to haul the paydirt out of the mine. We would use an electrical air driven driver in the drift. THe slope is needed for the O.S.H.A. safety standards. I don't think that O.S.H.A. would allow you to use a shaft like we used to use. Ours was a one shot shaft, without a ladder coming out of that shaft for escape or anything. The shallower mines, up to 50 feet, had a ladder, but not the deeper ones. A slope would probably be more acceptable to the safety standards.

Now, so far as I know, no one has invented a better method than steam to thaw the paydirt. I'd use a vibratory classifier down in the drift to sort out any rocks over 6 inches in diameter.

It is necessary to discuss slabbing. A word of caution for you would be drift miners--the ground will slab off. Ten foot pillars should be left at least every 50 feet along the tunnel. On the average, rooms 50 by 100 feet will hold, but all ground is not the same and the roof will not always hold up in a textbook fashion. You must always work the ground the furthest from the shaft first. Then, if you misjudge the strength of the roof and fail to leave sufficient pillars, you can drive a new cross-cut and continue the mine extraction by leaving more pillars. Usually when the drift mine slabs off, and I've been in a couple, they do it slowly. If it isn't too big a room, they'll start to drop very slowly in huge, frozen slabs. It seems to slab off in seams, where the creek has deposited different channels. There have been times when a roof falls rather suddenly. If you see a bunch of small pebbles falling quite fast, you'd better get out of there.

I worked in a drift mine once where (instead of driving their tunnels and working back toward the shaft) they steamed right off one side of the shaft and drifted 60' wide downstream. They went about 100' upstream without leaving any pillars. That thing began to slab. While timbering nights I watched those slabs fall. My job was to frame timber. I'd load about 6' of timbering materials into the bucket, and the hoistman would let me down to the height point I was timbering. I'd put in 4' to 6' of this timber, then, I would wheel a bucket load of gravel, get in the bucket, ride up and shovel the gravel in behind the timber, to hold it in place. I wheeled right over the top of the fallen slabs. The next day, that mine caved in. They lost the whole mine.

PERMITS AND REGULATIONS

J. P. Tangen
President, Alaska Miners Association

In order to talk about the regulatory process, I believe it's necessary to paint a background mural of what the law, which has given rise to the regulations, looks like. The body of words and ideas that we call the law is readily divisible in a couple of ways. One such division, which commends itself to your attention, is a division between what I'd like to call articulation and interpretation. Articulation, of course, is that which is actually written down, and interpretation is what people read into the words.

Most laws, whether State or Federal, are originally conceived of to resolve a perceived problem. But, since most lawmakers are not very well versed in the details of the subject that they are trying to deal with, they are very willing to compromise. You all know what a compromise is. A compromise is a situation where everyone gets what they don't want. Out of their recognition for their lack of technical knowledge, lawmakers hand the responsibility for carrying the laws out to administrative agencies for implementation. If the statutory language itself is the articulation of the principal the law intends to accomplish, the first cut at interpretation of the laws results from the promulgation of regulations by the administrative agencies.

Our system of government presumes that those who staff the administrative agencies possess the technical confidence to make knowledgeable interpretations of the statutory system. In fact, this may have once been true. At present, however, the regulations are, as often as not, premised upon arbitrary decisions selected because of the awareness inside the administrative agencies, that many of those matters intended to be regulated are not fully understood.

The second cut at interpretation comes in the regulations that are turned over to field personnel, with directions to implement them. This is where the hard line between theory and reality meets. It's where policy confronts practice. The recent trend in regulations, in my judgment, has been away from the prohibitory or instructional mode and toward what I would call an action-forcing approach. One explanation for this development is the notion that all problems are resolveable through technological innovation. This trend blind sides the economics of research and development and attempts to redirect certain funds towards socially identified objectives.

To illustrate this point, consider the problem of water pollution control. Throughout the first half of this century, industry generally regarded the waterways of the United States as the conduits for restoring industrial waste to its source. However, by overloading certain systems, fisheries were destroyed and the recreational use of some waterways diminished. A move took root to stop this so-called degradation of the environment. The theory was simple. The cost of restoration of waterways should be born pro-rata by those who defiled it. This formula did not work,

however, because there was no meaningful way to allocate the liability. Accordingly, in 1972, the Federal Water Pollution Control Act was amended to require that certain industries stop their polluting. The objective was to be accomplished through three steps. First, the polluter would be required to use the best practicable technology. Thereafter, he would be required to use the best available techniques, and ultimately, he would be required to accomplish 'zero' discharge. Step I and Step II were a couple of those famous compromises. The first one gave a nod to the fact that: Even if technology were available, it might not be affordable by those who need to employ it. The second step acknowledged that even the best possible technology might not achieve the pollution objective, no matter how expensive it may be. The final step; the action-forcing step, the idea was that there would be no discharge at all, implied the belief that, in due time, if the industries involved knew it was coming, they would generate the technology necessary to meet the standards. In my judgment, there never has been a greater or blinder tribute to the capabilities of American industry.

You may judge for yourselves whether the approach was effective. Most people, reluctantly or enthusiastically, have to agree that it has been. The cost can be measured in terms of the jobs and industries that have been lost. Many people question whether the results have been worth the price.

Another novel concept which has come of age is the idea of self-incrimination through permits. I say this is a novel approach, but of course it has been with us for a long time actually, in the area of tax returns. The tax system requires you to report all of your income, from whatever source. If your profession happens to be criminal, then you are placed squarely between the Devil and the Deep Blue Sea, because if you do admit to your criminal activity you're in trouble, and if you don't, you're also in trouble. The permit granting process, likewise, boxes the operator in, because if he fails to apply for the requisite permits and operates without them, he violates the law. If he does obtain the requisite permit, he may be forced to disclose sufficient information to cause him to be found in violation of the law.

The Constitutional Prohibition that some of you have heard about, against forcing people to incriminate themselves, has been made to vanish by a fete of word magic. They simply decriminalize the violations and call them "civil penalties". Now, in my judgment, a penalty is a penalty. Whether you call it a civil penalty or criminal penalty, it seems to be the same kind of thing. Others seem to see it differently.

Moving from the general to the specific, the placer miner in Alaska today has several difficult tasks to address before ever even turning a shovel full of dirt. He must ascertain which of the Federal, State and Local entities and agencies claim jurisdiction over them. If he is going to operate on Federal Land, he must know whether it is claimed by the Parks Service or the Fish and Wildlife Service or the Bureau of Land Management, or the Forest Service or the Department of Defense, or the State Department, or the Nuclear Regulatory Agency or some other agency. If he's on State Land, the choices are more limited; he must not only know whether the land is patented or tentatively approved or only selected, but he's also got to

make the statutory interpretations consistent with the constitutional requirement that our natural resources be developed in a reasonable manner.

One step that has been taken is the evolution of the tri-agency application form, which has been circulated in draft for the past couple of days. That draft, I am advised, is in close enough form to the final form as to make it appropriate for use this season.

This one application has on it questions or requests for all the information that is necessary for the issuance of those permits, which are needed for mining, from the Department of Environmental Conservation and the Department of Natural Resources and the Department of Fish and Game. By virtue of the fact that you only have to fill out one application form, and the State will reproduce it, distribute it and issue your permits on the strength of that application form, I think is a modest, but noteworthy step forward.

Yesterday, I noticed that several of you met after the afternoon session with Policy Level Representatives of the three State regulatory agencies, the Department of Commerce, and Bill Lamerow from the EPA to discuss those steps that need to be taken to establish a working relationship between those agencies' field representatives and the placer mining community.

In my view, this is an embryonic notion of how the State will interact with the Industry, hopefully for decades to come. If you have not done so already, please attain a copy of the document that was distributed yesterday called: Cooperative Effort for Placer Mining Proposed Field Program. There is enclosed in that document a policy statement, which bears the signature of Commissioners LaReuse, Mueller and Carl Rozier. That policy statement says in part: it is the policy of the undersigned three agencies to take legal action as a last resort. Then, only after notifying the operator of the violation, offering technical assistance and allowing a reasonable amount of time to solve the problem.

Now, I don't know how you react to that, but I react to that as a minor miracle, because if that policy is followed this season, then many of the conflicts which have occured in the past can be defused. I suggest each of you obtain a copy of that policy statement and in the course of your season, should you have an opportunity to do business with field representatives of these agencies, you can refer to it and remind them exactly what the policy of their agency is.

This is not Valhalla, but I believe it is a monumental step forward. The laws and regulations are not all that they appear. As a law professor I once studied under was fond of saying, "A word is not a crystal, it is the skin of a living thought". The words of the law, as articulated, are not nearly so important as the way they are interpreted. I believe that by interacting with those who do the interpreting, the interpretation can be rendered tolerable in many instances and the mischievous language of the law can, in fact, be contained.

As an idealist, I would repeal all the laws and start over with a blank page. But, as a pragmatist, I believe in the necessity of exercising one's influence in the war of competing desires and objectives. I believe that, through diligence, we can make progress, and if we must compromise, maybe we can get a little bit of what we do want.

