HEAVY MINERALS IN ALASKAN BEACH SAND DEPOSITS

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by

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FOREWORD

Beach sand deposits along Alaska's shoreline have been prospected and worked for their precious metal content since the time of Russian occupation. Areas such as the Nome Beaches of the Seward Peninsula have been very productive, and in recent years exploration has proceeded to include off shore extensions of these deposits.

Evaluation of associated heavy mineral contents of these deposits, however, have been cursory and in most cases neglected entirely. In view of the thousands of miles of Alaskan coastline with known mineral provinces on adjacent land; much information is needed concerning the origin of mineral constituents, evaluation of past and present beach deposits and possibilities of off shore extensions of the continental shelf.

This report is concerned with samples of beach sand material submitted to the Mineral Industry Research Laboratory by individuals. These samples, taken from various locations, cannot be viewed as programs designed to delineate reserves from the respective areas. They should be considered as reconnaissance samples to indicate the mineral constituents present and the need for more comprehensive evaluation.

Systematic and complete evaluation of all mineral constituents, including precious metals, is a major undertaking because of the erratic nature of the deposits. Special studies are required concerning sampling techniques, mining methods, recovery systems and marketing procedures. It is, therefore, beyond the financial capabilities of most individuals and requires the involvement of government agencies or corporations to obtain the necessary data to determine economic feasibility.

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INTRODUCTION

The oceans of the world contain a potential of mineral resources which are receiving increasing attention from both government and private organizations. Their efforts are aimed towards methods of evaluating, mining and processing these potential reserves. Most organizations interested in undersea investigations have confined their activities to three target areas: (1) Near shore deposits, on the continental shelves, carrying valuable placer minerals, (2) shallow water beds of phosphorite and glauconite, and (3) deep water deposits of manganese nodules.

Alluvial deposits of the continental shelf should offer the most attractive prospect in terms of capital investment and faster returns. Lying in near shore areas along the coast line they may contain economic concentrations of minerals commonly found in land placers. They offer the advantages common to placer deposits in that nature has provided the necessary liberation actions of crushing and grinding with some degree of sizing and concentration.

The advantages mentioned above, however, are somewhat compromised by problems presented in evaluating an underwater deposit in which the minerals are primarily in the liberated state. The sometimes erratic forces of nature involved are not conducive to the formation of a homogeneous deposit that lends itself to normal sampling procedures. In addition, both submerged beach and stream placers may be found to seaward of the present shoreline. These deposits formed as a result of lowering and the later rise of sea level during the last major glaciation period, tend to complicate evaluation procedures.

The logical starting point for exploration of continental shelf alluvial deposits is to obtain as much information as possible concerning the current beach deposits. In his recent book, "The Mineral Resources of the Sea," Dr. John Mero[15] states, "A study of the present beaches in any area, thus should provide valuable information concerning what can be expected to be found off shore." He further postulates that in general off shore beaches can be expected to be greater in size than present sea level beaches.

Beach Deposits

The mineral composition of present and submerged beaches is dependent upon the nature of the source rock from which the detrital material was derived, and consists of those minerals having greater resistance to the processes of weathering and transportation.

Weathering produces a leisurely but effective comminution of the source rocks in which the more resistant minerals are liberated as individual particles. These detrital products are carried down slope by the forces of erosion and deposited into waterways where the first mechanical separation of light and heavy particles is accomplished by the running water.

In some areas the adjacent sea floor or rock outcrops along the coast line may be the source for beach material, but normally the material is transported by rivers and streams to the coast line. In the latter case, the development of beach type deposits is initiated at the mouths of the transporting streams.

These marine beaches usually assume the shape of elongated ridges parallel to the shore line as a result of wave action and long shore currents. The beaches may be on the present shore line or at some distance inland, indicating some degree of elevation of the coast line subsequent to the weathering and transportation processes.

J. L. Gillson[9] has shown that those beach type deposits that have been favorable for the production of titanium minerals have occurred on continental land masses that have gone through a period of peneplanation and deep weathering. This has resulted in solution of magnetite and most iron silicates. He gives the following steps in geologic history as common to those deposits:

1. A "hinterland" of crystalline rocks in which ilmenite, rutile, monazite, and zircon were accessory constituents.
2. A period of peneplanation during which a deep soil zone formed and magnetite was decomposed.
3. Uplift and rapid erosion of the soil zone resulting in the products of stream erosion being dumped into the sea without intermediate deposition in long stream channels.
4. In all places, except India, an intermediate stage involving deposition of the heavy minerals into a coastal plain sediment. This was later elevated and eroded, causing the heavy minerals to be concentrated further.
5. Subsidence of the coast was followed by a process of shore straightening, which caused the formation of along shore sand bars extending from headland to headland. Shore currents moved sands and breakers carried the lower specific gravity minerals into the deep water on the landward side of the bar. The heavy minerals not so easily moved, remained behind on the bar itself.
6. Elevation of the coast permitted attacks on the partially concentrated sands in bars, or on coastal plain sediments, by the waves, by the wind or by both. Concentration results during times of storm when the waves reach out and carry the low specific gravity minerals out to sea.

This has been the general history in India, Senegal, Sierra Leone, Brazil, Florida and on the east coast of Australia where commercially important deposits of titanium and associated minerals exist. Parts of this general pattern are true to all beach sand deposits but in many areas the period of peneplanation and chemical decomposition of magnetite and iron bearing silicates has not occurred. Therefore, these minerals constitute a portion of the heavy material concentrated by the wave, wind and long shore current actions.

Mineral Constituents

The minerals found in beach sand deposits are those characteristic of granites, gneisses and pegmatites. As only those minerals resistant to chemical and mechanical weathering processes survive, most sand deposits are similar in mineral composition. They differ only in percentages of each mineral present which is a function of composition of the source rocks, duration of buildup period, and efficiency of the natural forces at work.

The majority of the material on most beaches consists of micas, feldspars, other silicates and quartz. Associated with these minerals, however, are varying concentrations of a group of minerals called "heavy minerals." This group can be composed of such minerals as magnetite, ilmenite, leucoxene, rutile, chromite, garnet, monazite, columbite-tantalum, cassiterite, scheelite, wolframite, kyanite, sillimanite and the precious metals, gold and platinum.

A common terminology of "black sand" is often used in connection with these deposits as many of the minerals in the heavy fraction are dark in color. "Ruby sand" is also used to designate those deposits having a high concentration of garnet. The term "radioactive blacks" has more recently been applied to compositions containing columbium, tantalum, uranium, thorium and some rare earth minerals.

Titanium Minerals: Titanium is the ninth most abundant element in nature; and it ranks fourth in abundance as a structural metal, exceded only by aluminum, iron and magnesium. It occurs in virtually all crystalline rocks, many minerals and in beach sands throughout the world. Widely varying amounts have been found in soils, clays, coal and oil ash; and it has been detected in fresh and sea waters. In contrast to this wide occurrence, only a few titanium bearing minerals are known to occur in large enough bodies and sufficiently concentrated to be of economic significance. These minerals are: Ilmenite, rutile, titaniferous, magnetite, titaniferous hematite, titanite, leucoxene, brookite, and perovskite. The principle minerals are rutile and ilmenite which are mined as ore bodies in crystalline rocks or as secondary deposits of sand in beaches and rivers. Rutile is primarily used in the production of titanium tetrachloride, the intermediate compound, in the reduction of titanium metal and for welding rod coating. For this purpose the main sources are the beach and dune sands of Australia and Florida. Ilmenite, the iron, titanium dioxide, is cheaper, more abundant and decomposed by sulphuric acid; therefore, it has found wide spread use in the production of the high-hiding white pigment in the form of pure titanium dioxide.

Zirconium: This element is widely distributed and ranks about eleventh in abundance as a constituent in igneous rocks. It is always found in association with the element hafnium, and chiefly as a minor constituent in granite, pegmatites and granodiorites. There are several zirconium bearing minerals, but zircon ($ZrSiO_4$) and baddeleyite (ZrO_2) are the only significant ore minerals. Zircon, the most abundant, is rarely found in minable concentrations in rock; but due to its high specific gravity and resistance to weathering it can occur in minable concentrations in the "heavy mineral" sands of rivers, beaches and dunes. In these cases it is intimately associated with rutile and ilmenite and becomes a coproduct or by-product in the production of these two minerals. The major product of this element is used in its mineral form, zircon, as refractories, foundary molds and cores, ceramics and abrasives. The remainder is used to produce zirconium metal, alloys and compounds, which like titanium has found many new applications during the past decade. Zirconium's high, corrosion resistance, mechanically properties at moderately elevated temperatures and its ability to pass slow speed neutrons has led to extensive use in nuclear reactors.

Rare Earth Minerals: There are more than 200 minerals known to contain the rare earths and thorium. These include elements constituting the rare earth metal group from lanthanum (Atomic No. 57) through lutetium (Atomic No. 71). Of these minerals, however, monazite and bastnaesite are the principal commercial ore minerals. Monazite is a thorium bearing phosphate of these elements and like zirconium and titanium is found as a minor constituent in granites, gneisses and pegmatites. Rare earth elements are valuable constituents of monazite and their oxides constitute a major proportion, by weight, of the mineral. However, thorium will substitute for rare earth elements and correspondingly lower the rare earth percentages. The economic concentrations of monazite are usually contained in beach sand deposits and recovered as a by-product with ilmenite, rutile, and zircon. The rare earth elements are used as compounds, metals and alloys in the following general catagories: (1) The glass industry, (2) in carbon cores for arc lighting, (3) as metallic alloying agents, and (4) miscellaneous applications. Thorium is used in minor amounts in the electrical industry and may have a future application in nuclear reactors.

Columbium-Tantalum Minerals: The oxides of these elements, as the minerals columbite and tantalite, are the most abundant and usually recovered from pegmatite deposits or the detrital deposits resulting from weathering of pegmatites or granites. Columbium is used most extensively as an alloying agent where it increases the strength and impact properties in low carbon and low-alloy steels and also acts as a carbide stabalizer. Because it possesses elevated-temperature strength properties, it is finding increasing uses as base alloys in nuclear reactors and corrosion resistance applications in space technology. Tantalum has similar applications in nuclear and space age requirements plus a growing usage in the electronic industry. The United States depends predominantly on imports of these minerals as our known resources are insufficient to supply the demands created by expanding technology.

Chromium Minerals: The mineral chromite, an oxide of chromium, iron, aluminum and magnesium in solid solution, is the only commercially important chromium mineral. It occurs as veins or embedded masses in peridotites and their derivative serpentines. The United States imports practically all of its chromite, with present commerical grade domestic ores being insignificant in supply with respect to demand requirements. The metal chromium is an important alloying element in steels in which its major use is derived from its corrosion resistant properties as in stainless steels and its durability in plating various types of metalware. Selected grades of chromite ore are used for the production of chromite refractory materials, principally as furnace linings. Chromium chemicals are also used as pigments, surface treatment, leather tanning, photography, lithography and numerous other applications. Chromite occurs in detrital deposits as a constituent of the "black sands" and with growing acceptance of fines by consumers constitute a reserve of sub-grade material.

Iron Minerals: Although magnetite (Fe_3O_4) is a common constituent of beach sands, they are seldom mined exclusively for this mineral. The notable exception to this occurs at the southern tip of Kyushu Island, Japan, where beach deposits of magnetite have been mined for many years. Other iron ore deposits are of higher grade with vast reserves, but if the operation were large enough, and the location favorable, magnetite on beaches and in near shore waters could be a potential source of iron.

Precious Metals: The precious metals, gold, silver, and platinum can survive attritional and chemical weathering, and will concentrate in the heavy mineral fraction in beach and off shore sands that adjoin favorable areas. This has led to intermittent attempts, over the years, to mine these deposits for their precious metal contents. These ventures usually prove to be short lived and uneconomic because the natural concentration forces have been erratic and changing and the gold and platinum are usually in fine flakes that are difficult to save by the usual gravity methods. Present beaches and submerged beaches offer promise for the recovery of precious metals and possible by-product minerals, but only if preceded by careful and systematic evaluation of the total deposit. This is necessary because of the lack of uniformity in these types of deposits and the information needed to design the subsequent mining and treatment processes.

World Occurrences

Submerged and exposed sand deposits, enriched by gravity segregation of such heavy minerals as ilmenite, magnetite, zircon, rutile, chromite, cassiterite, monazite, rare earths and precious metals occur in many parts of the world. Those of commerical importance are on continental land masses that adjoin favorable areas where transportation by stream or glacial action has occurred.

Marine beaches have or are being mined commercially for their heavy mineral content, these include: East Coast of the United States in Florida and New Jersey for ilmenite, rutile, zircon and monazite; Thailand, Malaysia, and Indonesia for tin; Japan for magnetite sand; India and Ceylon for ilmenite; East Coast of Africa for diamonds and ilmenite; Nome, Alaska, for gold; and Australia for rutile, zircon and ilmenite.

Australian production has increased markedly over the past few years according to Norman R. Paterson[16], he indicates that more than 10% of Australian mineral production comes from exposed beaches giving a $13,000,000 export value annually. This represents 95% of the worlds rutile, 70% of the worlds zircon and 25% of the worlds ilmenite production. He further indicates that improved techniques have reduce minimum minable grade from 50% heavy minerals in 1934 to less than 3% in 1967.

Although annual mineral production from these types of deposits, exclusive of diamonds, sea shells and oil, is still quite small, exploration activities are increasing to include investigations of adjouring submerged areas. Increased economic interest, new exploration methods and improved processing should accelerate world production.

Alaskan Occurrences

Beach sand deposits, with heavy mineral concentrations are known to occur in several areas along Alaska's coastline. Some of these deposits have been mined intermittently over the past century for gold, but there is no record of recovery of other minerals.

The United States Bureau of Mines has conducted reconnaissance surveys of beach sand deposits as noted in Reports of Investigations 5986 and 6214 on the Eastern Gulf of Alaska and Bristol Bay areas, respectively. The former report states:

> "Black sands are known to occur in unconsolidated marine deposits at many localities along the 6,640 miles of Alaska's coastline. The easily accessible beaches have long been prospected for gold and in some localities, as at Nome on the Seward Peninsula, have been enormously productive. Prospecting for other minerals in these deposits has been either cursory or entirely neglected. If no indications of gold in paying quantities were found on preliminary examination, the beach deposit received little or no further attention. Some less accessible areas, such as those along the eastern coast of the Gulf of Alaska, have been recognized as containing potentially commerical black sand deposits. Some gold has been recovered from these deposits, notably in the vicinity of Cape Yakataga and Lituya Bay. However, few attempts have been made to evaluate the accessory heavy-mineral content."

H. D. Hess[10] of the United States Bureau of Mines Marine Technology Center of Tiburon, California, has indicated that there are a number of promising heavy mineral sand deposits off the Alaskan coast containing tin, mercury, tungsten, columbium-tantalum, uranium, thorium, and rare earths. In addition, he suggests that off shore beaches with considerable promise for recovery of precious metals and possible heavy mineral by-products may be located off the coast of: Seward Peninsula in Norton Sound; Kodiak Island in the Shelikof Straight and Marmot Bay; Kenai Peninsula in Nuka Bay; near Anchorage and vicinity in Prince William

Sound; near Juneau and vicinity in Stephens Passage; Chichagof Island along the outer coast; near Sitka in Sitka Sound; and Prince of Wales Island along the east coast in Clarence Strait.

Within the past few years considerable interest has developed on the possibility of the existence of economic mineral deposits along Alaska's shore line. This is evidenced by the prospecting permits issued by the State, particularly in the Norton Sound area. Other off shore areas located adjacent to gold producing regions should be potential sources of that element. However, investigations should not be limited only to this facet, but should include appraisal of all mineral constituents.

The Mineral Industry Research Laboratory of the University of Alaska has received requests from individuals to process and evaluate sand samples taken from various locations along Alaska's shore line. Generally, these samples are not products of a systematic and comprehensive prospecting program, but represent material taken from selected areas. Consequently, an evaluation of a deposit cannot be undertaken, but information is presented concerning the precious metal and heavy mineral contents of the samples as submitted. This information is of value in determining the advisability of further work in the particular area and the possibility of off shore extensions that should be investigated.

YAKATAGA AREA

Introduction

Fifty-two beach sand concentrates, one unclassified concentrate of magnetic material and one bulk sample of beach surf concentrate were submitted for study from the Cape Yakataga area as shown in Figure 1.

The samples collected were either hand dug to a depth of from two to four feet below a debris cleaned surface or gathered from the surface of creek or beach where a concentration appeared to be evident. Samples marked with an asterisk on Table 1 fall into the first classification, and the others are indicated to be grab samples from the surface of selected creek and beach locations.

Original samples from each location were screened at 3/16" and the screen undersize concentrated by hand panning. A portion of this concentrate was then submitted for the purpose of this study. This information is presented in Table 1 and indicates the concentration ratio for each sample and the percent of each concentrate submitted. The average concentration ratio indicates that 19.7 tons of beach sand must be processed to obtain one ton of concentrate similar to the material received.

Size Analysis

Unfortunately, no record is evident on the amount of plus 3/16" material discarded, and screen analyses were not obtained for the light fraction of the hand panning process. This could be important in determining the advisability of primary screening to discard a portion of the light material prior to concentration.

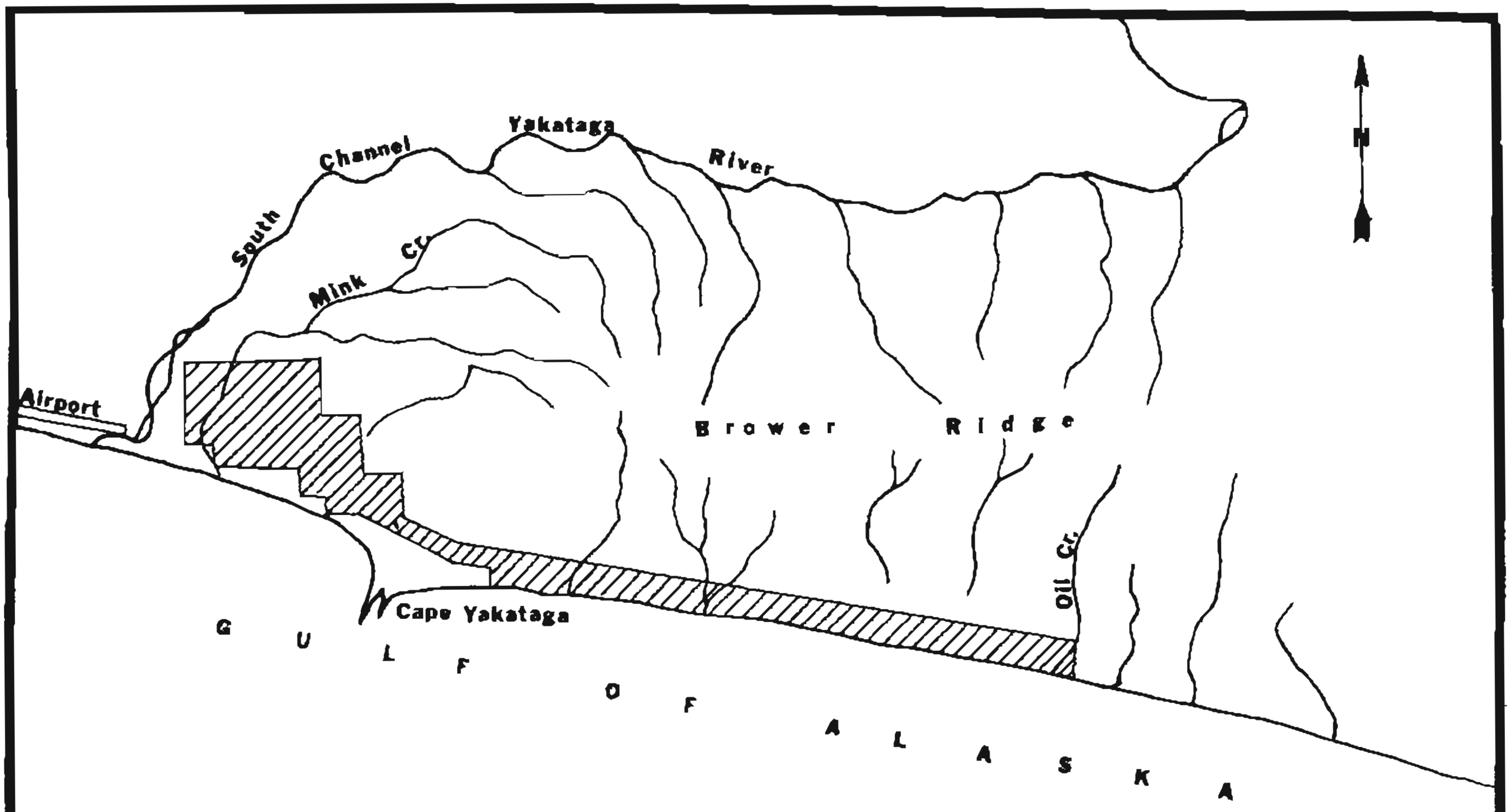


Figure 1
YAKATAGA
Scale 1:63360

From USGS
Bering Glacier (A-4)

Table 1

Sample Weight Data, Yakataga

Sample No.	Original Sample Wt. (Grams)	Original Concentrate Wt. (Grams)	Ratio of Concentration	Concentrate Received Wt. (Grams)	Percent of Original Concentrate
Sunrise #1	18,480	1,520.0	12.2	452.2	29.7
Sunrise #2	18,480	1,321.0	14.0	438.0	33.1
Sunrise #3	19,176	2,040.0	9.4	494.3	24.2
Sunrise #4	36,960	1,117.5	33.0	551.3	49.3
Hope #1	7,392	2,069.5	3.5	841.2	39.3
Hope #2	7,392	1,485.0	4.9	305.8	20.5
Hope #2-B*	18,480	560.5	33.0	332.2	59.2
Hope #3	18,480	1,153.5	16.0	300.7	26.0
Hope #4	25,872	947.0	27.3	233.8	24.7
Hope #5	36,960	978.5	37.7	300.3	30.6
Hope #5-B	36,960	332.0	111.3	217.8	65.6
Hope #6	36,960	1,308.5	28.2	433.4	33.1

Table 1 (Cont.)

Sample No.	Original Sample Wt. (Grams)	Original Concentrate Wt. (Grams)	Ratio of Concentration	Concentrate Received Wt. (Grams)	Percent of Original Concentrate
Hope #7*	36,960	1,236.0	29.9	361.3	29.2
Hope #7-B*	44,352	571.0	77.7	299.2	52.4
Hope #8	36,960	1,448.0	25.2	483.7	33.4
Hope #8-B	19,176	243.5	78.7	131.3	53.9
Anchor #1	3,696	1,660.0	2.2	372.0	22.4
Anchor #2	7,392	1,698.0	4.4	332.5	19.6
Anchor #2-B	44,352	489.5	90.6	489.5	100.0
Anchor #3	4,784	1,454.5	3.2	443.4	30.4
Anchor #4	29.568	1,983.0	14.9	470.6	23.7
Anchor #5	36,960	1,594.0	23.2	437.6	27.5
Anchor #7	14,874	1,493.5	9.9	299.7	20.0
Anchor #8	29,568	1,447.0	20.4	314.6	21.7
Pauli	18,480	1,812.0	10.2	492.5	27.2

Table 1 (Cont.)

Sample No.	Original Sample Wt. (Grams)	Original Concentrate Wt. (Grams)	Ratio of Concentration	Concentrate Received Wt. (Grams)	Percent of Original Concentrate
Unclassified	681	684.2	1.0	684.2	100.0
Bower #9	11,088	230.0	48.2	117.4	51.0
Bower #11*	18,480	871.5	21.2	208.4	23.9
Bower #12*	18,480	983.5	18.7	215.3	21.8
Bower #13*	44,352	1,604.0	27.6	457.8	28.5
Bower #13-B*	18,480	500.0	37.0	303.1	60.0
Bower #14*	36,960	1,203.5	30.7	321.6	26.7
Bower #15*	19,176	1,020.0	18.8	458.3	44.9
Bower #15-B*	18,480	888.0	20.8	425.6	47.9
Bower #15-C*	19,176	387.0	49.5	190.1	49.1
Maui #1*	19,176	1,683.5	11.3	393.5	23.3
Maui #2*	36,960	1,919.0	19.3	516.5	26.9
Maui #3*	36,960	1,277.0	28.9	422.3	33.1

Table 1 (Cont.)

Sample No.	Original Sample Wt. (Grams)	Original Concentrate Wt. (Grams)	Ratio of Concentration	Concentrate Received Wt. (Grams)	Percent of Original Concentrate
Maui #7*	19,176	1,294.5	14.8	420.7	32.4
Maui #8	11,088	1,756.5	6.3	396.7	22.5
Maui #9*	36,960	1,543.5	23.9	429.2	27.8
Maui #16*	36,960	1,376.0	26.9	347.9	25.3
Maui #17*	18.480	1,264.5	14.6	449.9	35.5
Maui #18*	18,480	1,170.0	15.8	401.3	34.3
Maui #21	36,960	1,459.5	25.3	496.2	33.9
Maui #22	18,480	1,545.5	11.9	391.8	25.3
Maui #23*	18,480	1,505.0	12.3	466.1	31.0
Maui #24*	7,392	376.0	19.6	178.9	47.6
Maui #26	36,960	1,670.0	22.1	470.8	28.2
Maui #26-B*	18,480	461.0	40.1	258.5	56.1
Maui #28*	11,088	190.0	58.4	77.7	40.9

Table 1 (Cont.)

Sample No.	Original Sample Wt. (Grams)	Original Concentrate Wt. (Grams)	Ratio of Concentration	Concentrate Received Wt. (Grams)	Percent of Original Concentrate
Maui #29*	18,480	1,363.0	13.6	346.9	25.5
Maui Fraction*	19,176	949.0	20.2	280.8	29.6
Total and Average**	1,233,122	62,464.0	19.7	19,245.2	31.9

**Excluding Unclassified Sample

A screen analysis was obtained on the total weight of each individual sample; but for purposes of brevity here, these data have been compiled to show a composite screen analysis for all samples. This analysis as shown in Table 2 indicates that 98.9% of the concentrate is plus 150 mesh with the majority of the material in the 35/150 mesh range. The unclassified magnetic sample, as shown in Table 3, is an exception to this observation in that 56% of this sample is plus 35 mesh in size.

Gold Recovery

The determination of gold content by a analytical method, such as fire assaying, is impractical for the type of sample in which gold is in the free state. The probability of obtaining a representative distribution of gold in the assay portion is not too good. Consequently, it was deemed advisable to recover the free gold in the total sample by amalgamation.