NATURAL REVEGETATION OF DREDGE TAILINGS AT FOX, ALASKA

Kay W. Holmes
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School of Agriculture and Resource Management

Introduction

Large-scale, gold-dredging operations are now largely a part of Alaska's history and the giant gold dredges responsible for recovering over 7 million ounces of gold from interior Alaska's rich placer deposits lie unused, now of more interest to historians and tourists. Other forms of land disturbance, however, including road and pipeline construction, logging, and the extraction of a variety of minerals and rock, continue to generate areas stripped of vegetation and, in many cases, of productive soils as well.

Between the years 1928 and 1964, active gold mining in the Goldstream Creek and Tanana River drainages resulted in the removal of vegetation and soils as well as the gold from large areas of land leaving behind elongated parallel mounds of coarse gravel tailings. Mined at a time when there was little concern for assisted revegetation, which involves any of a number of deliberate measures taken by man to promote the reestablishment of vegetation on a disturbed surface, these lands were left to nature to revegetate.

Information dealing with assisted revegetation in high latitudes is relatively scarce, largely because concern for environmental quality is only recent. Studies of natural succession in the far north have been the source of much of our information on revegetation in arctic and subarctic regions. Peterson and Peterson (1977) note that the oldest known attempts at assisted revegetation in these areas are less than 10 years old. In order to gain an understanding of ecological trends it is necessary to look at the natural revegetation on surfaces of known age. While accurate dating of disturbed land surfaces often proves to be the greatest obstacle in this pursuit, the dredge cleanup maps owned by the Alaska Gold Company documenting dates of mining made the Fox tailings ideal for successional studies.

The primary objective of the study project was to determine what plants have recolonized the Fox dredge tailings without man's assistance and to assess the relative importance of each species present. A second objective was to determine if any vegetational patterns could be detected and related to readily measurable physical features of the tailing mounds such as dates of mining, mound orientation, slope, and percentage of fine particles mixed in with the coarser gravels. Knowledge of what factors most affect regrowth would help land managers decide what practices, implemented during and/or after mining, would be most apt to encourage successful plant invasion. We are optimistic that the findings from a broad-scoped study such as this will aid in more detailed ecological studies and facilitate assisted-revegetation programs in the future.

Methods

We selected the study area with the help of Dean Earl Beistline of the School of Mining and Mineral Engineering of the University of Alaska and Mr. Dan Eagan, vice president of the Alaska Gold Company. The study area is located near Fox, Alaska, about 10 miles north of Fairbanks. The site for intensive study was chosen because it was easily accessible by Fairbanks road systems, was under single ownership, and its tailings surfaces remained relatively undisturbed since dredging. Much of the rest of the mined area surrounding Fox has been subjected to other land uses.

After an initial reconnaissance of the area, it became apparent that in many instances, tailings of the same approximate age varied widely in the amount of plant growth each supported and that a direct and positive correlation between date mined and degree of growth seemed doubtful. For example, mounds deposited in 1930 and 1931 could be found that were still nearly bare of vegetation except for some lichen growth, while other mounds, mined the same time, supported dense stands of trees. In order to minimize further variation, we decided to restrict the intensive study to tailings of the same age.

Investigation of the vegetation on the various sites was conducted between June and October of 1979. Areas of relatively uniform vegetation were selected that represented an array of differing degrees of recolonization. The following descriptive factors were:

1. Relative amounts of crown or shoot cover of different kinds of plants, i.e. trees, tall shrubs, low shrubs, herbs, mosses and lichens.

2. Relative height and girth of tree and tall shrub species.

3. Physical features of the mound surface that were estimable such as the percentage of fine particles, average gravel size, etc.

4. Any physical features of the mounds as a whole such as: orientation and steepness of the mounds and whether the dredge deposited gravel while moving up or downstream.

All but the most common species were collected and brought back for identification and verification. Hulten's Flora of Alaska and Neighboring Territories (1968) was used for identification of the vascular species. Crum's Mosses of the Great Lakes Forest (1976) and Dahl and Krogs' Macrolichens of Denmark, Norway and Sweden (1973) were the main sources used for identification of mosses and lichens, respectively.

Permanent plots were set up on a limited number of mounds so that vegetational changes could be followed over time. Certain vegetative features of these stands were mapped and information on plant size, vitality, and distribution were recorded. In addition to providing a permanent record, mapping furnishes the only practical method of securing reasonably precise

quantitative data from a limited number of stands that were too small to be plot sampled at the tree and large shrub level. Soil samples were collected on these permanent plots and nutrient analyses were carried out by the Agricultural Experiment Station Soils Laboratory at Palmer. Data collected are currently being analyzed and we hope that additional patterns that may exist but were not detected in the field will emerge.

Preliminary Results

The vegetation present on the Fox tailings represents a wide range of natural recolonization from almost totally unsuccessful to stable productive mixed hardwoods forests. Though there exists a continuum of intermediates between these two extremes it is impossible to divide the range of vegetation types into three broad categories for purposes of discussion.

Bare Stands

As noted above, vegetation on the sites ranged from relatively little to dense. The barest sites had less than 25% total ground cover by woody species (Fig. 1). The fines mixed in with the coarse surface gravel comprised about 5% on these sites; deficiency of fine particles was the only obvious reason for the failure of these sites to revegetate. Paper birch (*Betula papyrifera*) was the most common tree species, but it accounted for less than 2% cover. Most of the tree species were sapling sized; tree-sized individuals 10 ft. tall and 2 in. in diameter 4 1/2 ft. above ground level were rare and widely scattered. Balsam poplar (*Populus balsamifera*) and quaking aspen (*Populus tremuloides*) saplings were present in lesser amounts. Willows (*Salix* spp.) accounted for 1 to about 5% ground cover. Other tall shrub species, frequent on the more developed sites, were absent or rare in these stands.

Bare gravel predominated in the ground cover and any accumulated litter was restricted to the furrows of the small secondary undulations which characterized the surface of the mound tops. Herbaceous plants were few to occasional and always accounted for less than 5% total ground cover. The more common herbaceous species present were: fireweed (*Epilobium angustifolium* and *E. latifolium*), hawksbeard (*Crepis elegans*), a shield fern (*Dryopteris fragrans*), and a crucifer (*Arabis Holboellii*).

The most abundant plants were the lichens of which *Stereocaulon* spp. was the most common and formed loose mats on bare rock as well as on pockets of exposed mineral soil. Though present with far less cover, species of *Umbilicaria* were as numerous as *Sterocaulon* spp. Several moss species were found in very low numbers and provided little cover.

Intermediate Stands

These stands had greater than 25% cover by woody species but less than 50% cover by all species (Fig. 2). Generally, the same tree species were present as in the sparsely covered stands, but in greater abundance, with

Figure 1. Nearly bare of vegetation except for some lichen growth, these tailings deposited in the 1930's support some birch saplings in the valleys between ridges.

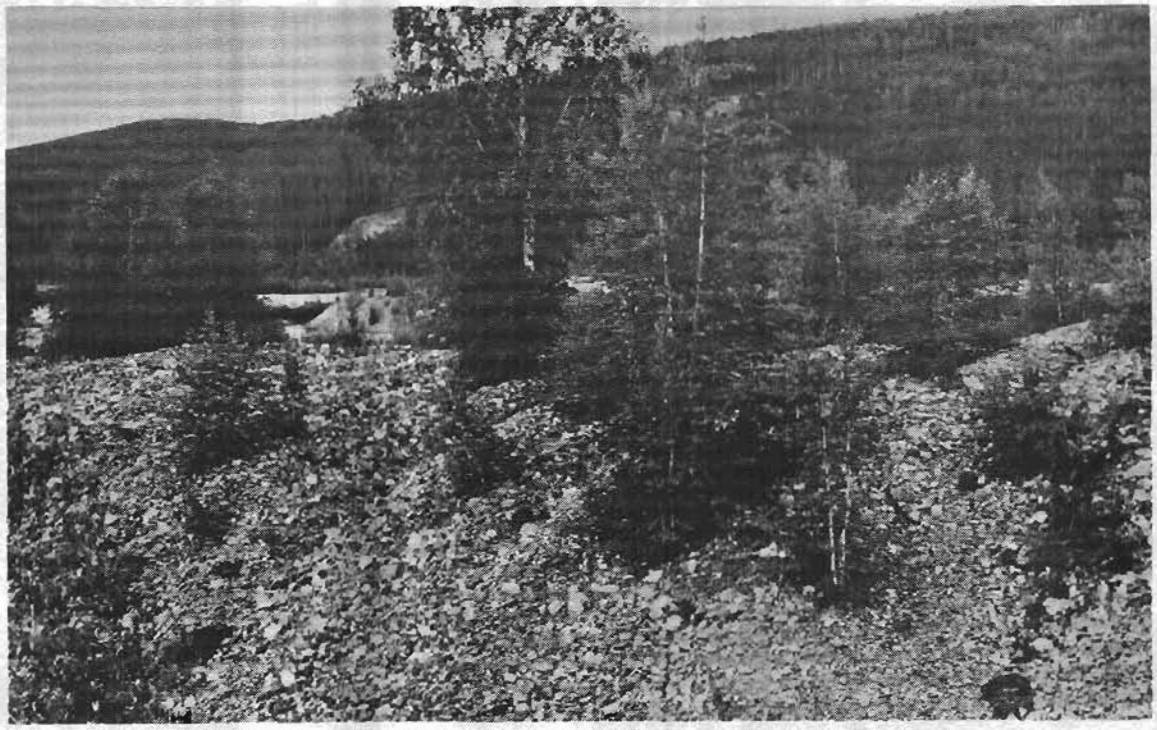

Figure 2. An "intermediate" stand of birches, aspens and balsam poplars of varying sizes. Clumps of mineral soil with abundant moss and lichen growth are evident in undulation furrows.

relative cover percentages varying from stand to stand. Birch had the greatest abundance and cover in all of these stands. One or two white spruce (Picea glauca) saplings or seedlings were commonly found in these stands, though they were usually suppressed and stunted.