Screen fractions of each sample were re-combined and the total sample amalgamated for a three-hour period using 1/4" steel shot to provide a scouring action for removal of possible oxide coating on the free gold. The gold recovered was weighed and calculations performed to present this information in milligrams and ounces per ton of concentrate as received.

After amalgamation, a split portion of each sample was assayed to determine the effectiveness of amalgamation in ounces of gold remaining per ton of concentrate. These data are shown in Table 4 and indicate the results expected if the concentration is similar to that in the samples received.

Table 2

Composite Screen Analysis, Yakataga

Tyler Mesh		Weight Grams	Weight %	Cumulative Weight %	
Passed	Retained			Retained	Passed
-	28	632.4	3.3	3.3	100.0
28	35	514.4	2.6	5.9	96.7
35	48	3,288.2	17.0	22.9	94.1
48	65	7,627.7	39.4	62.3	77.1
65	100	5,509.8	28.5	90.8	37.7
100	150	1,558.6	8.1	98.9	9.2
150	Pan	213.3	1.1	100.0	1.1
	TOTAL	19.244.4	100.0		

Table 3

Unclassified Sample Screen Analysis, Yakataga

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
-	28	227.9	33.3	33.3	100.0
28	35	157.4	23.0	56.3	66.7
35	48	162.2	23.7	80.0	43.7
48	65	87.0	12.7	92.7	20.0
65	100	35.7	5.2	97.9	7.3
100	150	12.2	1.8	99.7	2.1
150	Pan	1.8	0.8	100.0	0,3
	TOTAL	684.2	100.0		

Table 4

Gold Recovery by Amalgamation, Yakataga

Sample Number	Weight Grams	Gold Rec. Mgs.	Oz./Ton Concentrate	Assay of Tails Oz./Ton	Total Oz./Ton Concentrate	Gold Value $/Ton Concentrate @$35.00
Sunrise #1	452.2	4.85	0.31	0.02	0.33	$11.55
Sunrise #2	438.0	3.78	0.25	Trace	0.25	8.75
Sunrise #3	494.3	5.70	0.34	Trace	0.34	11.90
Sunrise #4	551.3	4.40	0.23	Trace	0.23	8.05
Hope #1	814.2	15.45	0.55	Trace	0.55	19.25
Hope #2	305.8	5.20	0.50	Trace	0.50	17.50
Hope #2-B	332.2	0.50	0.04	Trace	0.04	1.40
Hope #3	300.7	1.00	0.10	Nil	0.10	3.50
Hope #4	233.8	1.26	0.16	Trace	0.16	5.60
Hope #5	300.3	3.85	0.37	Nil	0.37	12.95
Hope #5-B	217.8	2.33	0.31	Trace	0.31	10.85

Table 4 (Cont.)

Sample Number	Weight Grams	Gold Rec. Mgs.	Oz./Ton Concentrate	Assay of Tails Oz./Ton	Total Oz./Ton Concentrate	Gold Value $/Ton Concentrate @ $35.00
Hope #6	433.4	32.45	2.19	0.02	2.21	$77.35
Hope #7	361.3	10.40	0.84	Trace	0.84	29.40
Hope #7-B	299.2	1.96	0.19	Nil	0.19	6.65
Hope #8	483.7	5.91	0.36	Nil	0.36	12.60
Hope #8-B	131.3	1.63	0.36	Trace	0.36	12.60
Anchor #1	372.0	2.05	0.16	Trace	0.16	5.60
Anchor #2	332.5	2.20	0.19	Nil	0.19	6.65
Anchor #2-B	489.5	32.60	1.94	0.02	1.96	68.60
Anchor #3	443.4	0.88	0.05	Nil	0.05	1.75
Anchor #4	470.6	Nil	Nil	Nil	Nil	Nil
Anchor #5	437.6	4.75	0.32	Trace	0.32	11.20
Anchor #7	299.7	56.20	5.47	0.02	5.49	192.15

Table 4 (Cont.)

Sample Number	Weight Grams	Gold Rec. Mgs.	Oz./Ton Concentrate	Assay of Tails Oz./Ton	Total Oz./Ton Concentrate	Gold Value $/Ton Concentrate @ $35.00
Anchor #8	314.6	5.80	0.54	Trace	0.54	$18.90
Pauli	492.5	9.05	0.54	Trace	0.54	18.90
Unclassified	684.2	0.15	0.01	Nil	0.01	0.35
Bower #9	117.4	0.50	0.12	Nil	0.12	4.20
Bower #11	208.4	0.20	0.03	Nil	0.03	1.05
Bower #12	215.3	0.05	0.01	Nil	0.01	0.35
Bower #13	457.8	0.95	0.06	Trace	0.06	2.10
Bower #13-B	303.1	0.60	0.06	Nil	0.06	2.10
Bower #14	321.6	2.18	0.20	Nil	0.20	7.00
Bower #15	458.3	1.20	0.08	Nil	0.08	2.80
Bower #15-B	425.6	1.15	0.08	Nil	0.08	2.80
Bower #15-C	190.1	0.80	0.12	Nil	0.12	4.20

Table 4 (Cont.)

Sample Number	Weight Grams	Gold Rec. Mgs.	Oz./Ton Concentrate	Assay of Tails Oz./Ton	Total Oz./Ton Concentrate	Gold Value $/Ton Concentrate @ $35.00
Maui #1	393.5	0.75	0.05	Trace	0.05	$ 1.75
Maui #2	516.5	2.00	0.11	Nil	0.11	3.85
Maui #3	422.3	0.75	0.05	Nil	0.05	1.75
Maui #7	420.7	0.62	0.04	Nil	0.04	1.40
Maui #8	396.7	1.55	0.11	Trace	0.11	3.85
Maui #9	429.2	1.45	0.10	Nil	0.10	3.50
Maui #16	347.9	0.43	0.04	Nil	0.04	1.40
Maui #17	449.9	1.00	0.06	Nil	0.06	2.10
Maui #18	401.3	1.40	0.10	Nil	0.10	3.50
Maui #21	496.2	2.02	0.12	Trace	0.12	4.20
Maui #22	391.8	0.80	0.06	Nil	0.06	2.10
Maui #23	466.1	0.40	0.03	Nil	0.03	1.05

Table 4 (Cont.)

Sample Number	Weight Grams	Gold Rec. Mgs.	Oz./Ton Concentrate	Assay of Tails Oz./Ton	Total Oz./Ton Concentrate	Gold Value $/Ton Concentrate @ $35.00
Maui #24	178.9	0.35	0.06	Nil	0.06	$ 2.10
Maui #26	470.8	0.85	0.05	Nil	0.05	1.75
Maui #26-B	258.5	0.25	0.03	Nil	0.03	1.05
Maui #29	346.9	0.10	0.01	Nil	0.01	0.35
Maui Fraction	280.8	0.05	0.01	Nil	0.01	0.35

Magnetic Separations

Each sample was processed through a "Carpco" low intensity magnetic separator to recover the ferro-magnetic minerals. The results of these tests, as shown in Table 5, indicate that an average of 4.2% ferro-magnetics are present in the concentrates with a maximum of up to 10% in some instances. X-ray diffraction analysis of these magnetic components show them to be primarily magnetite with minor amounts of ilmenite and chromite present.

The non-magnetic portions from the above process were subjected to high intensity magnetic separation in a "Carpco" induced-roll separator. Magnetic field was controlled with current adjustment between 0.25 and 0.50. amperes. This allowed concentration of other paramagnetic material without collecting garnet as a magnetic component. An average of 3.3% of the concentrate was recovered in this fraction with the maximum in the neighborhood of 7 percent. This material was predominately ilmenite, and the results of these tests are also shown in Table 5.

Non-Magnetic Material

The non-magnetic fractions of all samples were subjected to x-ray diffraction analysis for determination of mineral constituents. They were composed of garnet, pyroxenes, quartz and feldspars, usually in that order of abundance. By increasing the magnetic field it is possible to separate the garnet and pyroxenes as magnetic components, but this was not deemed necessary in this case. Split portions were obtained from the non-magnetic fraction of each sample and analyzed by x-ray spectrographic techniques to determine the amount of zirconium present.

Table 5

Magnetic Separations, Yakataga

Sample Number	Weight of Concentrate Grams	Low Intensity Fraction Grams	Low Intensity Fraction Weight % of Concentrate	High Intensity Fraction Grams	High Intensity Fraction Weight % of Concentrate
Sunrise #1	452.2	17.4	3.8	8.0	1.8
Sunrise #2	438.0	21.3	4.9	3.5	0.8
Sunrise #3	494.3	29.3	5.9	5.4	1.1
Sunrise #4	551.3	9.5	1.7	24.5	4.4
Hope #1	814.2	87.5	10.7	15.7	1.9
Hope #2	305.8	9.0	2.9	7.0	2.2
Hope #2-B	332.2	0.8	0.2	17.5	5.2
Hope #3	300.7	15.1	5.0	15.3	5.1
Hope #4	233.8	14.1	6.0	12.4	5.3
Hope #5	300.3	19.3	6.4	14.1	4.6
Hope #5-B	217.8	6.6	3.0	13.4	6.1

Table 5 (Cont.)

Sample Number	Weight of Concentrate Grams	Low Intensity Fraction Grams	Low Intensity Fraction Weight % of Concentrate	High Intensity Fraction Grams	High Intensity Fraction Weight % of Concentrate
Hope #6	433.4	46.2	10.6	14.3	3.2
Hope #7	361.3	30.8	8.5	13.0	3.5
Hope #7-B	299.2	10.5	3.5	11.5	3.8
Hope #8	483.7	35.5	7.3	8.0	1.6
Hope #8-B	131.3	2.2	1.6	6.5	4.9
Anchor #1	372.0	36.9	9.9	7.6	2.0
Anchor #2	332.5	28.1	8.4	10.3	3.0
Anchor #2-B	489.5	58.7	11.9	18.4	3.7
Anchor #3	443.4	10.2	2.3	20.4	4.6
Anchor #4	470.6	15.8	3.3	16.1	3.4
Anchor #5	437.6	11.2	2.5	13.0	2.9
Anchor #7	299.7	7.9	2.6	12.4	4.1

Table 5 (Cont.)

Sample Number	Weight of Concentrate Grams	Low Intensity Fraction Grams	Low Intensity Fraction Weight % of Concentrate	High Intensity Fraction Grams	High Intensity Fraction Weight % of Concentrate
Anchor #8	314.6	5.5	1.7	14.7	4.6
Pauli	492.5	22.2	4.5	11.4	2.3
Unclassified	684.2	152.7	22.3	531.5	77.7
Bower #9	117.4	0.2	0.1	4.7	4.0
Bower #11	208.4	0.9	0.4	14.8	7.1
Bower #12	215.3	3.4	1.5	14.6	6.7
Bower #13	457.8	21.8	4.7	20.2	4.4
Bower #13-B	303.1	9.9	3.2	10.7	3.5
Bower #14	321.6	21.3	6.6	10.1	3.1
Bower #15	458.3	10.5	2.2	19.9	4.3
Bower #15-B	425.6	18.2	4.2	22.4	5.2
Bower #15-C	190.1	5.7	2.9	8.6	4.5

Table 5 (Cont.)

Sample Number	Weight of Concentrate Grams	Low Intensity Fraction Grams	Low Intensity Fraction Weight % of Concentrate	High Intensity Fraction Grams	High Intensity Fraction Weight % of Concentrate
Maui #1	393.7	1.4	0.3	12.8	3.2
Maui #2	516.5	5.2	1.0	8.9	1.7
Maui #3	422.3	0.7	0.1	8.2	1.9
Maui #7	420.7	0.7	0.1	6.7	1.5
Maui #8	396.7	34.2	8.6	7.9	1.9
Maui #9	429.2	17.3	4.0	18.3	4.2
Maui #16	347.9	10.9	3.1	16.6	4.7
Maui #17	449.9	12.5	2.7	12.6	2.8
Maui #18	401.3	15.4	3.8	12.1	3.0
Maui #21	496.2	23.6	4.7	12.4	2.4
Maui #22	391.8	7.0	1.7	14.8	3.7
Maui #23	466.1	27.1	5.8	24.7	5.2

Table 5 (Cont.)

Sample Number	Weight of Concentrate Grams	Low Intensity Fraction Grams	Low Intensity Fraction Weight % of Concentrate	High Intensity Fraction Grams	High Intensity Fraction Weight % of Concentrate
Maui #24	178.9	0.8	0.4	2.3	1.2
Maui #26	470.8	8.7	1.8	7.0	1.4
Maui #26-B	258.5	5.7	2.2	6.9	2.6
Maui #28	77.7	0.2	0.2	-	-
Maui #29	346.9	5.0	1.4	14.3	4.1
Maui Fraction	280.8	2.5	0.8	12.1	4.3
Total and Average*	19,245.2	822.4	4.2	639.0	3.3

*Excluding Unclassified Sample.

These results were then calculated to give the amount of zircon ($ZrSiO_4$) present in the sample as received. These data are shown in Table 6 as percent zirconium and zircon respectively.

Platinum Determinations

Semiquantitative spectrographic analyses for platinum were conducted on the low intensity magnetic, high intensity magnetic and non-magnetic fractions. The method used had a predicted accuracy of plus or minus 30%, and with the small amount of sample used (10mg.) is dependent upon obtaining a highly representative sample.

The low intensity fractions all indicated the presence of platinum in an amount less than 0.001%. This is less than 0.29 troy ounces of platinum ± 30% of the amount reported per ton of low intensity magnetic concentrate. Platinum was not detected either in the high intensity concentrate or in the non-magnetic tailings.

To verify the non-existence of platinum in the non-magnetic fraction, a 15 gram quantity of each sample was analyzed by conventional fire assay procedures. Each sample was inquarted with silver and the silver bead analyzed spectrographically. A faint trace was noted in two samples, but in all other samples, platinum was not detected.

Bulk Sample

A sample consisting of 12,573 grams of concentrate was also submitted for processing. This sample, obtained from one location where surf action gave a natural concentration, was further concentrated by hand panning to a 3 to 1 ratio.

Table 6

Zircon Analysis, Yakataga

Sample Number	Zirconium Percent	Calculated Zircon Percent
Sunrise #1	0.22	0.44
Sunrise #2	0.07	0.14
Sunrise #3	0.07	0.14
Sunrise #4	0.13	0.26
Hope #1	0.12	0.24
Hope #2	0.18	0.36
Hope #2-B	Trace	Trace
Hope #3	0.30	0.60
Hope #4	0.13	0.26
Hope #5	0.46	0.92
Hope #5-B	0.18	0.36
Hope #6	0.13	0.26
Hope #7	0.15	0.30
Hope #7-B	0.27	0.54
Hope #8	0.07	0.14
Hope #8-B	0.11	0.22
Anchor #1	Trace	Trace
Anchor #2	0.03	0.06
Anchor #2-B	0.12	0.24
Anchor #3	0.07	0.14

Table 6 (Cont.)

Sample Number	Zirconium Percent	Calculated Zircon Percent
Anchor #4	0.30	0.60
Anchor #5	0.17	0.34
Anchor #7	0.30	0.60
Anchor #8	0.08	0.16
Pauli	0.23	0.46
Unclassified	Trace	Trace
Bower #9	0.07	0.14
Bower #11	0.07	0.14
Bower #12	0.07	0.14
Bower #13	0.27	0.54
Bower #13-B	0.10	0.20
Bower #14	0.20	0.40
Bower #15	0.07	0.14
Bower #15-B	0.07	0.14
Bower #15-C	0.10	0.20
Maui #1	0.32	0.64
Maui #2	0.48	0.96
Maui #3	0.35	0.70
Maui #7	0.36	0.72
Maui #8	0.13	0.26
Maui #9	0.27	0.54

Table 6 (Cont.)

Sample Number	Zirconium Percent	Calculated Zircon Percent
Maui #16	0.19	0.38
Maui #17	0.15	0.30
Maui #18	0.22	0.44
Maui #21	0.22	0.44
Maui #22	0.08	0.16
Maui #23	0.40	0.80
Maui #24	Trace	Trace
Maui #26	0.13	0.26
Maui #26-B	Trace	Trace
Maui #28	0.08	0.16
Maui #29	0.08	0.16
Maui Fraction	0.03	0.06

As the exact weight of the original surf concentrate is not known, the results expressed here are indicative only of the concentrated material received.

To supplement work conducted on the previously discussed samples from this area, it was deemed advisable to study the heavy mineral content to determine the size distribution of these constituents. To accomplish this, the total sample was screened to individual size fractions and each size fraction subjected to the processes as shown in the flowsheet of Figure 2.

Size distribution in the total sample is shown in Table 7. These data show that 99.34% of the material is plus 100 mesh with 96.80% in the 35/100 mesh range. This relatively coarse size is understandable as the material is predominately composed of garnet which is resistant to abrasive actions.

Each screen fraction was processed with the low intensity magnetic separator to remove the highly magnetic magnetite fraction. The results, as shown in Table 8, indicates that the magnetite fraction represents 5.1% of the total concentrate. The largest percentage of the total magnetite is found in the 35/48 mesh size with 96.5% in the 35/100 mesh size range. The data in the final column of this Table shows that the weight percent of magnetite, as compared to the total sample, increases with decreasing mesh size.

The non-magnetic fraction, of each screen size, from the low intensity magnetic separation was processed through a "Carpco" electrostatic separator in a high tension application. The high conductive, thrown fractions were composed primarily of ilmenite and represented 2.9% of the total sample, as shown in Table 9. The major portion of the gold was recovered in this product, and will be discussed subsequently.

Figure 2

YAKATAGA BULK

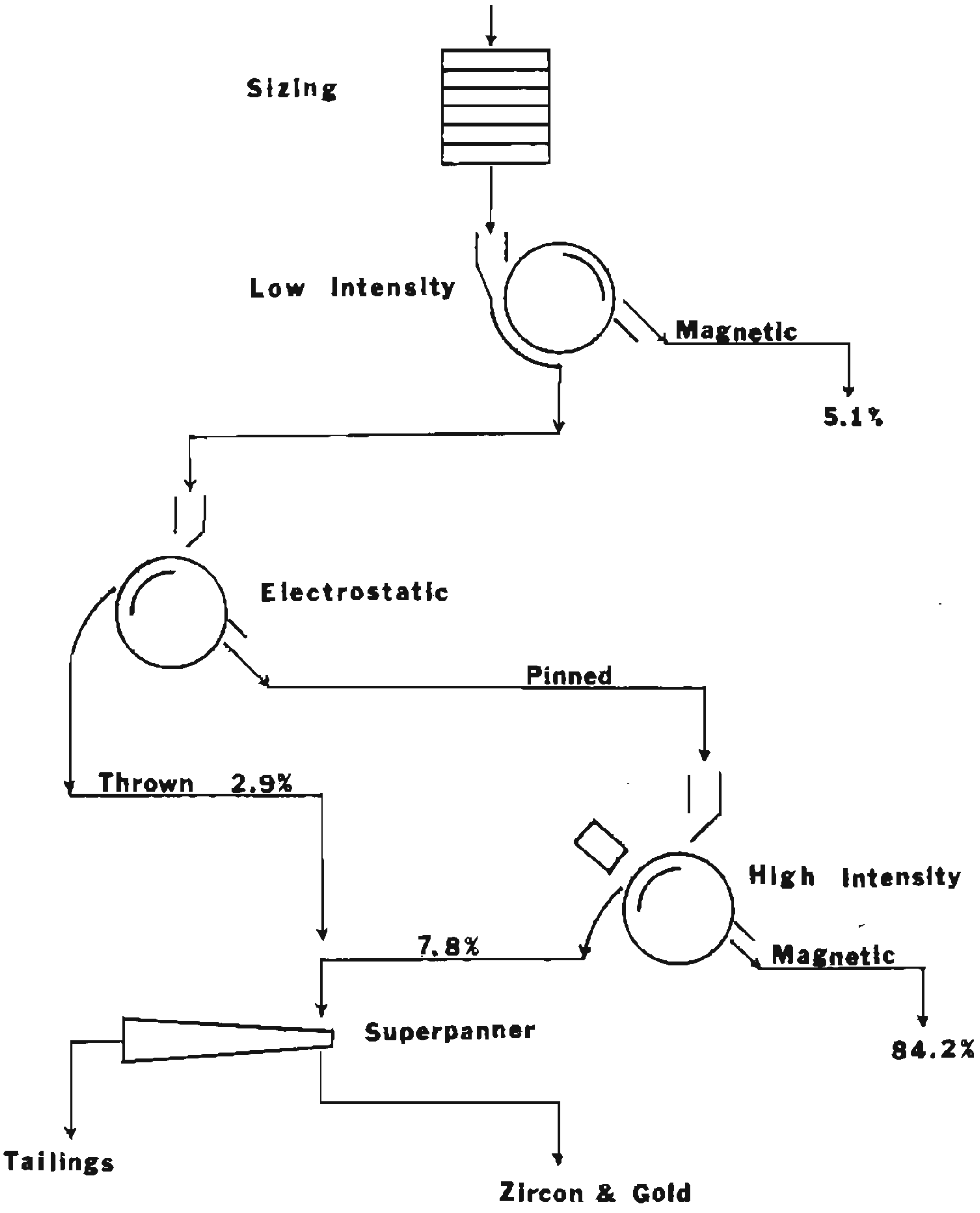


Table 7

Screen Analysis, Yakataga Bulk Sample

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
	35	320	2.54	2.54	100.00
35	48	8,547	67.98	70.52	97.46
48	65	3,152	25.07	95.59	29.48
65	100	471	3.75	99.34	4.41
100	150	77	0.61	99.95	0.66
150	200	5	0.04	99.99	0.05
200	Pan	1	0.01	100.00	0.01
Totals		12,573	100.00		

Table 8

Low Intensity Magnetic Separation, Yakataga Bulk Sample

Tyler Mesh Passed	Tyler Mesh Retained	Total Weight Grams	Magnetic Concentrate Grams	Weight % of Concentrate	Weight % of Total
	35	320	5.6	0.9	1.7
35	48	8,547	370.0	57.5	4.3
48	65	3,152	198.5	30.8	6.3
65	100	471	52.5	8.2	11.1
100	150	77	15.2	2.4	19.7
150	200	5	1.4	0.2	28.0
200	Pan	1	0.2	-	20.0
Total or Average		12,573	643.4	100.0	5.1

Table 9

High Tension Electrostatic Separation, Yakataga Bulk Sample

Tyler Mesh Passed	Tyler Mesh Retained	Total Weight Grams	Electrostatic Concentrate Grams	Weight % of Concentrate	Weight % of Total
	35	320	3.2	0.9	1.0
35	48	8,547	195.4	53.2	2.3
48	65	3,152	119.0	32.4	3.8
65	100	471	36.7	10.0	7.8
100	150	77	11.7	3.2	15.2
150	200	5	1.1	0.3	22.0
200	Pan	1	-	-	-
Total or Average		12,573	367.1	100.0	2.9

Poor conductors, or pinned portions, of the high tension electrostatic separation were processed with the high intensity magnetic separator to recover the remaining paramagnetic minerals. These data, shown in Table 10, indicate that 84.2% of the total concentrate falls in this catagory. This material is predominately garnet with some pyroxenes and is 95% within the 35/65 mesh size range.

The non-magnetic fractions, consisting predominantly of quartz and feldspars, were concentrated by wet gravity methods on a superpanner for recovery of gold and zircon. The gold content of each screen fraction from electrostatic, low intensity magnetic and high intensity magnetic processes were also reclaimed by gravity and amalgamation processes. These data, as presented in Table 11, show that 97.5% of the gold is recovered in the electrostatic concentrate with the ilmenite fraction. The balance of the gold is mechanically entrapped in the high intensity magnetic and the non-magnetic fractions. The gold is mainly minus 35 mesh with the maximum amount found in the 100/150 mesh size. A total of 92.35 mgs. of gold recovered gives a calculated value of 0.21 troy ounces per ton of concentrate received.

Non-Magnetic portions of each screen size were processed on the superpanner to recover zircon. Representative samples of this, as well as, the magnetic and electrostatic concentrates, were analyzed by x-ray spectrometry for zirconium content. The amount of zircon ($ZrSiO_4$) present was then calculated for each fraction. These data, presented in Table 12, shows the original sample to obtain 1.14% zircon with 99.5% of the total zircon present in the 35/150 mesh size range. The non-magnetic portion contained 89.45% of the zircon, and 10.55%

Table 10

High Intensity Magnetic Separation, Yakataga Bulk Sample

Tyler Mesh Passed	Tyler Mesh Retained	Total Weight Grams	Magnetic Concentrate Grams	Weight % of Concentrate	Weight % of Total
	35	320	171.9	1.6	1.4
35	48	8,547	7,374.3	69.7	58.7
48	65	3,152	2,684.1	25.3	21.3
65	100	471	327.3	3.1	2.6
100	150	77	28.1	0.3	0.2
150	200	5	1.1	-	-
200	Pan	1	0.3	-	-
Total or Average		12,573	10,587.1	100.0	84.2

Table 11

Gold Distribution, Yakataga Bulk Sample

	High Tension Electrostatic Concentrate		High Intensity Magnetic Concentrate		Non-Magnetic Fraction			
Tyler Mesh	Mgs.	% of Total	Mgs.	% of Total	Mgs.	% of Total	Total by Screen Size Grams	Total by Screen Size %
+35	Nil	0.00	0.25	0.27	0.08	0.09	0.33	0.36
35/48	10.45	11.32	0.10	0.10	0.05	0.05	10.60	11.48
48/65	20.15	21.82	0.20	0.22	0.10	0.10	20.45	22.14
65/100	17.16	18.58	0.65	0.72	0.03	0.03	17.84	19.31
100/150	34.01	36.83	Trace	0.00	0.85	0.92	34.86	37.76
150/200	8.27	8.95	Trace	0.00	Nil	0.00	8.27	8.95
Totals	90.04	97.50	1.20	1.31	1.11	1.19	92.35	100.00

Table 12

Zircon Distribution, Yakataga Bulk Sample

Tyler Mesh	High Intensity Magnetic Fraction		Non-Magnetic Fraction		Superpanner Concentrate		Total by Screen Size Grams	Total by Screen Size %
	Grams	Total	Grams	% of Total	Grams	% of Total		
+35	0.17	0.12	0.14	0.10	-	-	0.31	0.22
35/48	7.37	5.16	2.20	1.54	18.84	13.20	28.41	19.90
48/65	2.68	1.88	3.32	2.33	50.63	35.46	56.63	39.66
65/100	0.92	0.64	0.92	0.64	36.75	25.74	38.59	27.03
100/150	3.93	2.75	-	-	14.61	10.23	18.54	12.98
150/200	-	-	0.30	0.21	-	-	0.30	0.21
Totals	15.07	10.55	6.88	4.82	120.83	84.63	142.78	100.00

was mechanically trapped with the high intensity magnetic concentrate. Superpanner concentration of the non-magnetic portion recovered 84.63% of the total zircon and 4.82% was retained in the tailings. These were rougher concentrations and would be improved by cleaner applications.