Tall willows and other tall shrubs, especially wild rose (Rosa acicularis), were also more abundant than in the bare stands. Low shrubs and herbs, while infrequent in the bare stands, were more common in these stands, though none had high cover values.

As with the vascular plants, the cover values for lichens and mosses were much higher; members of the lichen genus Stereocaulon accounted for up to 50% of the total ground cover.

Litter was a much more important component of the ground cover than it was in the barer stands. Discontinuous to sometimes nearly continuous layers of leaves were apparent in the undulation furrows of the surface. On gravel substrates such as these, the accumulated organic matter in the form of leaf litter provides the moisture essential to the growth of a number of understory low shrubs, herbs, mosses and lichens.

Dense Stands

The sites with the heaviest growth (greater than 50% cover by woody species) had a much smaller percentage of exposed rock, and the fine-particle component of the gravel matrix averaged 30 to 50% of the total volume of solids (Fig. 3).

Tree species present in the dense stands were the same as those growing on the other stands, though densities, average height, and average girth were substantially greater. Larger and more vigorous white spruce also appeared to occur more regularly in these more developed sites.

The composition of tall shrubs was also similar to those of the intermediate stands with increases in the occurrence of high-bush cranberry (Viburnum edule), American red currant (Ribes triste), and rose. Increases in the abundance of Labrador-tea (Ledum palustre spp. groenlandicum), bearberry (Arctostaphylos uva-ursi), blueberry (Vaccinium uliginosum) and Lingonberry (Vaccinium vitis-idaea) characterized the low shrubs of these sites. Bluejoint reedgrass (Calamagrostis canadensis) and tall fireweed were the two most abundant herbaceous plants, together comprising up to 15% ground cover.

The greatest compositional changes seemed to occur in the moss and lichen flora. Members of the lichen genus Stereocaulon which were dominant as a ground cover in the intermediate stands were all but absent from these denser stands and Peltigera and Cladonia lichen species predominated. Feathermoss (Hylocomium splendens), rarely found on the more open sites, was a dominant moss species in these stands. This position of dominance was shared by members of the moss genus Drepanocladus, a genus well represented in the intermediate stands.

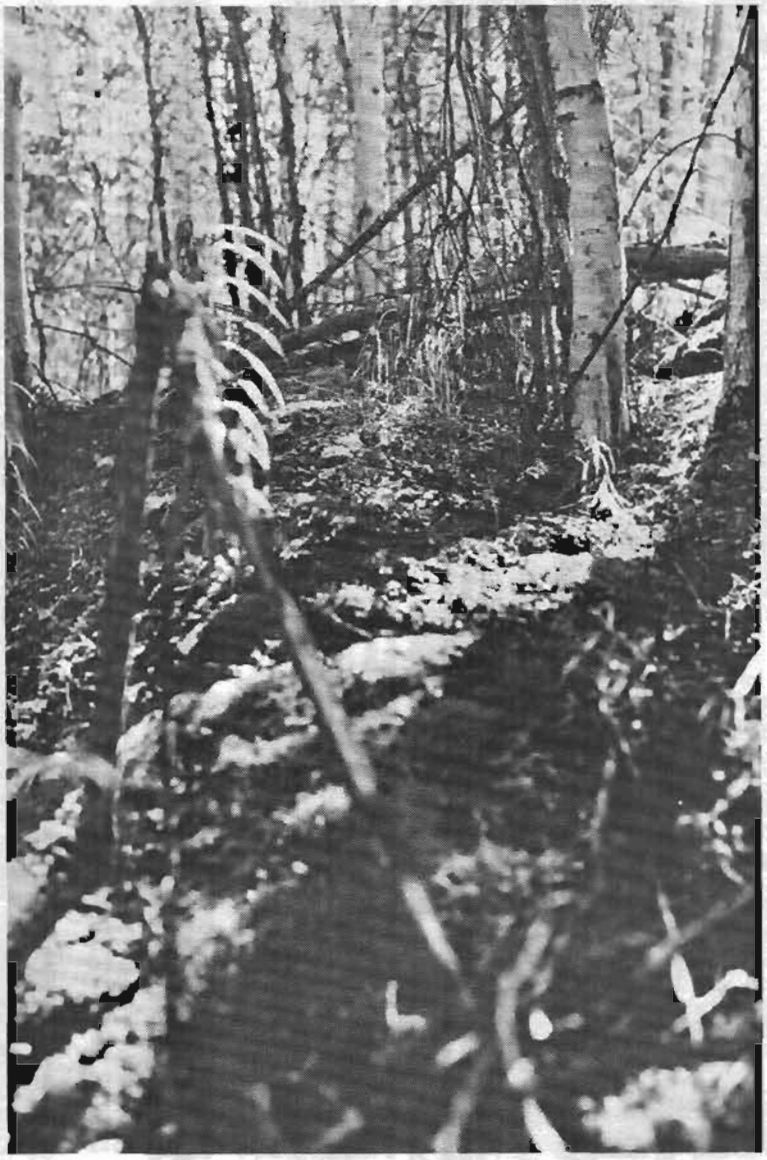

Figure 3. A "dense" stand with developing moss mat and tall fireweed and grasses in the understory.

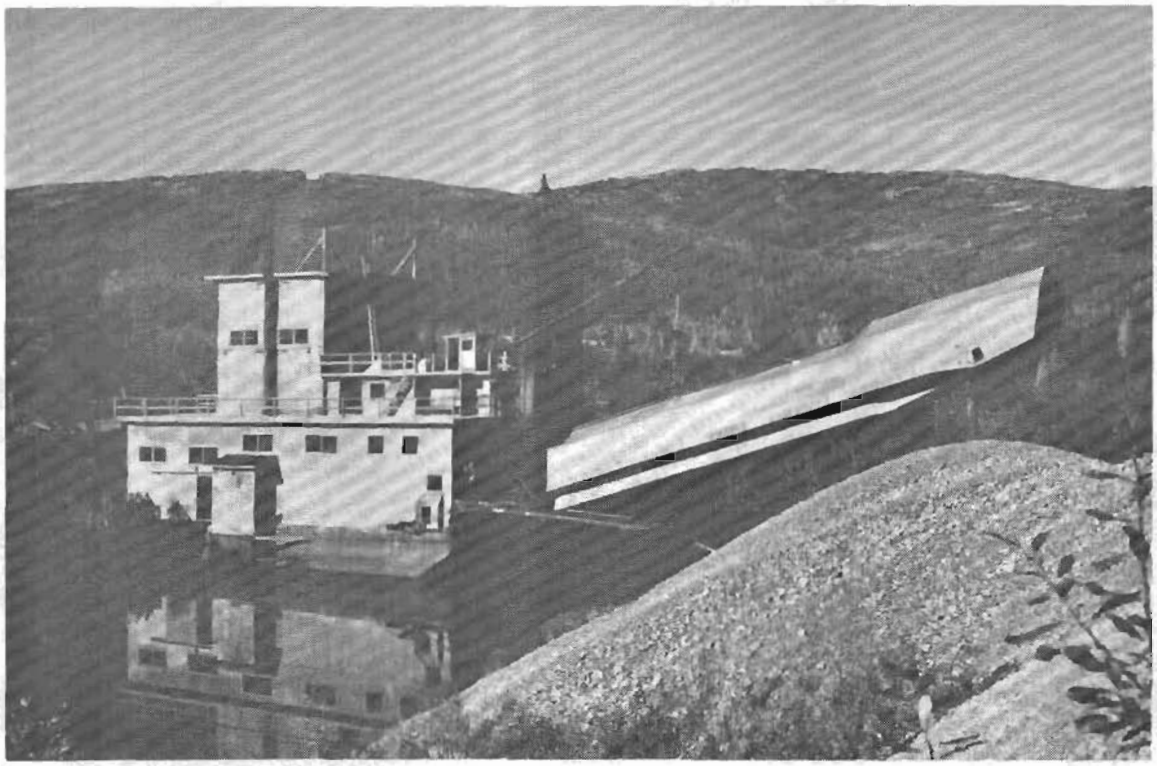

Figure 6. Dredge #8 (6 cubic foot) in Fox, Alaska, reminds us of a bygone era. The bare tailings were deposited in 1959.