Conclusions

The information presented is concerned entirely with the results obtained from concentrated material. Consequently, this must be taken into account when considering the ratio of concentration of the original sands as shown in Table 1. The gold content appears to be amenable to amalgamation with a minimum of loss and the platinum should be recoverable through a magnetic concentration process.

Unfortunately, these figures cannot be indicated on a cubic yard basis as the density of the original sand is not known. Evaluation on a cubic yard basis would probably be more practical or material of this type. It would also be more appropriate to have samples of the original sand without concentration to determine how much of the bulk material could be discarded through primary screening. Sink-float analyses of the original material would also determine the percentage of total heavy minerals and give an indication of the ratio of concentration to be expected.

LITUYA BAY AREA

Introduction

Beach deposits along the west coast of southeastern Alaska for several miles on either side of Lituya Bay have been briefly described in the literature with indications that they may contain concentrations of heavy minerals warranting further investigations. (Mertie[14], Rossman[18], and Thomas and Berryhill[20].)

J. B. Mertie[14] who visited the area in 1917 briefly described the deposits, and Darwin L. Rossman[18] made a cursory examination of the beaches between Dry Bay and Dixon Harbor in 1952. Rossman states that most of these beach deposits contain concentrations of heavy minerals some of which extend over considerable areas. Concentrations consisting of 5 to 40 percent heavy minerals are indicated with the following general order of decreasing abundance: garnet, pyroxene, ilmenite, amphibole, magnetite, staurolite, eqidote, rutile, sphene and zircon. The light mineral fraction includes quartz, feldspar, mica and calcite.

A sample of approximately 550 pounds of sand was obtained from a low wave-cut beach north of Lituya Bay between Eagle and Portage Creeks. It is believed to be representative of the sand deposit above tide level where past wave action caused a natural concentration of heavy minerals. The purpose of this investigation was to determine the amount and types of heavy minerals present and to supply information concerning the feasibility of continued work in this area.

Size Analysis

A representative sample was obtained from the bulk material and subjected to a screen analysis with the results as shown in Table 13. These data show the individual percentages of each size and the cumulative percent either passed or retained on any particular sieve.

Each size fraction was then treated as an individual sample to determine the amount and type of heavy minerals present and their distribution in the various size ranges. This information was collected by a combination of sink-float analysis, superpanner concentration, magnetic concentration, electrostatic concentration and amalgamation. A flow sheet indicating this procedure is shown as Figure 3.

Sink-Float Analysis

A representative portion of each screen fraction was obtained for sink-float analysis. These analyses aided in the determination of the heavy minerals present and established a theoretical amount recoverable by gravity concentration processes. Tetrabromoethane, specific gravity 2.96, was the heavy liquid used in these determinations.

The data presented in Table 14 shows the distribution of float and sink products for each size fraction and the cumulative percent sink and float distributions. This analysis shows that 55.2% of the sand is heavier than a 2.96 specific gravity with the percentage of heavy minerals in each size fraction increasing toward the finer sizes. As an example, 78.8% of the heavy minerals present are found in the minus 35 mesh fraction.

Minerals lighter than 2.96 specific gravity constituted 44.8% of the sample. Due to a large percent of heavy gangue minerals in the courser size ranges, the increase in the amount of heavy minerals such as magnetite, ilmenite

Table 13

Screen Analysis, Lituya Bay

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
-	10	1,951	9.8	9.8	100.0
10	14	448	2.2	12.0	90.2
14	20	770	3.9	15.9	88.0
20	28	1,899	9.5	25.4	84.1
28	35	3,943	19.8	45.2	74.6
35	48	4,173	20.9	66.1	54.8
48	65	4,688	23.4	89.6	33.9
65	100	1,784	9.0	98.6	10.4
100	150	247	1.2	99.8	1.4
150	200	15	0.1	99.9	0.2
200	Pan	7	0.1	100.0	0.1
Totals		19,925	100.0		

Figure 3

LITUYA BAY

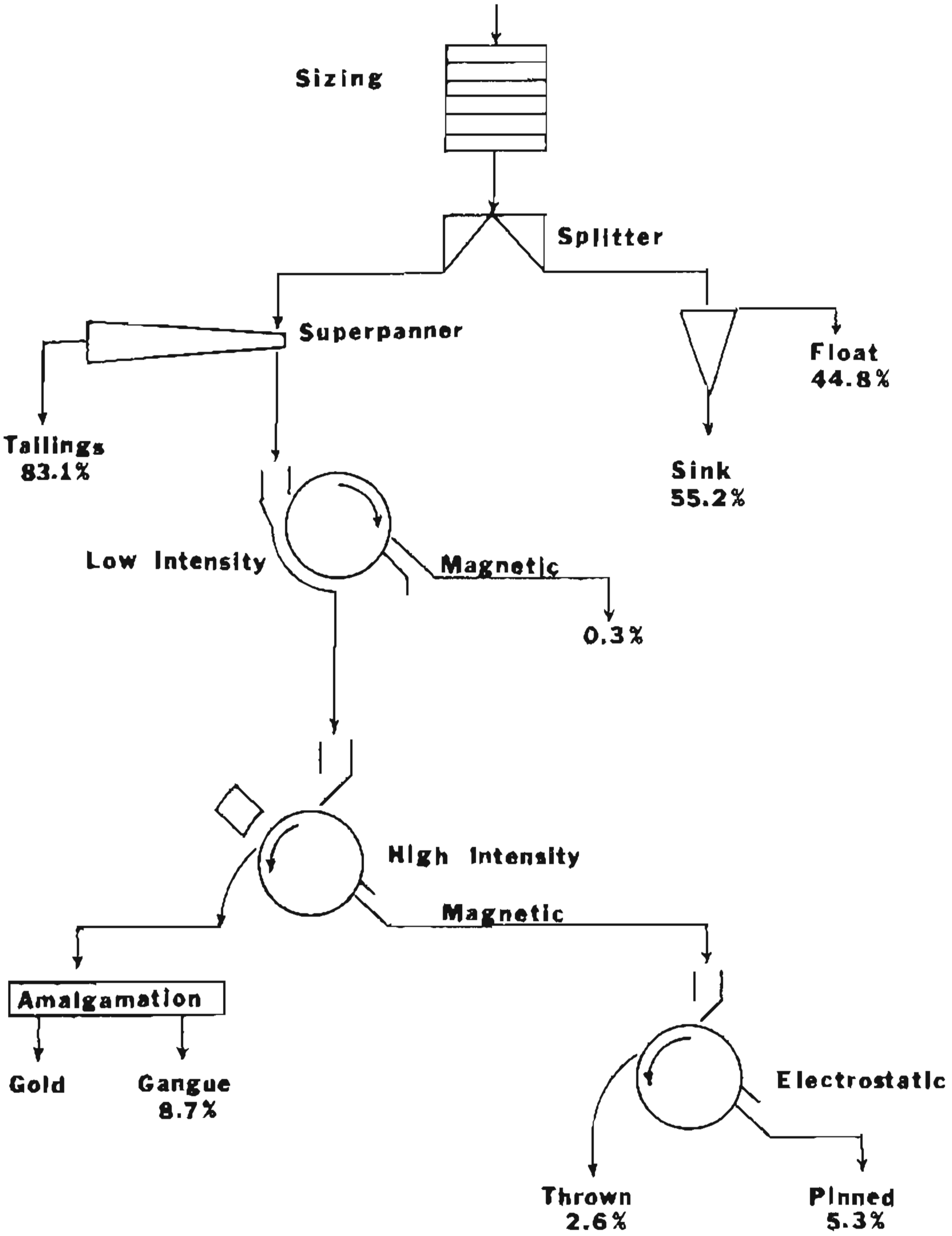


Table 14

Sink-Float Analysis, Lituya Bay

Tyler Mesh		Wt. Float Grams	Wt. % Float	Wt. Sink Grams	Wt. % Sink	Cumulative Wt. % Float		Cumulative Wt. % Sink	
Passed	Retained					Retained	Passed	Retained	Passed
10	14	24.0	27.3	6.4	5.9	27.3	100.0	5.9	100.0
14	20	15.9	18.1	4.4	4.1	45.4	72.7	10.0	94.1
20	28	15.4	17.5	5.9	5.5	62.9	54.6	15.5	90.0
28	35	12.8	14.6	6.2	5.7	77.5	37.1	21.2	84.5
35	48	10.5	11.9	10.0	9.2	89.4	33.5	30.4	78.8
48	65	5.7	6.5	17.1	15.8	95.9	10.6	46.2	69.6
65	100	1.1	1.3	15.7	14.5	97.2	4.1	60.7	53.8
100	150	0.7	0.8	30.9	28.6	98.0	2.8	89.3	39.3
150	200	1.8	2.0	11.6	10.7	100.0	2.0	100.0	10.7
Totals		87.9	100.0	108.2	100.0				

and zircon present in the minus 35 mesh fraction is not readily apparent from this table. Correlation of x-ray diffraction studies of sink products and ilmenite-magnetite size distributions substantiates the fact that these minerals are found primarily in sizes below 35 mesh. The heavy gangue minerals are mainly garnet, pyroxene and hornblende, while the light gangue material consists primarily of quartz, mica and feldspar.

Gravity Concentration

Each screen fraction was concentrated on a superpanner to recover the heavy mineral fraction. To insure maximum recovery, no attempt was made to separate a clean magnetite-ilmenite concentrate. Rougher concentrates were made which included a considerable amount of the heavier gangue minerals. Size fractions courser than 28 mesh were not concentrated as microscopic examinations indicated only trace amounts of magnetite and ilmenite.

The data obtained indicated a ration of concentration for various size ranges as follows:

Mesh Size	Sample Wt. Grams	Concentrate Wt. Grams	Ratio of Concentration
28 x 200	14,857	3,384	4.4
35 x 200	10,914	3,162	3.4
48 x 200	6,741	2,412	2.8

Magnetic Separation

The distribution of magnetite in each screen fraction was determined by processing each of the superpanner, rougher concentrates with a low intensity magnetic separator. Recovery and distribution of magnetite by size fractions is shown in Table 15. These data show that 97.6% of the magnetite is minus 35 mesh in size.

Non-magnetic material from the low intensity separator was processed at a higher magnetic field with the induced roll high intensity separator. The paramagnetic concentrates contained ilmenite, amphiboles, pyroxenes and other iron containing silicates. Tailings, or diamagnetic material, from this process were composed predominately of quartz with trace amounts of zircon, sheelite and gold.

Electrostatic Separation

The paramagnetic concentrates were subjected to electrostatic processing to produce a gangue-free ilmenite concentrate.

Table 16 presents the results obtained from processing each screen fraction. These data show that 98.8% of the ilmenite is of minus 35 mesh size.

Amalgamation

The tailings (diamagnetic products) from the high intensity magnetic separation were recombined and the gold collected by an amalgamation process. A total of 0.40 milligrams of gold was recovered, representing 0.002 ounces of gold per ton of sand or 0.0053 ounces per cubic yard of sand.

This value of gold is indicative of the material split for screen analysis. Its accuracy as representing the total sample received is dependent upon a truly representative portion of gold content being obtained.

Table 15

Magnetite Distribution, Lituya Bay

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
28	35	1.5	2.4	2.4	100.0
35	48	4.9	8.0	10.4	97.6
48	65	12.7	20.6	31.0	89.6
65	100	24.7	40.1	71.1	69.0
100	150	17.8	28.9	100.0	28.9
Totals		61.6	100.0		

Table 16

Ilmenite Distribution, Lituya Bay

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
28	35	6.3	1.2	1.2	100.0
35	48	35.7	6.9	8.1	98.8
48	65	143.7	27.7	35.8	91.9
65	100	239.0	46.1	81.9	64.2
100	150	93.6	18.1	100.0	18.1
Totals		518.3	100.0		

Bulk Test

As a check on the results obtained on the individual screen fractions a bulk sample of 98.31 pounds was split from the remaining sand. This test was conducted in the same manner as the smaller scale tests with the following exceptions: The sample was hand screened on a 35 mesh ton cap screen, a Wilfley Table was used as a gravity concentrator, and electrostatic separation preceeded high intensity magnetic separation. This flowsheet is illustrated as Figure 4.