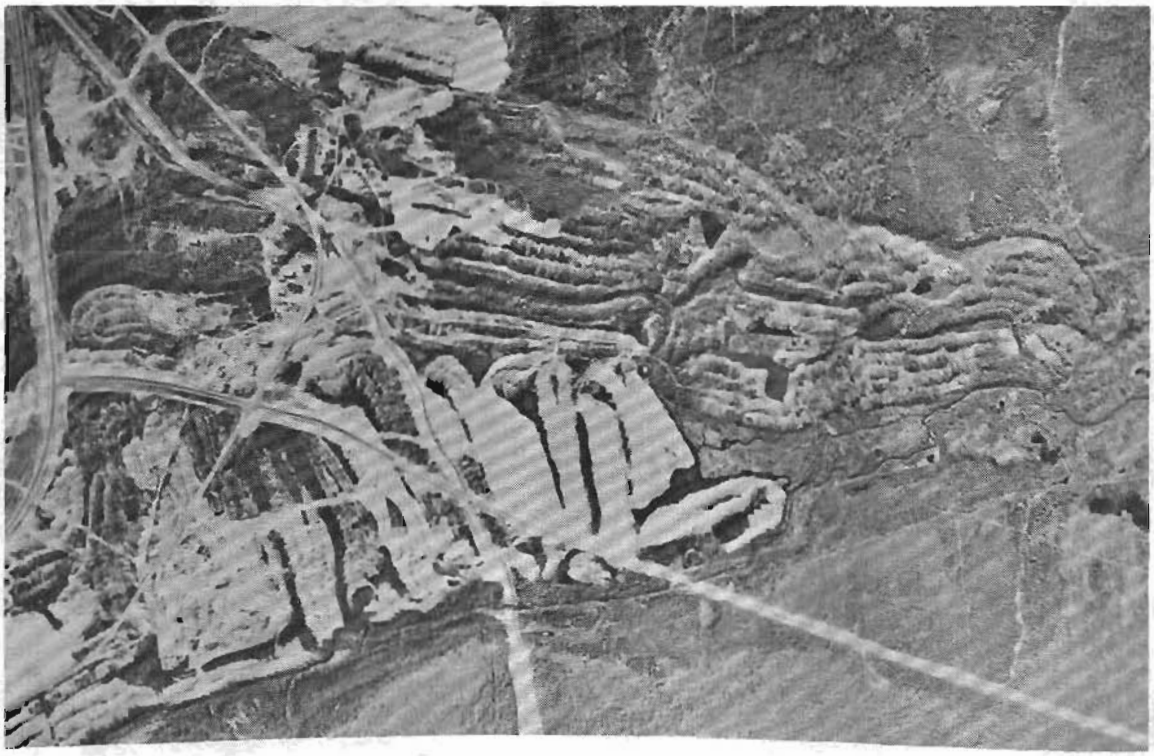

Figure 7. Air photo coverage over the study area. Note Dredge #8 in pond upper right corner. Goldstream Road and Old & New Steese Highways, Pipeline.

Concluding Remarks

Extensive and limited intensive studies of the Fox tailings revealed a wide array of vegetational types in which vegetative cover was not consistently and positively correlated with age. The presence of 50-year-old tailings mounds with essentially no vegetation on them indicates that without assistance these areas may well remain barren for several hundreds of years. Other densely vegetated mounds of similar age supporting vigorous mixed hardwood forests indicate that man's assistance may not be requisite to successful revegetation in many instances. Findings such as these suggest the need for a variety of revegetation techniques selected according to the capabilities and location of the site, concentrating assistance on those areas of high value and nearest population centers and which have little potential for natural rehabilitation.

Acknowledgments

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A MINING OPERATION IN THE YENTNA DISTRICT

Bill Hall
Hall Gold Dredges

Peters Creek is on the southside of McKinley, in the Yentna District, about 150 miles by road and 100 miles by air, northwest of Anchorage.

A mining operation involves valuation of the ground prior to mining. It is important to evaluate a property not just at the start of an operation but as a continuous process right ahead of one's mining operation. It's important to know where the gold is laying, right ahead of the operation; and for planning future expansion and the design of equipment and plants. One has to know the texture of the material, the clay content, how tough it is, how long it's going to take to break it, how deep to cut the bedrock and what size recovery methods are needed. Is a 6 foot trommel with a 30 second retention time (75 H.P.) needed, or a 12 foot one with a 3 minute retention time requiring 2,000 H.P. to drive it needed to release the minerals?

The recoverability of values is important; not how much gold there is, but what recovery system is needed. A lot of gold is not adapted to simple systems. It may be flat, fine, and hard to recover. Some gold bangs when it hits the gold pan. It's quite heavy, but it's shaped like skipping rocks; the kind one picks up along a stream that skip well in the water. That type of rock, or gold, has come a long way down river, and as it tips over in the undercurrent under a standard riffle, it will expose enough surface for the water flow to carry it on by. I've run tests where recovery is as low as 20% in a standard box. With a standard Hungarian ripple, changing the pits, changing the water, everything, one is looking at 20% recovery. The size and shape of the gold is very important, as well as the amount. The depth of the deposit is important; to determine the type of machinery needed to recover the gold. Availability of water and accessability to the property must not be overlooked. Certain types of equipment may not be able to move in. One must determine the feasibility of mining at the current prices.

The primary recovery system will be determined by the texture of the material; the recoverability of the values; the depth of the deposit; the availability of water; accessibility of the property and economics. If only 1/2% or less of the gold is running over 3/8", it would be foolish to run a 1 1/2" screen. I'd screen less than 3/8" in size, and use a nugget trap for the remainder. One might double the capacity of the plant by dropping from 1 1/2" down to 3/8" and probably sacrifice less than 1/10 of 1% of one's total recovery. The finer you screen your material, the better the recovery. When one starts running bigger material through a box, it is not possible to use a block riffle on top of the Hungarians; the material will hang up or the rocks will knock them off. Too much water is needed, flowing through the box, to carry your material. The secondary recovery system is important; more important than most people think. Is is no problem to sink $100,000, at least, into a secondary recovery system to adequately handle your cleanup.

I'm a believer in new equipment. I think there are two ways to go in mining. It's like any business; if one is building houses, he can build two or three and make a profit by doing it himself. The name of the game is making a profit. When one goes from a family operation to an operation that requires hiring people, I think it's very important to have new equipment; the best manpower, the best wages and to encourage the best people. I have a long "don't" list.

If you manage for, or work with bigger companies, you learn a lot of don'ts. The bigger companies do not have exclusive rights to them. No. 1, don't move the material more than necessary. A lot of people go out with D-8's and D-9's. Sometimes it's the way to go in an operation. But you've got a lot of equipment. You're moving material to the plant; you're feeding the plant and you're moving away from the plant. You're trying to keep a drain open. Every time you move it, it costs you money.

Most operations require down-time to skid a plant; to move it to avoid the excess distance pushing materials to a plant. Don't lose time during cleanup. Most miners don't clean up enough; if one doesn't clean up often the riffles will pack, and you start losing fines. That's money. Our fines may run 80% in the minus 20 screen and up to 40% in the 200 and finer, even in high country where most of the gold has traditionally been heavier than that.

Don't fight nature! Nature is a tool we should use whenever we can. Any time that one fights nature, it costs money and requires more moving parts; if one puts on stackers and gravity feeds material through the system, to avoid lifting the material more than one time, it is a saving on down-time, moving parts and fuel cost. Try to set up the plant accordingly. Don't use moving parts! I don't like to use moving parts any more than I have to. It's hard enough keeping welds together, or solid pieces that are now welded. If one starts dropping 3, 4 and 5 foot rocks on a Grizzley, it is hard to hold your recovery system together.

Don't use poor help! When the operation requires hired labor, I think it's very important to pay the best wages. I try to pay well over union scale; time and a half, double-time and a good bonus at the end of the season. This encourages the best men to work with me. Machines are back on line in record time; it's done right and doesn't have to be redone. Down-time will really kill an operation.

We don't sit down for lunch; we overlap the lunch-breaks. We run a plant with two men. It takes one person to run the entire plant and operation. We have two there for safety reasons, assistance, auxillary work and primarily to switch off with the main line operator for coffee breaks, rest breaks and lunch breaks. Fifteen minutes a day, on two shifts, doesn't seem like much but it adds up. The men sit there 45 minutes waiting to go on line. All those 15 minutes added together amount to perhaps one hour a day. One hundred days and 100 hours equals 25,000 cubic yards, if the plant capacity is 250 yards per hour. We are talking about quite a bit of money; just by adding up the 15 minute breaks.

I think cleanup is important and must be done daily. If not done daily the riffles pack and one starts to lose fines, up to half of it out the end of the box. It isn't a good way to make money. Cleanups, for most miners, is a very cumbersome, time consuming effort, not carried out often enough. Let's say that it takes an hour a day, on the average. It might take three hours a day, or three days to complete a cleanup. Some operations take 8 or 9 hours once a week.

If the men aren't able to fix the equipment as fast as a good man that really knows what he's doing, then you may lose a total of 6 hours a day. Of course, this is discounting the lunch breaks that we overlap on. It is kind of theoretical, but if one loses 6 hours a day during a 100 day season, you've lost 600 hours. If you're in $20 ground, then you're talking a total of 3 million dollars in lost revenue. In many cases, that's the profit. I think the main thing is: stay on line with the equipment; eliminate down-time.