The results of this test were comparable to tests performed on the individual screen fractions as well as another smaller scale test on the Wilfley Table. A comparison of these tests are as follows:

Test	-35 Mesh %	% Magnetite -35 Mesh	Magnetite % in Head	% Ilmenite -35 Mesh	Ilmenite % in Head
Screen Fractions	54.8	0.55	0.31	4.70	2.60
Small Sample Table	52.5	0.57	0.28	4.83	2.28
Large Sample Table	77.4	0.38	0.29	3.03	2.35

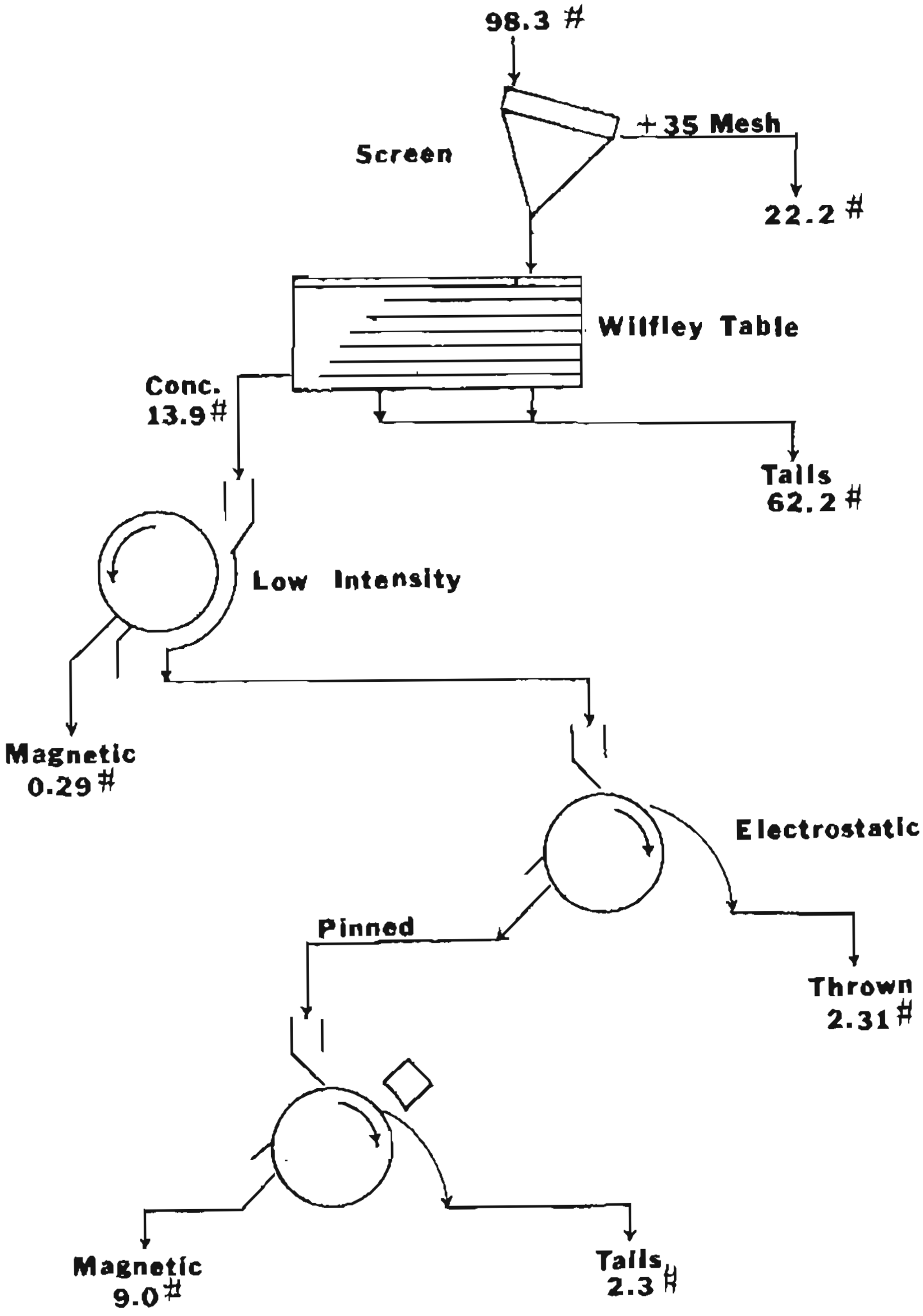
Analyses of magnetite and ilmenite correlate very well when related to the head sample, but there appears to be a discrepancy in the -35 mesh material of the larger sample. This is due to the screening technique used in which the ton cap screen allowed more material to pass into the -35 mesh size, thereby diluting the percentage of magnetite and ilmenite.

Conclusions

The heavy mineral content of this sand is found predominately in the minus

FIGURE 4

LITUYA BAY BULK



35 mesh size and can be conveniently recovered by a combination of gravity, magnetic and electrostatic processes.

The sample submitted contained 16 pounds of magnetite and 138 pounds of ilmenite per cubic yard. Other heavy minerals consisted of 0.0053 ounces of gold and trace amounts of zircon and scheelite on a cubic yard basis. Tests for radioactive materials proved to be negative.

BRADFIELD CANAL - KETCHIKAN AREA

Introduction

A sample consisting of approximately 700 pounds of beach sand was submitted to the Mineral Industry Research Laboratory to determine the amount and types of heavy minerals present, methods by which they may be recovered and give the claim holders information by which they could determine advisability of continued efforts in this area.

This sample was obtained from the head of Bradfield Canal at low tide, and is assumed to be representative of the sand deposit below the beach line where present wave action would cause a natural concentration of heavy minerals.

Laboratory methods of evaluating the sample consisted of a combination of gravity, magnetic, electrostatic and amalgamation processes. Figure 5 illustrates the flowsheet for these tests.

Size Analysis

A representative sample weighing 13,534 grams was split for screen analysis with the results shown as Table 17. These data show the percentage of material to be expected in each size fraction and the cumulative percent retained or passing any particular screen size.

The size analysis is typical of most beach type deposits with possibly a slightly larger amount of material in the finer size ranges. This is probably due to the fact that the sample was taken in an area where some tidal classification had occurred.

Figure 5

BRADFIELD CANAL

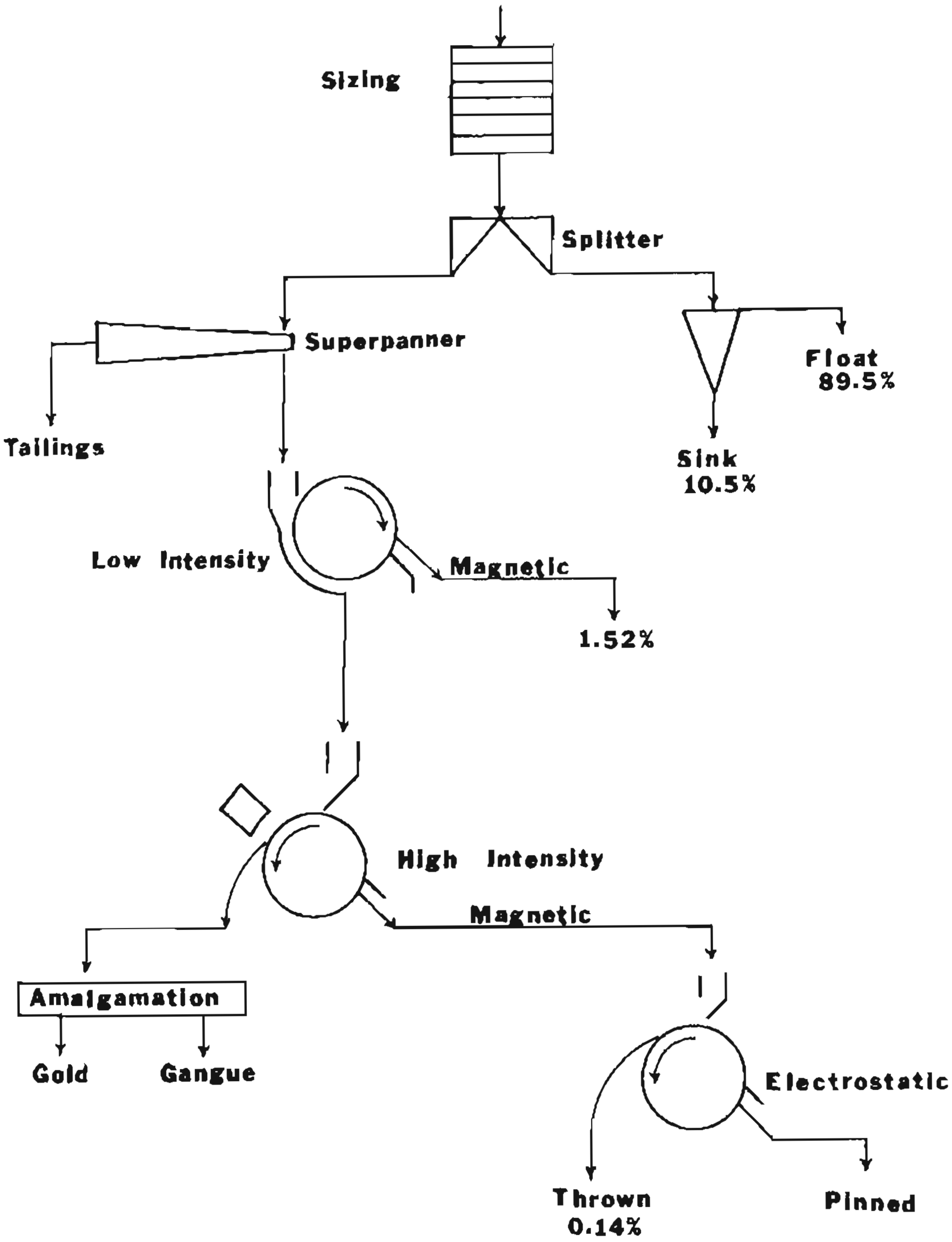


Table 17

Screen Analysis, Bradfield Canal

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
-	14	275	2.0	2.0	100.0
14	20	363	2.7	4.7	98.0
20	28	1,070	7.8	12.5	95.3
28	35	1,782	13.2	25.7	87.5
35	48	2,320	17.1	42.8	74.3
48	65	2,690	19.8	62.6	57.2
65	100	2,112	15.7	78.3	37.4
100	150	896	6.6	84.9	21.7
150	200	724	5.4	90.3	15.1
200	Pan	1,302	9.7	100.0	9.7
Totals		13,534	100.0		

Sink-Float Analysis

A representative portion of each screen size was subjected to sink-float test to determine the amount of heavy minerals present and the theoretical recovery possible by gravity processes. Tetrabromoethane, specific gravity 2.96, was used in these determinations.

Table 18 shows the results of these tests indicating the percent material in each size fraction that is either lighter or heavier than a specific gravity of 2.96.

These data show that 10.5% of the material in the combined mesh sizes has a specific gravity greater than 2.96 and x-ray diffraction analysis of this heavy portion shows it to consist primarily of mica, hornblende, magnetite and ilmenite. The greater percentage of the heavier minerals are concentrated in the finer mesh sizes with 88.2% minus 35 mesh in size.

Gravity Concentration

The remaining portion of each screen size fraction was concentrated on a superpanner to recover a rougher concentrate of the heavy minerals. Due to the action of the superpanner and the flat shape of the mica, this mineral floated off and was removed prior to the quartz which was lighter in specific gravity.

A concentration ratio of 16.0 was obtained for the combined screen fractions which means that 16 tons of sand must be treated to obtain one ton of concentrate.

Magnetic Separation

To determine the distribution of magnetite in each screen fraction, the superpanner concentrates were processed through a low intensity magnetic separator at a field strength of approximately 345 gauss. The recovery of magnetite from this

Table 18

Sink-Float Analysis, Bradfield Canal

Tyler Mesh		Wt. Float Grams	Wt. % Float	Wt. Sink Grams	Wt. % Sink	Cumulative Wt. % Float		Cumulative Wt. % Sink	
Passed	Retained					Retained	Passed	Retained	Passed
14	20	14.3	11.2	0.3	2.2	11.2	100.0	2.2	100.0
20	28	20.4	15.9	0.6	4.4	27.1	88.8	6.6	97.8
28	35	16.9	13.2	0.7	5.2	40.3	72.9	11.8	93.4
35	48	25.0	19.5	1.3	9.6	59.7	59.7	21.4	88.2
48	65	12.1	9.5	1.3	9.6	69.3	40.2	31.0	78.6
65	100	9.4	7.3	1.8	13.4	76.6	30.7	44.4	69.0
100	150	11.9	9.3	3.2	23.7	85.9	23.4	68.1	55.6
150	200	9.8	7.7	3.0	22.3	93.6	14.1	90.4	31.9
200	Pan	8.2	6.4	1.3	9.6	100.0	6.4	100.0	9.6
Totals		128.0	100.0	13.5	100.0				

process is shown in Table 19. These data show that magnetite is concentrated in the minus 35 mesh fractions with 97.9% of the total magnetite recovered in the minus 48 mesh material.

The non-ferromagnetic material from the above magnetic process was subjected to a higher magnetic field to concentrate paramagnetic minerals. This was accomplished with a high intensity induced roll separator operated with a field strength of approximately 3,460 gauss. The concentrate contained ilmenite, hornblende and other iron containing silicates. Tailing material from this separation was predominantly quartz with minor amounts of gold and zircon.

Electrostatic Separation

The paramagnetic concentrate from the high intensity magnetic separator was processed through a high tension electrostatic separator to remove ilmenite from the other paramagnetic silicates.

Results of these tests are shown in Table 20 and indicate that practically all of the ilmenite present is minus 48 mesh in size. One-half of the total ilmenite is found in the 48/65 mesh fraction.

Amalgamation

The non-magnetic products from the high intensity magnetic separation were recombined and amalgamated for a four hour period to determine the amount of gold present. From this test, 3.1 milligrams of gold was recovered. This gives a calculated value of 0.01 troy ounces per ton of sand.

The gold particles have a top size of 48/65 mesh, an average size of 100/150 mesh and a minimum size below 400 mesh.