I buy two backholes for each plant. We feed with a backhoe. One we pull out once in a while for exploration. A backhoe is a good exploration tool; probably one of the best, if your ground isn't too deep. The hoes we use have the capacity to go to 40'. If we bench them down, we can go 50' or 60' deep, if the necessity arises. One can cut 30' or 40' shale bedrock; as easy as cutting clay. They are large machines and they are fast, we put trenches across the claims every 200', from one side to the other. Even with water coming into the trench, the backhoe, with a large bucket and cycle capacity, makes a pretty good pump. One can keep the water table down and walk behind the backhoe. One can pile certain levels of material in different areas; log it all, do a little panning, check the texture of the material and see how it's laying. The information that you can learn in the trench may allow one to follow the paystreak. The operator can then tell when he's coming into the pay or going out of it; by the material that is coming up in the bucket.

We use a pilot plant, which follows the exploration backhoe. It may take a week to catch up. We have a week to pull the auxillary hoe off to explore. We sometimes use the hoe to keep water diverted. The hoe will build roads faster than a cat. One can put a big backhoe up against a few D-9's; because it cycles so fast, it will cycle three loads a minute and swing at 80'. You can dig in mucky ground; you can lift up and lift over. I think for a good machine, the 245 backhoe is just coming into its own.

The 245 can carry a small 3 yard bucket with about 54 inches across the face. It has about a 50' reach, and it will dig to depths of 40'. It will dig a flatbottomed trench at 35'. It works very comfortably at 20' and less. It will rip bedrock. It will pick up 6, 7 and 8 foot boulders. Normally, unless they're real hard boulders, it will break the boulder in two.

The top of our grizzley is 3 stories high, to give you some idea of the size of the machine. Our old grizzley was made out of 14 inch "I" beam. That's a problem on a grizzley. We now have a flatbed grizzley; it is a replaceable grizzley with a flat deck of 1 1/4" spring steel; T-1 steel keeps the entire deck flat.

We selected the 245 because it has the capacity to lift 27' to dump. We use a floating plant. We get by with a lot smaller flotation and get around a lot better than with a bucket dredge. The hookup to the backhoe is always the right distance to dump so that, fully extended, it does not hit the straight bars. The plant walks back and forth across the valley. The backhoe has control of the plant, and when he moves, the plant doesn't necessarily have to move. If there is a solid hookup, something is going to tear. We use a yoke type hookup with large springs. That way, he can grab his undercarriage slightly and change the position of the tailings. If he's got high bedrock behind him and he's digging 20' in front, he can swing his tailings over into a hole to give him control. When he moves, the drawbar horsepower is pretty high. If the plant is not going to move through the water that fast, it's going to tear something up, without the springloaded system to hook it up.

This whole plant was put together in a hurry. We put it on line in about 30 days. One of our backhoes lost a swing pinion when it was new. There was no reason for it to break. The swing pinion snapped with a big boulder in it and the operator couldn't drop the bucket. He tried to elevate to get above the plant, but he didn't make it. It knocked the top of the plant off and cost us 10 days. Those things can happen once in a while.

We use a 12" grizzley; 12" minus. In a frost situation, the expansion coefficient (the differential between the expansion of the rock and the clays) will cause the clay material to break loose from rocks larger than 12". Smaller than 12" and they freeze as a mass, staying stuck together pretty well. We find that a 12" grizzley works pretty well. There are about 2,000 gallons a minute, coming through the spray bars, from an 18" nozzle on each side. Our grizzley is 30' across, with hoppers on the side and pipes going down into the bottom of the upper boxes, to catch spill from the backhoe as it's coming up. We had to change the configuration of the linkage to elevate that height and keep from spilling. Any overrun from the grizzley goes into the side hoppers and then into the top boxes. We use two pumps on it instead of one big one, so that we have three engines that match for our spare parts inventory. We hydraulically drive, so that if they're servicing one engine, we don't have to shut down for cleanup. We don't have to hold up our cleanup while they service or change oil on an engine. We cross-manifold, and can use either pump for the cleanup operation.

We raise the material to about 11:00 and drop it, to get a good churning action. This is adequate for most peat situations; without too much clay. We use a 3/8 screen. It is important that the screen matches the amount of water coming in. 4,000 gallons a minute come in here, with an additional 2,000 gallons a minute coming into the main grizzley hopper and another 2,000 coming through the spray bar. It's important that your water doesn't pass through too soon. With this type of churning action, the spray bars can't be inside. It's important to maintain the water to lubricate the material and wash all the fine slough wealth clear to the end of the screen, but not running out the end. Gauge the holes properly to match the amount of water, and get good lubrication to the end of the trommel section.

The top boxes are set at a fairly steep hitch; 1 3/4" to 2" to the foot. The bottom boxes are 20' boxes; 30" wide with a block riffle on top of the Hungarian riffle. They have an oscilation of about a 1" stroke, at 200 strokes to the minute, in a sideways motion.

I've said before that I don't like moving parts, but that keeps the bed alive; if we do lose the shaking motion, we've still got the boxes hanging there and running. We don't shut down our plant; we don't slow down our capacity or our feed. We may sacrifice, slightly, on recovery, but when it fails, we've got a loose box with loose riffles that still give us pretty good recovery.

At the end are hoppers that come down on the end of these boxes. We're rigged for a fast cleanup. We clean up this plant in less than 30 minutes. There's quite a bit of boxed area on it. Thirty minutes from when we're backing up to the plant until we're driving down the road.

The troughs on the back tip up for cleanup. The truck just backs up and hooks a quick couple to the troughs. The riffles pop in the air. They are hydraulic, and lift 14" vertically. They lock down on eccentric arms. Each set is matched to the box. The matting is bolted to the riffles.

The water goes through the block riffler like a meandering river, if the pitch and the water are right, and a boil effect is produced that is like a river coming out of a canyon. Now, if one can set the box so that a cigarette butt thrown in it will still be there a half hour later, the surface tension will be broken and the fine recovery improved. It is not possible if one is forcing larger materials through the box. Too much water is then needed, and of course, one can't use the block riffles. The oscilation keeps the bed alive, so that when the material gets in, it has a place to hide behind; it isn't packed under the riffle (we use holes in the Hungarians, which in effect gives us more surface area and a whirlpool effect and an undercurrent). The oscilating box keeps it open under the riffle at all times. The silt doesn't pack in, and the heavy material will vibriate right down. If one screens at 3/8", use about a 7 1/2" on center block riffle, staggered between the riffles. We also use a 2 inch riffle set on a 15 degree pitch, about level, when the box is pitched.

The matting is bolted on to the riffle and comes down and under the next riffle. There is a rubber lining in the bottom of the box to seal the riffles. Each set of riffles is made for the particular box it's used with; not even a sixteenth of an inch gap, it seals down tight. The eccentric arms, facing upstream, keep the riffles locked down when you're in operation, the hydraulic ram just pops them up to damn the box. When they go up, the matting hangs vertically off of each riffle, the material is hosed into the box, washed right into the hopper and blown out into the cleanup truck in one quick operation. It can be done while refueling or changing oil.

The block riffle, used on a solid base, isn't as effective as if it were placed on top of a Hungarian. If we put it on top of the Hungarian, it works like the inside corner of a sandbar with the current running upstream behind the block riffle. The flat gold will lay in there (the type that

would miss a Hungarian) and, with the live bed, it is shaken right down. It seems to help in recovery considerably.

Secondary Recovery

The material is separated and screened on the cleanup truck. There's a slight overlap in the recovery system, but it's minimal. The material comes in from the cleanup truck into the cleanup building, and goes over a 16 by 24 duplex jig. We can handle the cleanup in about 30 minutes, from the plant through the secondary cleanup; at least a major portion of it. It comes across the 16 by 24 jig, which is set to take all the heavies through and pass the waste materials. That automatically feeds to a little 8 by 12 simplex.

The simplex is set up to take out a little higher concentrate. We smelt what comes over the top of it. What comes out of the bottom of the simplex feeds automatically to two 4' spirals. The first one we set up just sets the scalps and automatically feeds to the second one, which we set to take out about 95% of the free gold. It's fairly clean; we lose about 2% in the fire when we send it to the smelter and fire it. We get it fairly clean on a wheel. What comes off of both wheels goes into a rod mill in mercury to take the remainder of the gold out of it. We fire up the equipment all at one time, and when we start feeding, everything goes through automatically. It takes about 30 minutes to go through the plant cleanup. The rodmill is run for a day. When they are done with a cleanup, they dump yesterday's material out of the rodmill and put this day's charge into it.

QUESTIONS & ANSWERS

Q (Inaudible)

A If you leave a little waterflow, it takes a fairly stiff matting that is very durable, usually a heavy ozite. With just a little water flowing through the box, there's usually no problem. Once in a while you might have to stuff a mat under a riffle, but it's rare. We usually stop the riffles about 1/2" before they are set down tight, and check them. Then we set them down tight and check them. If a piece of scrap iron or something happens to hang up in the box it can hold your riffles up. If you get something under the riffles, it will hold the whole set of riffles up. You can feel the riffle and tell that it's down. You won't have much of a problem if you use the fairly stiff ozite mat. We're not so concerned about a mat with a lot of recovery capabilities like you would if it was blowing clean, because we keep the bed alive, and the live bed is more our trapping medium than the mat itself. The mat is there to seal the riffles. I don't know that the mat is that important, as long as you have a live bed.

Q What is the capacity of your operation?

A If you figure about 80% of what the backhoes will comfortably move, using a 50 minute hour and a 20 hour day (we usually run 22), conservatively around 5,000 yards a day; or about 250 yards an hour. In a 100 day season,

we will have turned half a million yards. If one can stay on line 150 days, we might get it up to 700,000 to 750,000.

We use two backhoes in every operation. The second backhoe is there as stand-by. We can change out in 30 minutes. Without it you may lose two days of operating time. If you're down two days you've paid for the second backhoe, or lost $50,000 out of your pocket, in $20 ground. It's important to have spare equipment. We have more tools to build the backhoes and parts for caterpillars than N.C. Cat has in Anchorage. If we blow a hose we can pick up another one in 15 minutes. We try to match all of our engines. We can keep our parts inventory down and only need one engine to replace any of them. We keep spare pumps; you can change a pump out faster than you can rebuild it. We can change out a pump in 30-45 minutes. If we've got to rebuild it it's going to take 2 hours with good men. If you've got bad ones, it will take 5 or 6 hours.

Q (Inaudible)

A No, about the only thing you lose off of there is the 12 inch plus, because the hoppers on the sides catch the fines; once in a while, they throw 4 or 5 inch rolls over there. There are 32 nozzles up there with about 60 or 70 pounds behind them. They wash the plus 12 pretty well. In every bucket you've got a few of them. Once in a while a 5 footer sneaks up in that bucket, or a 4 footer. We run the trommel on rubber to cushion the noise; it works well and may avoid some down-time; they're not so expensive to build. We use a rubber system with 20,000 pound access to run our trommel. The trommel is about the only thing that gives us down-time. The grizzlies are replaceable; we can switch a grizzley out in 20 minutes; in 30 minutes we can rotate it 180 degrees to take the wear on the opposite side. They control the way they dump by which side of the crown they dump on, of course. The plant only draws about 24 inches of water.

Q (Inaudible)

A No. Of course, the riffles don't vibrate, they have more of a stroking action. It's about like a "good pat shake" on a pan; just enough to keep the vent alive. If you vibrate it, you get more packing. If you stroke it and keep it alive, you get less packing. This isn't the ultimate system. We change all the time. We set up this operation for 20 foot ground; we can handle the big boulders, we can handle the clay and we can run a lot of yardage through. We do it more economically than the big bucket dredges; with a lower initial cost.

Q (Inaudible)

A You have to keep the pond water diluted, or you're going to start losing fines. Usually, if you have a big creek, you can kick some of the creek in. We'll build a dike and riff-raff to separate the two and leave a little water coming in at the head end. You do need enough water to keep your pond diluted; that's about all the water you need. You can handle a lot of water with a plant like that, or you can get by with almost none. The pump intakes are on the front and the sluice discharge is on the rear. The muddier the water, the more fines you will hold in suspension.

Q (Inaudible)

A We sell them for about $450,000 (complete) for the flotation and everything. Our cost is a little less than that, of course (but not a heck of a lot). You start talking about 150,000 - 200,000 pounds of steel at today's steel prices and the labor involved; it starts running into some money, pretty fast. The time involved--probably about 5 men for a couple of months. They start getting 40 hour shop time and start maintaining a shop. . . It's not a lot of money for a plant. If you're in $20 ground you'll pay for the plant and your two backhoes in probably 10 days. That's paying over union scale, etc.

Q (Inaudible)

A It isn't too hard, in some areas, to stay in $20 ground, if you've got exploration ahead of you and you're selective. There are a lot of areas that run $10 on an average; there are parts that would run $5 and parts that would run $20. If you can stay in the $20, you'll be better off. A backhoe is a good exploring tool. If you can get a big hole in and you can reach bottom with it, you can dig a trench there 6-7 feet wide; you can bale the water and the man can walk right down that trench and look at everything, and you can come by with a pilot plant later, work 5 yards out of each pile you've put out separately, and come up with pretty good yardage values instead of a 6 inch drill hole. A backhoe is a good exploration tool if it's big enough to handle the rocks and the bedrock.

Q (Inaudible)

A If you were prospecting? Sloughing could give you a problem. If it does, you're going to have to dig your trench a little bit wider. Usually, if you've got enough clay and your rocks are keyed in well enough, you won't have much of a sloughing problem. In most creek situations, even in clay, if the material is that loose and that fine, there's probably not much gold in it. Usually, up in higher country you won't have that problem, and the backhoe will bale water at probably 1,000 gallons per minute. You can use it as a pump if you need to. You can also dike the trench off, behind the hoe, to keep water from following you down trench.

Q (Inaudible)

A The tail is cut off on those things. It just dumps out of the end of the trommel, about 15 feet past the outlet of the sluice boxes. So it automatically stacks. We keep our water table up to within about a foot of the surface, ahead of the plant, so the hoe is walking about a foot above the water table. The tailings are dumping out 15 feet behind, eliminating stackers. The tailings tend to swell a little bit on you; they might be stacking 3 or 4 feet higher back there. You level them off and keep your water table up.

Q (Inaudible)

A We've run some tests on free gold. We were taking out about 97% of the free gold on wheels--without the gigs--if you dry it, screen it and re-run it about 4 times. The wheels are slow; we use the jigs to speed it up. In that system we're only concerned with taking out about 95% of the free stuff. The rest is locked in. We try to get all we can in the amalgam barrel. You can grind it up to talcum powder in that. You can pick most of it up, yet there's still going to be some left that we fire.

Q (Inaudible)

A We test the tailings ahead of the plant pretty thoroughly, maybe every 50 feet. Behind the plant we check them regularly; we check at the end of the boxes. Our recovery seems to be excellent. Percentage wise, it's going to depend a little bit on the type of gold in a particular creek, and how heavy your water is. If you happen to pump plenty of water, you're going to sacrifice. I think our recovery is excellent. Last year we worked in ground that had been worked three times ahead of us. We made money. We were working a lot of fines and a lot of quartz gold that had gone through their boxes.

Q Do you think you recovered 60 or 70%?

A Yes, way in excess of 60. If you can keep the block riffles and the holes in them alive, and do a cleanup regularly, I imagine over 90% recovery. But if you don't clean up, don't keep the bed alive and don't have the block riffles, you're going to start sacrificing.

Q How often do you clean up?

A We clean up at least daily, sometimes twice a day. We don't lose any time for it. We do a cleanup right when they are fueling at noon. (They have to shut-down twice a day for fueling.) We can also cleanup at midnight, while we're fueling, if we're picking up a lot of heavies.

Q (Inaudible)

A We use either of the mainline pumps. If we're servicing one, we can use the other. We cross-manifold.

Q (Inaudible)

A The backhoes will go places where cats won't go. You can take a backhoe just about any place. You can go in, taking enough fuel and equipment to build an airport, and then get parts in there. You might have to walk the basic hoes overland. You can't fly them if they're too big. The plant can be broken down and moved and put back together. Probably moved a few miles and put back together in a day. It can break down into 6 or 7 component pieces. The grizzlies have spares that just lift off, with no bolts, turn 180 degrees and set back on.

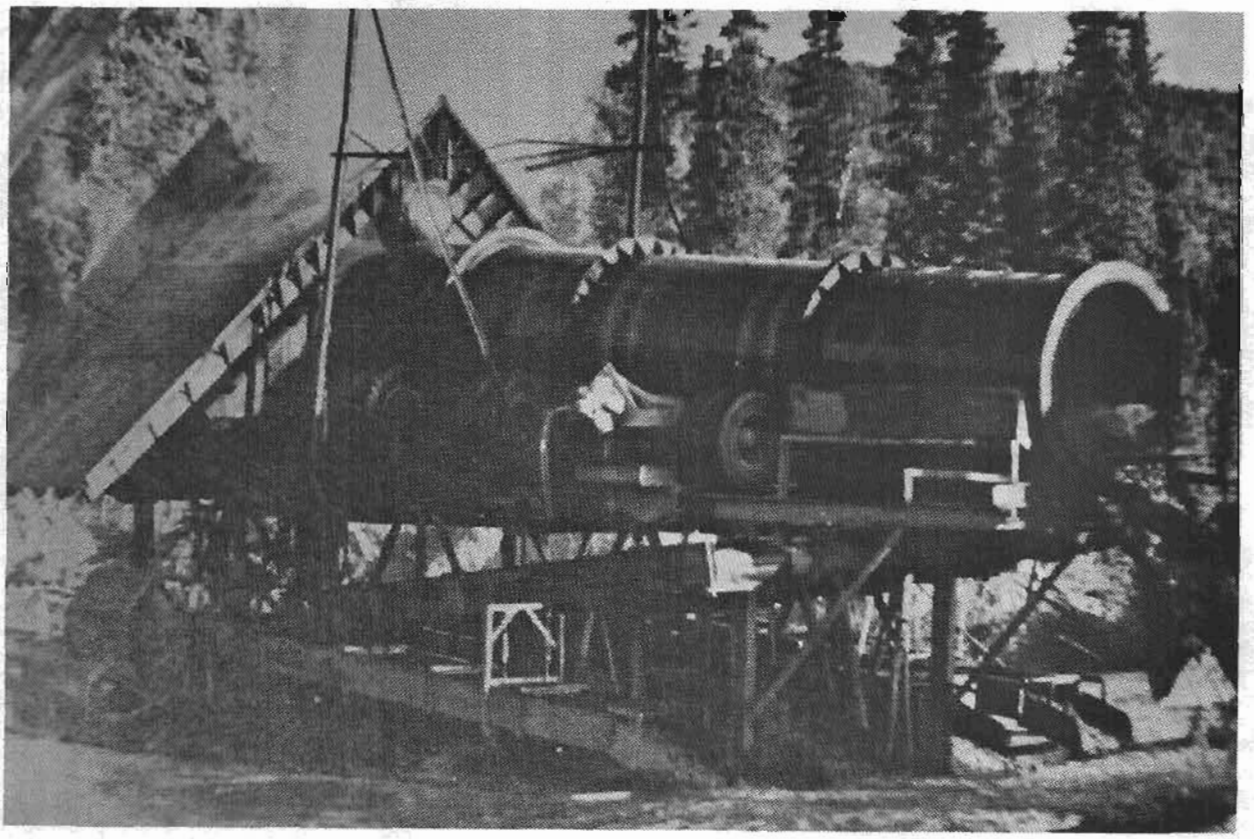
Q Do you have trouble with permafrost?