Table 19

Magnetite Distribution, Bradfield Canal

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
14	20	0.0	0.0	0.0	-
20	28	0.0	0.0	0.0	-
28	35	0.1	0.0	0.0	-
35	48	4.6	2.1	2.1	100.0
48	65	27.1	13.2	15.3	97.9
65	100	59.2	28.8	44.1	84.7
100	150	46.4	22.6	66.7	55.9
150	200	40.3	19.6	86.3	33.3
200	Pan	28.2	13.7	100.0	13.7
Totals		205.9	100.0		

Table 20

Ilmenite Distribution, Bradfield Canal

Tyler Mesh		Weight Grams	Weight %	Cumulative Weight %	
Passed	Retained			Retained	Passed
14	20	0.0	0.0	0.0	-
20	28	0.0	0.0	0.0	-
28	35	0.0	0.0	0.0	-
35	48	0.0	0.0	0.0	-
48	65	9.6	50.0	50.0	100.0
65	100	4.3	22.4	72.4	50.0
100	150	2.6	13.6	86.0	27.6
150	200	2.5	13.0	99.0	14.0
200	Pan	0.2	1.0	100.0	1.0
Totals		19.2	100.0		

Bulk Test

A bulk sample containing 110.5 pounds of sand was processed as a check on the results obtained from the smaller scale tests.

This sample was processed in a manner similar to the preceding tests with the exceptions that: The plus 35 mesh material was discarded as waste, a Wilfley Table was used for gravity concentration and electrostatic concentration preceded high intensity magnetic separation. The flow sheet for this test is shown as Figure 6.

Screening discarded 23.58% of the total sand, and results of the concentration processes are as follows:

Unit	Feed (lbs.)	Concentrate (lbs.)	Tailings (lbs.)	Ratio of Concentration
Table	84.44	8.47	75.97	9.97
Low Intensity Magnetic	8.47	1.63	6.84	5.20
Electrostatic	6.84	0.13	6.71	52.62
High Intensity Magnetic	6.71	1.35	5.36	4.97

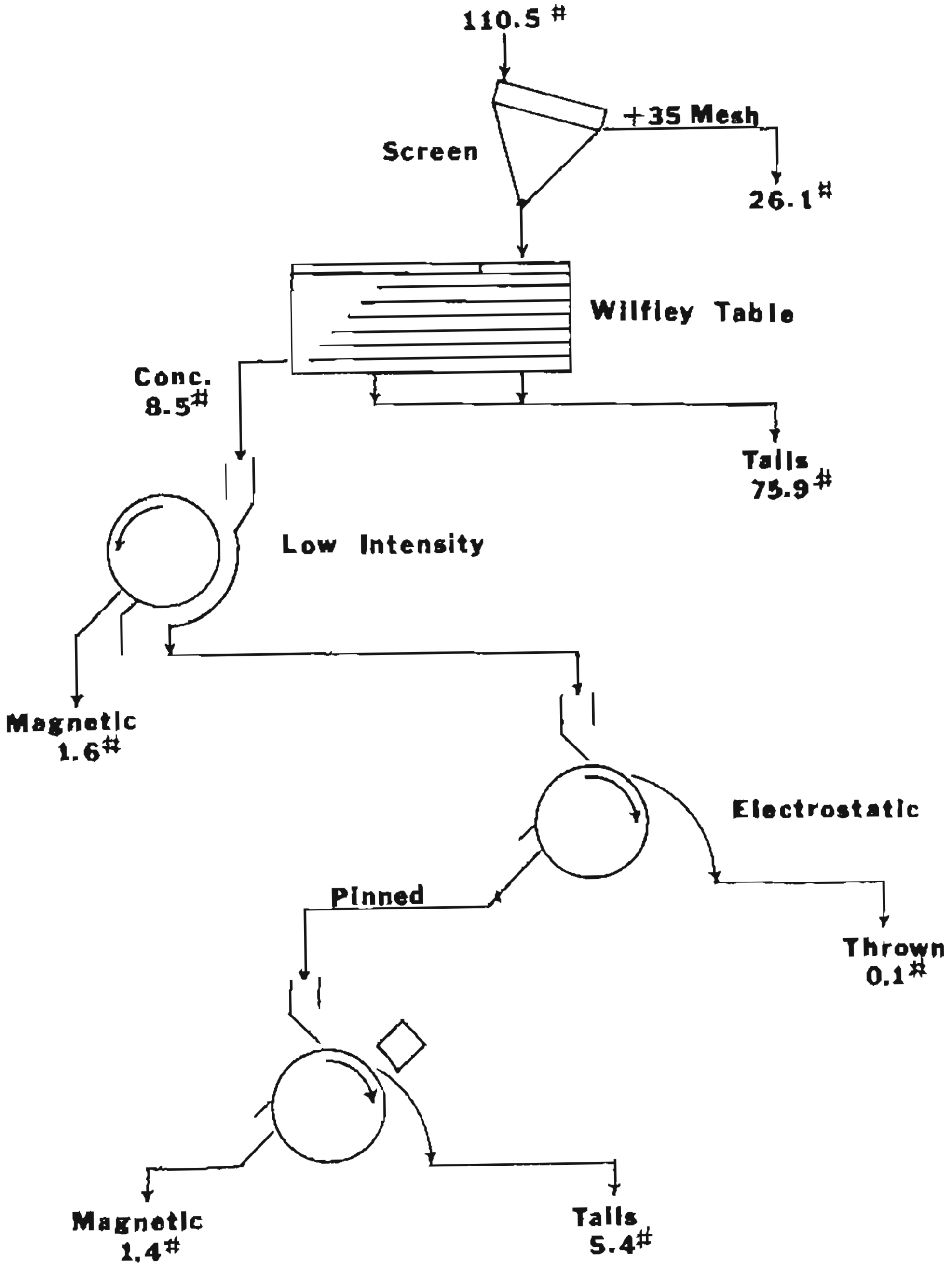
Conclusions

Tests indicate that the heavy mineral content of these sands can be conveniently recovered by a combination of gravity, magnetic and electrostatic processes.

The sample as submitted contained 68 pounds of magnetite, 6 pounds of ilmenite, 0.02 troy ounces of gold and a trace amount of zircon on a cubic yard basis. Radioactive tests indicated only trace amounts of equivalent uranium in the ilmenite concentrate.

Figure 6

BRADFIELD CANAL BULK



Results of the two tests were comparable as shown in the following tabulation:

Test	-35 Mesh %	% Magnetite 35 x 0	% Magnetite Head	% Ilmenite Head	% Ilmenite Head
Small	74.3	2.05	1.52	0.20	0.14
Bulk	76.4	1.93	1.47	0.12	0.09

NOME AREA

Introduction

A sample consisting of 2,943 grams of beach sand was received. This material was taken from below the sea wall at Nome and is assumed to be a grab sample taken from an area where natural concentration by wave and tidal action had occurred.

The total sample was sized and each individual size fraction processed according to the flowsheet shown as Figure 7.

Size Analysis

To obtain information relative to particle size and mineral associations in the various size ranges, a screen analysis was performed with the results as shown in Table 21.

These data show that 15.3% of the sample is cumulatively retained on a 20 mesh sieve. The 20 mesh size is significant in that subsequent processing indicates that no heavy mineral concentration occurred at sizes coarser than this mesh.

Low Intensity Magnetic Separation

A Carpco Low Intensity Magnetic Separator was used to remove the ferro magnetic minerals in each size fractions with the results as shown in Table 22.

The magnetic concentrate amounted to 0.5% of the total sample and was predominately minus 20 mesh in size.

Figure 7

NOME

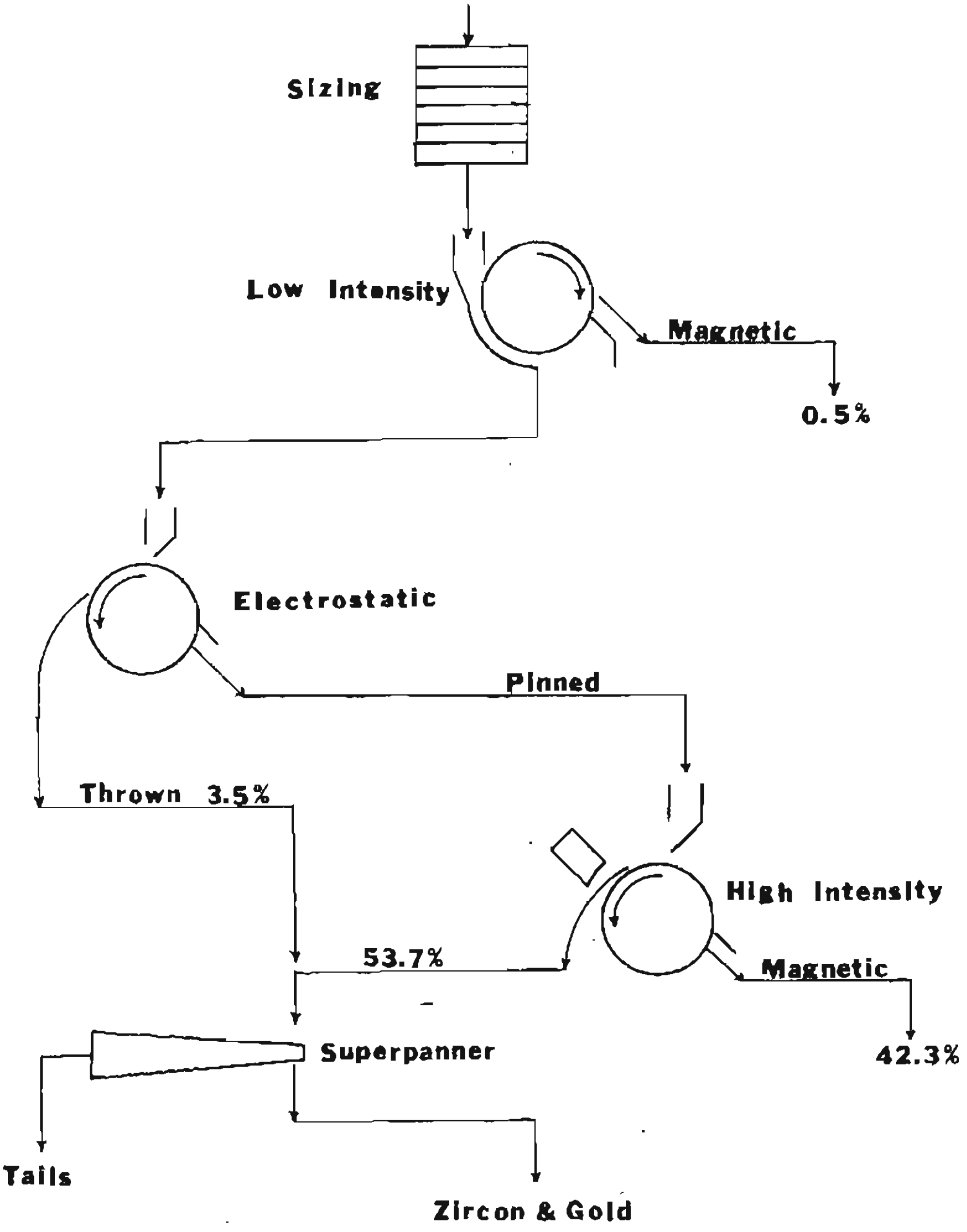


Table 21

Screen Analysis, Nome

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
-	3	30	1.0	1.0	100.0
3	4	30	1.0	2.0	99.0
4	6	54	1.8	3.8	98.0
6	8	62	2.1	5.9	96.2
8	10	49	1.6	7.5	94.1
10	14	77	2.6	10.1	92.5
14	20	153	5.2	15.3	89.9
20	28	322	10.9	26.2	84.7
28	35	608	20.7	46.9	73.8
35	48	680	23.2	70.1	53.1
48	65	639	21.8	91.9	29.9
65	100	187	6.4	98.3	8.1
100	150	30	1.0	99.3	1.7
150	200	7	0.2	99.5	0.7
200	Pan	15	0.5	100.0	0.5

Table 22

Magnetite Distribution, Nome

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
10	14	0.1	0.8	0.8	100.0
14	20	0.2	1.5	2.3	99.2
20	28	0.4	2.9	5.2	97.7
28	35	0.6	4.3	9.5	94.8
35	48	1.0	7.2	16.7	90.5
48	65	3.2	23.1	39.8	83.3
65	100	6.0	43.4	83.2	60.2
100	150	2.1	15.2	98.4	16.8
150	200	0.1	0.8	99.2	1.6
200	Pan	0.1	0.8	100.0	0.8
Totals		13.8	100.0		

Electrostatic Separation

The non-magnetic material from the low intensity magnetic separations were subjected to electrostatic concentration in which good conductors such as ilmenite and gold were recovered as a thrown product and the poor conductors were pinned to the rotor.

The concentrate consisted of 3.5% of the total sample and was found entirely as minus 20 mesh material. The weight percent in each size fraction is shown in Table 23.

X-ray diffraction analysis showed this concentrate to be primarily ilmenite with some hematite present. The proportion of gold recovered in this process is covered in a later section.

High Intensity Magnetic Separation

The non conductor minerals (pinned portion) from the electrostatic separation were treated on the induced roll separator to concentrate those minerals having paramagnetic characteristics.

These data as presented in Table 24 show that 42.3% of the total sample was concentrated magnetically in this process. This material was predominately garnet and gives the reddish hue to the sand.

The non-magnetic portions were concentrated on the superpanner to determine free gold and zircon contents. A total of 2.0 grams of zircon was recovered, and as this is less than 0.1% of the total sample it is recorded as a trace amount.