A No, we don't have any permafrost in this situation. I think the plant would work well, if it was thawed out ahead of it. The backhoes are capable of breaking the bedrock or breaking some frost if you have to. It's just like any other permafrost type of situation; you're probably going to have to clear a year ahead of time, and thaw it. It if's thawed, and it's 20 to 25 feet deep, maximum, this operation will work well.

Q (Inaudible)

A They're on a septic arm, every 4 feet, that slopes upstream on the side of the box. One of them is a heavy arm that goes underneath and hooks to a hydraulic ram. When these bars are activated, upstream, they just swing up in an arc and raise the riffles 14 inches off the bottom. When we drop them back down the matting slips back under the riffle below it and they lock to the bottom of the box. Because the arms are sloping upstream they'll tend to lock tight; the longer you run, the tighter they lock. We pitch the box out on the sides and put rubber on the sides, so that you don't get rocks wedged in between steel and steel, and have a binding problem when you try to lift your riffle. Use rubber on the side; the riffles tighten to the sides of the box and clear one side of the box by probably an inch. The other side could be vertical. That way, they'll break free easily.

The photograph below is a dredge designed by Mr. Bill Hall.



MINING ON SLATE CREEK

Douglas B. Colp
Placer Consultant

For the past month I've been hauling in our summer's fuel, equipment and everything we're going to need for the entire year. It has been no small undertaking. It is more than 100 miles per round trip. I've made 12 trips so far, encompassing about 50 different, individual loads. It's quite an undertaking.

"Where the devil is Slate Creek?" In fact, there are 38 Slate Creeks in Alaska. We are located on the Slate Creek in what is known as the Chitna Area, off the Tok cut-off. If you use Big Delta on the west, the town of Tok on the northeast and the town of Gakona on the southeast, Slate Creek is right in the middle of that triangle. Slate Creek is an east-west flowing creek, coming into the Chesta Chena, near its head. The camp is at 2,300 feet elevation.

Gold was discovered in the area about 1898. Gold was discovered on Slate Creek about 1899. Mining of some sort has been conducted in the area from 1899 to about 1960, when the price of gold was so low that it just wasn't economical no matter how you did it.

The richest gold placers were reconcentrated deposits. A lot of the tertiary conglomerates, or high gravels, were deposited there by the glaciers. Some of these deposits are now 2,000 feet above the creek bottoms. The placers are a reconcentration of the old glacial deposits. Part of the gold comes from the bedrock slates and conglomerates. Part of the gold probably came from the lower deposits; probably from the north side of the Denali Fault.

The gold is quite fine, about the finest gold that I've ever seen. Of the gold that we recovered last year, probably 98 or 95% would fall through a 10 mesh screen. The largest nugget was 1/5 of an ounce, and would barely stay on a 1/4 inch screen. There were some small nuggets on our trail tributary, called Miller Gulch, but that's the only place where sizeable gold was found. The gold is, however, scattered from the grass roots on down to bedrock. Very little gold is right on bedrock. The main concentration is from bedrock, to about 10 feet above bedrock. However, you do get gold from the grass roots down, and then some places it's pretty deep; up to 80 and 90 feet, which poses the problem of drainage. So, all in all, it's not an easy mining venture.

During the field seasons of 1974 and 1975 we did a lot of prospecting exploration in the area. We ran churn drills, clams and a Becker 180 Hammer Drill with center hole return. The results were surprisingly close. In 1975, the price of gold was down, as I recall, less than $200. It was not economical to mine at that price. We put the property on cold storage for a while and last year we decided that the price was right, that we should go in, take out a test cut, see if our drilling was reasonably accurate and learn about the recovery problems.

There happened to be a 30 inch box on the property, about 48 or 50 feet long. We built a Grizzley out of railroad iron, some experimental riffles including a set of 2 inch angle iron riffles; a set of 1 1/2 inch angle iron riffles and a set of expanded metal (No. 3 gauge) which measures about 1/2 inch high. We welded 1/2 inch round iron under the expanded metal sections, raising them up high enough to have a little daylight between the astro turf and the expanded metal, which we felt would give more bristling effect. We experimented back and forth with the various types of riffles.

To feed the Grizzley, set at 2 1/2 inch centers, we installed a 10 yard dump box set on a 15 degree slope and fed with a front-end loader. The washing action, in the dump box, moved the material forward across the Grizzley, which was set at 38 degrees. The material passing through the Grizzley went into the sluice box. For wash water we used the same type of giant as is used on a ross box. We experimented with 1 1/2 inch and 2 inch tips; with an open 2 1/2 inch nozzle. We did a lot of experimenting with various amounts of water, various types of riffles and various ways of cleaning up.

The 2 inch angle iron riffles were too large. They filled in too tightly and we couldn't keep them open. They'd pack overnight. We'd have to take a pick and open them up every morning before we started. Not only is this a lot of work, but anytime you open up the riffle with a pick you're going to lose gold. The 1 1/2 inch riffles worked a lot better. The expanded metal worked best and eliminated a lot of material to clean up and to handle.

We couldn't operate without astro turf. The savings we made by using astro turf paid for the astro turf in a few hours. The astro turf is 3/4 of an inch high and is sold here locally. It's very expensive when you compare it with indoor-outdoor carpeting that some people are using. The depth of it and the ease of washing is no comparison. It is 3 feet wide and well worth its cost of about $7.00 a foot.

In addition to the expanded metal we experimented with a quick silver (mercury) trap. We took a 2 inch by 12 inch plank; bored 1 1/2 inch holes half way through; filled each of those half full of quick silver; and set that under the lower edge of the section of the box, below the expanded metal. That helped, everything we tried helped. We concluded that nothing that we did on that box was efficient enough for us to continue with. This year, we're scraping the whole outfit. We are going in there with another outfit.

The tests that we made showed that we need to do something pretty drastically. I had a 6 inch test sluice box at the end of the large box. Every night I'd pan the test sluice down and weigh the gold. The first day, after a cleanup, there wouldn't be much gold; second day there'd be more; the third day there'd be even more, until it got pretty sizeable.

We cleaned up every 7 days. It was an enormous job to clean up. Mr. Hall has the right idea, as far as cleanup is concerned. I don't agree with him in every respect, but anytime you're having downtime, you're losing

money. You can't dispute that.

We not only had losses through the box, but we had losses over the Grizzley, which necessitated a change in Grizzley setup. All in all, we didn't consider our operation last year very efficient, but we did prove that the exploration was within tolerances. If we can improve our recovery system, they're going to come out real close.

We took several pounds of our sluice box concentrate and had several tests run. We didn't make tests on the plus 10 mesh material, but we did make tests on the minus 10 plus 20 and the minus 20 plus 80; the minus 80 plus 150 and the minus 150 plus 325. We had already scalped off most of the gold from the plus 10 mesh. The percentage distribution of the gold is as follows: The plus 10 mesh equaled a little over 1 1/2%. The minus 10 plus 20 had 26% of the values. The minus 20 plus 80 had 62.4% of the values. The minus 80 plus 150 yielded 6.86% and the minus 150 to 325 was almost 2%. This is part of the information we used to redesign the box.

We decided to change our mining plant completely and use screens. This year we are starting out with three D-8's, two equipped with U blades and rippers; one with a straight blade and a heister. We will have a 988 fixed yard loader but may not use it except as a spare.

The Cedar Rapids vibrating feeder is 42 inches wide and 17 feet long. It has a 5 foot Grizzley on the back end. The Grizzley is going to be set at 10 or 11 inches. Anything plus 10 or 11 inches will go to tailings, directly. Anything minus that size, will go onto the belt, a portable feed conveyor belt. The feeder uses a 40 H.P.; electric drive, 440 volt motor. Above the feeder is a hopper constructed to be fed either with a D-8 or the loader. We can either push into the hopper, which in turn will feed the belt, or we can load it with a loader. It will be versatile in that respect.

From the feeder, the material will go up a portable conveyor that is 60 feet long and 42 feet wide, and powered with 20 H.P. electric motors (440 volts). It will go into an LJ 3-deck horizontal vibrating screen, powered with a 40 H.P. motor. The screen is 16 feet long and 6 feet wide. The top deck is heavy, punched plate for 4 feet, to prevent rocks from damaging it or the belt. The bottom 12 feet will be 2 inch, heavy punched plate.

Under the 2 inch plate will be a 3/4 inch wire cloth, which is actually a heavy screen with 3/4 inch squares in it. Under the 3/4 inch cloth there is a 1/4 inch cloth. Above and between each set of screens are high pressure 3/8 inch spray bars, squirting down on the screen and up under the screen to get the maximum washing capability.

We feel that by the time the material hits the sluice box it will have been washed. The sluice box is not going to be a washing plant, it's going to be a concentration plant. When the material comes over the conveyor belt it will go through a vertical dump box, a wetting box if you want to call it that. This box is 18 inches by 2 feet by the width of the belt, which is 42 inches. The material will dump into that box. The box will have spray bars and steps in it. One step will be on each side. The rock and material that

leaves the belt and passes through the wetting box will be completely saturated and washed before it hits the vibrating screen below. It will also help mix things up, and take the brunt of the pounding that the screen would otherwise get. The plus 2 inch and the plus 3/4 inch will go up another conveyor into the tailing piles.

We've built a 5 section sluice box; 12 1/2 feet wide and 41 feet long. The riffling arrangement is 12 1/2 feet wide and 36 feet long. The material dumps into the upper 5 feet. The plus 1/4 minus 1/4 fraction will go into one section of this distributor; the minus 1/4 material will go into the other section. This distributor is arranged to feed 2 or 3 sluices, and it can be fed from left to right, or from right to left. If we've made a mistake in the quantities of material in these two fractions, we can change the feed to the different sluices.

To flatten out the feed, there are sway bars in the distributor which will allow each one of the 5 sluices to take the correct amount of material. We figure on processing about 200 yards of bank run material per hour. After screening, the sluice box will only have to take about 40 yards an hour.

The sluice box is equipped with close-off shutes at the head of the box, to block off any of the 5 sections. The box is equipped with clean-out shutes that run transversely across the box; the clean-out shutes are one foot wide. The bottom of the sluice box has a false bottom at each shute. Lift out the false bottom, and the material will go into the clean-out shute. A firehose can be put in the other end of the clean-out shute and a pickup tub on this end. We can drop a gate in any one of the sluices and clean it up while the other four are in operation. We don't have to shutdown for cleanup. One shute is in the middle of the box, and one is at the end of the box. If we have to clean up every day in the top section, but can let the bottom section go for two or three days, we have that capability.

The concentrates that we take out of the box go to a separate cleanup house. It is run through a Sweeko screen. Sweeko screens are 30 inches in diameter with 3 decks. We run the concentrates through that. The large fractions, plus 10 will be handled by hand. The minus 10 plus 20 will go into a particular tub; the minus 20 plus whatever the next size, plus 60 will go into another tub. The material will be screened well enough for the vibrating table to accept the feed. You cannot have too wide a size range in the feed for a table. The vibrating table will have 3 products; the nice clean gold, the middling and the tails. Depending on the quality of a recovery, the tails will probably be topped immediately. The middlings will have to be put through an amalgamator, and hopefully, the concentrate will be saleable as is.

The gold on this particular creek is quite dirty. It has iron oxide and chloride on it; a lot of it does not accept quick silver readily or won't quick at all.

We can make a much better recovery if we add metallic sodium. We cut off a piece of metallic sodium about one centimeter square (3/8") and dump

it into a cup of quick silver. That soups up the quick silver to the point that it will amalgamate. We may have to use wetters (detergents) to cut the surface tension; to help in the amalgamation. The product will then be put through circular bolts to pick up the amalgam. We've been toying with the idea of using an allutriator as another way of cleaning up the concentrate, if necessary.

This has been a thumb nail sketch of the plant that we proposed to put in operation this summer at Slate Creek. It may be entirely different from others, but that's the point of this whole conference, to get other people's ideas.

DISCUSSION

Q How were you losing gold from the Grizzley?

A Going across the Grizzley too fast, with an improper spring arrangement and improper construction of the Grizzley, in the first place. I don't think it was too steep, but the Grizzley was constructed out of railroad iron, with the flats up. We had deflectors on it, but they still didn't prevent rocks from blocking the grid. To build a grizzley out of railroad iron, the right way, I would put the ball up, then cut off the flats to make the bottom narrower than the ball, and then weld the ties together with spreaders and tighteners. A 60 pound rail is 4 1/2 inches high and 4 1/2 inches wide. You could also weld an angle iron or a piece of metal, bent round in a press, on top of those flats; it would create the same effect as cleaning the Grizzley sides.

SECURITY FOR THE PLACER MINER

Mark Hewitt
Stanley Smith Security

You are concerned with the three basic forms that gold comes in. 1) The raw state in the ground. 2) The gravel concentrated in your sluice box, which represents a lot of work and money. 3) A refined state, ready to sell. We are interested in helping you securely retain your gold.

One type of security alarm cannot be turned off without tripping it. It will alert you to someone entering an unauthorized area, via a small electronic beeper, which you wear.

Another device is similar to those used in automobile alarms. I built a special one, trying to keep in mind the average miner's problems. It uses two lazer beams which are bounced off passive reflectors. A passive reflector is a simple device that does not require electricity. The lazer beam bounces back when something of sufficient mass interferes with it. A relay then closes, energizing the transmitter. If the transmitter becomes energized, your electronic beeper goes off. Another part of this system is a receiver, located inside the box, which can be tripped from a device located, say, at a cabin, where you might hold your refined product. You can arm your cabin as you leave and should someone try to enter a contact trips the receiver and sets off your beeper. This gets your attention; mine wakes me up.

A device may be built in several different forms. In one, the lazer beams can be aimed in any direction within an arc of 180 degrees. You could set up a triangle, with two passive reflectors against some form of cliff, where you might have your sluice box located. In another arrangement, two of these devices could cordon off an entire area, using passive reflectors at each corner and one of these devices at each active corner.

The advantage of this system is that it detects objects about the size of a man (100 pounds or greater). Something of smaller size, such as a rabbit; even a wolf, would be able to by-pass the item, without tripping it; this prevents false alarms. It does have one disadvantage; a moose or a bear will also trip it. That may not be such a disadvantage if you want to fill your freezer.

Each mine, sluice box, or residence that you may be trying to protect has an individual need. My chief function is to design something that meets your particular needs. You've done a lot of work and invested a lot of money, time and effort to obtain your finished product. Somebody else would like to have it just as much as you. Unfortunately, with the state that our economy is in right now, a lot of people would like to take your hard earned gold, rather than work for it themselves. There are many ways to deal with these people, but you have to know that they're there before you can deal with them. I see a lot of familiar faces around here, and I'm sure that most of you know that I'd just as soon catch someone in the act, rather than

scare them away. That's one of the reasons that I build a device in this particular fashion.

Another device is like a TV camera. It senses the body heat transmitted from you or an animal. There is no way to turn the device off, without alerting the receiver. It resets itself if the beam is interrupted. A solar array, that I've worked out, will keep the batteries charged. In fact, the solar array is sufficiently powerful to charge batteries, for example, for a radio that you might have.

After the gold is concentrated, it may be necessary to put it somewhere, where even people that you might usually trust wouldn't have access to it. The English make a safe, which has become very popular with miners. It provides protection on all 6 sides, and has a glass plate on the inside that breaks if someone tries to force it open, throwing 5 relocking devices.

There is little that I can say to the group of you, as each individual's problems are a little different. I would prefer to address you on an individual basis. I would like to answer any questions that you may have, regarding individual security.

QUESTIONS & ANSWERS

Q (inaudible)

A The actual transmitted beam is straight. The reflected beam is dispersed. Because it is not such a narrow beam, it can determine the size of an object passing through it; a bird or a rabbit has insufficient volume to trigger the device. The other answer is, yes. It is possible to go under the beam if you know where the beam is. You can't see the beam because it's infra-red.

Q (inaudible)

A I do have another device that is more expensive, and forms a 12 foot wall of light. Its range is about 3 miles, more than sufficient in most cases. There's no way to go through it.

Q (inaudible)

A One particular device has a 5 to 7 mile range, depending on the terrain.

Q (inaudible)

A This particular one I put together rounds out at about $1,500. Anywhere from $1,000 to $2,000 can put together some form of protective device for most installations.

Q (inaudible)

A One set of beams has an effective range of 150 feet, from the box to the passive reflector. They can be patterned in any direction.

Q (inaudible)

A Below 20 degrees centigrade you start to have problems with the optics. If your needs require devices for, say, 60 below zero, there are devices capable of those temperatures. The only problem is the power source. Nicad Batteries are about the only ones that will handle low temperatures, and even they have problems at extremely low temperatures.