Gold Distribution

Gold was found to be present in both the high tension electrostatic

Table 23

Ilmenite Distribution, Nome

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
20	28	6.1	5.9	5.9	100.0
28	35	7.5	7.2	13.1	94.1
35	48	11.1	10.7	23.8	86.9
48	65	34.8	33.7	57.5	76.2
65	100	33.8	32.7	90.2	42.5
100	150	8.8	8.5	98.7	9.8
150	200	0.5	0.5	99.2	1.3
200	Pan	0.8	0.8	100.0	0.8
Totals		103.4	100.0		

Table 24

High Intensity Magnetic Separation, Nome

Tyler Mesh Passed	Tyler Mesh Retained	Total Sample Grams	Magnetic Concentrate Grams	Weight % of Concentrate	Weight % of Total
-	3	30.0	0.0	0.0	0.0
3	4	30.0	0.0	0.0	0.0
4	6	54.0	0.0	0.0	0.0
6	8	62.0	0.0	0.0	0.0
8	10	49.0	0.0	0.0	0.0
10	14	77.0	0.0	0.0	0.0
14	20	153.0	0.0	0.0	0.0
20	28	322.0	8.0	0.6	2.5
28	35	608.0	162.0	13.0	26.6
35	48	680.0	431.2	34.6	63.4
48	65	639.0	504.4	40.5	78.9
65	100	187.0	124.5	10.0	66.6
100	150	30.0	11.0	0.9	36.7
150	200	7.0	2.0	0.2	28.6
200	Pan	15.0	3.0	0.2	20.0
Total or Average		2,943.0	1,246.1	100.0	42.3

concentrate and the tailing material from the high intensity magnetic separations. Each screen fraction of both products were processed on the superpanner with the distribution of gold in the non-magnetic portion shown as Table 25.

The total sample has a calculated gold value of 0.19 ounces per ton with approximately 60% of the gold recovered with the electrostatic concentrate. The remaining 40% of the total gold was reclaimed from the non-magnetic material.

Conclusions

The sample, as submitted, was obviously not representative of a large portion of beach area. The results, therefore, are only indicative of the sample received.

The heavy mineral content, including gold, is all in the minus 20 mesh material, consequently, 15% of the total sample can be scalped off as having no significant value. This would have the effect of raising the gold value from 0.19 ounces per ton to 0.22 ounces per ton. To determine the true value of a deposit of this nature would require a large scale comprehensive evaluation program.

Table 25

Gold Distribution - Non-Magnetic Portion, Nome

Tyler Mesh Passed	Tyler Mesh Retained	Weight Non-Magnetics Grams	Gold Recovery Mgs.	Gold Recovery Ounces/Ton
-	10	49.0	0.0	0.00
10	14	76.9	0.0	0.00
14	20	152.8	0.0	0.00
20	28	307.5	7.0	0.66
28	35	437.9	3.5	0.23
35	48	236.7	6.0	0.73
48	65	96.6	1.0	0.30
65	100	22.7	0.5	0.64
100	150	8.1	0.5	1.80
150	200	4.4	Trace	Trace
200	Pan	11.1	0.3	0.78
Total or Average		1,403.7	18.8	0.39

BRISTOL BAY AREA

Introduction

Twenty-two individual samples were submitted from the Bristol Bay area for the primary purpose of determining the amount of zircon present. These samples were not hand concentrated in any manner, but were grab samples selected over several miles of beach. The samples were contained in plastic bags, and unfortunately, had no identifying marks to distinguish one sample from another.

Under the circumstances the only possible way to gain any information for the time and effort expanded was to combine the samples into a composits sample representing an average over the area randomly sampled. This was regretable in that some samples showed a much higher natural concentration of heavy minerals and would indicate selected areas that should be investigated in more detail.

Size Analysis

To obtain information relative to particle size and mineral associations in the size ranges, a screen analysis was conducted, on the composits sample, from 4 through 150 mesh. The data from this analysis is shown in Table 26. These data indicate that 25.9% of the composite sample is greater than 20 mesh size. The 20 mesh size is significant in that subsequent processing indicates that no heavy mineral concentration occurs at sizes larger than 20 mesh, and this oversize material could be discarded because of no value.

Each screen size fraction was processed according to the flowsheet shown as Figure 8. The percentage figures indicated on this flowsheet represent the total

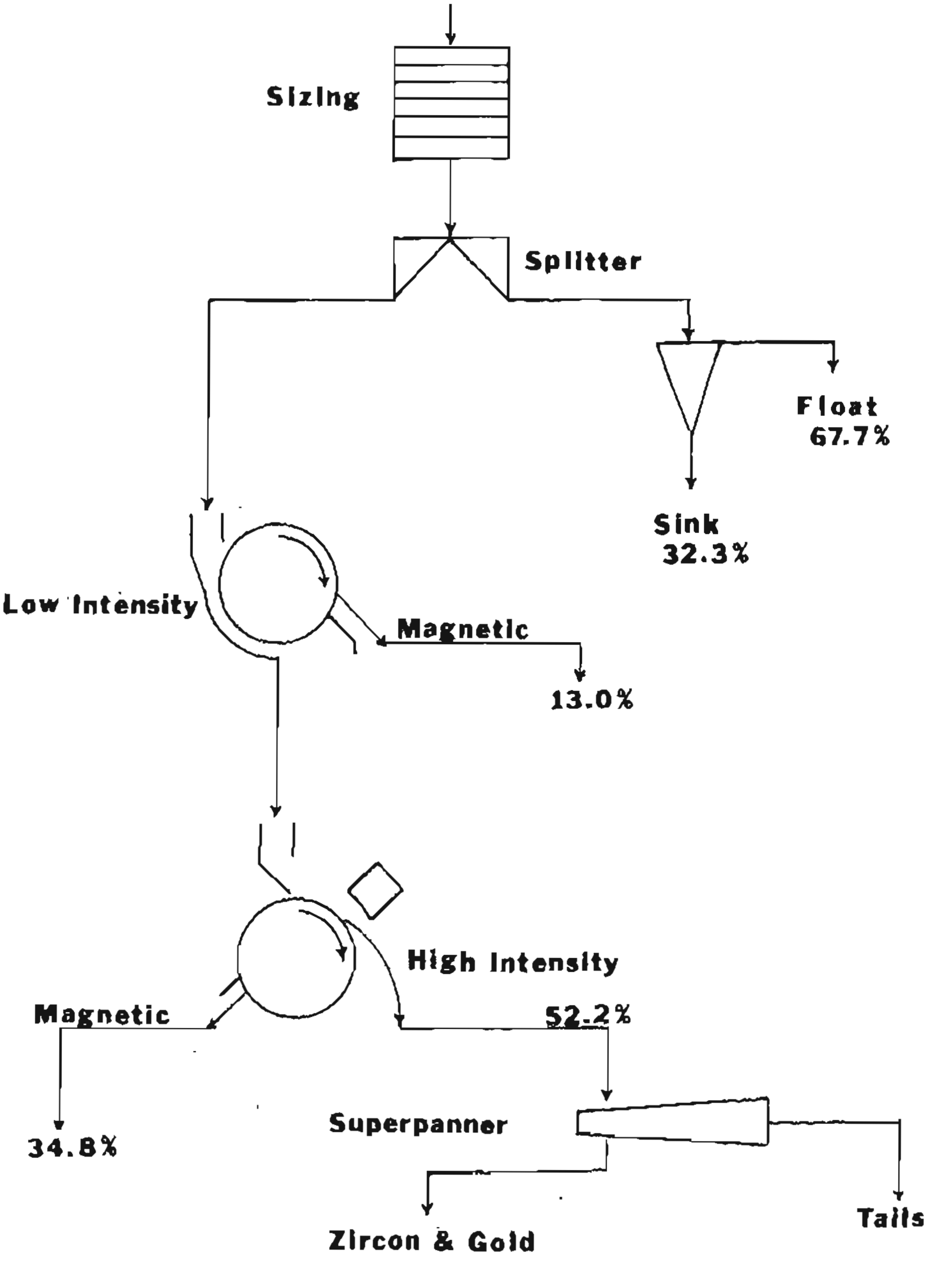
Table 26

Screen Analysis, Bristol Bay

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
	4	584.0	7.1	7.1	100.0
4	6	182.0	2.2	9.3	92.9
6	8	182.0	2.2	11.5	90.7
8	10	171.0	2.1	13.6	88.5
10	14	331.0	4.0	17.6	86.4
14	20	681.0	8.3	25.9	82.4
20	28	1,980.5	24.1	50.0	74.1
28	35	981.5	11.9	61.9	50.0
35	48	2,324.0	28.2	90.1	38.1
48	65	353.2	4.3	94.4	9.9
65	100	300.9	3.7	98.1	5.6
100	150	100.8	1.2	99.3	1.9
150	Pan	58.0	0.7	100.0	0.7
Total		8,229.9	100.0		

Figure 8

BRISTOL BAY



of all size fractions processed.

Low Intensity Magnetic Separation

Each screen fraction was processed through a Carpco Low Intensity Magnetic Separator to remove the highly magnetic minerals. The results of these tests are shown in Table 27. These data show that the highly magnetic minerals represent 13.0% of the total sample, and they are all minus 20 mesh in size. The greatest concentration of this material (56.5%) is found in the minus 35 plus 48 mesh size range.

X-ray diffraction analysis of this magnetic concentrates shows this material to be predominately magnetite with a minor amount of chromite present. Qualitative spectrographic analyses indicate a high iron concentration, 1.5% titanium and a trace amount of zirconium.

High Intensity Magnetic Separation

Efforts to separate minerals in the low intensity magnetic tailings by electrostatic methods proved fruitless, so further magnetic separations were conducted. In this process a Carpco High Intensity induced roll magnetic separator was utilized with maximum amperage to give a magnetic and non-magnetic products.

The results of these tests, as shown in Table 28, indicates that 34.8% of the total material was recovered as a high intensity magnetic product and the remaining 52.2% of the total sample exhibited non-magnetic characteristics. The magnetic material was predominately minus 20 mesh in size with the greatest concentration in the minus 20 plus 48 mesh size range.

To expedite identification of minerals in the magnetic fraction, sink-float

Table 27

Low Intensity Magnetic Separation, Bristol Bay

Tyler Mesh Passed	Tyler Mesh Retained	Total Weight Grams	Magnetic Concentrate Grams	Weight % of Concentrate	Weight % of Total
-	4	584.0	0.0	0.0	0.0
4	6	182.0	0.0	0.0	0.0
6	8	182.0	0.0	0.0	0.0
8	10	171.0	0.0	0.0	0.0
10	14	331.0	0.0	0.0	0.0
14	20	681.0	1.0	0.1	0.1
20	28	1,980.5	6.0	0.6	0.3
28	35	981.5	46.0	4.3	4.6
35	48	2,324.0	609.0	56.5	26.2
48	65	353.2	176.0	16.3	49.8
65	100	300.9	187.0	17.3	62.1
100	150	100.8	50.0	4.6	49.6
150	Pan	58.0	3.0	0.3	5.2
Total or Average		8,229.9	1,078.0	100.0	13.0

Table 28

High Intensity Magnetic Separation, Bristol Bay

Tyler Mesh		Total Weight Grams	Magnetic Concentrate Grams	Weight % of Concentrate	Weight % of Total
Passed	Retained				
-	4	584.0	0.0	0.0	0.0
4	6	182.0	0.0	0.0	0.0
6	8	182.0	0.0	0.0	0.0
8	10	171.0	37.0	1.3	21.6
10	14	331.0	103.0	3.6	31.1
14	20	681.0	234.0	8.1	34.4
20	28	1,980.5	823.5	28.6	41.6
28	35	981.5	432.0	15.0	44.0
35	48	2,324.0	1,037.5	36.1	44.6
48	65	353.2	103.0	3.6	29.2
65	100	300.9	71.4	2.5	23.7
100	150	100.8	28.6	1.0	28.4
150	Pan	58.0	4.5	0.2	7.8
Total or Average		8,229.9	2,874.5	100.0	34.9

tests were conducted on split portions of each size fractions. Tetrabromoethane with a specific gravity of 2.96 was utilized as the media. These data are shown in Table 29 and indicate that 55.0% of the magnetic concentrate was heavier than a specific gravity of 2.96 and 45.0% was lighter.

The sink fraction was found, by x-ray diffraction analysis, to be predominately composed of the pyroxene mineral hypersthene. This is a magnesium silicate containing approximately 15% iron. Qualitative spectrographic analysis verified high iron, magnesium and silicon contents with a minor amount of titanium and a trace of zircon.

The float fraction was found to consist of pyroxenes with a lesser amount of contained iron. Mechanically entrapped quartz and feldspar was also present. A trace amount of zirconium was again indicated.

Non-Magnetic Material

The non-magnetic fraction was found to be composed of quartz and feldspar minerals. The feldspar mineral anorthite was predominate in this group. The presence of zircon was also indicated in this fraction.

Each screen fraction of the non-magnetic material was processed on a superpanner to recover zircon and indicate the presence of free gold. A mineral light was utilized with the superpanner to effect concentration of the zircon. Table 30 shows the recovery and distribution of zircon by screen size. These data show that the non-magnetic material contains 0.4% zircon. This would mean that the total sample would have a zircon content at approximately 0.2%.

Table 29

Sink-Float Analysis High Intensity Magnetic Concentrate, Bristol Bay

Tyler Mesh Passed	Tyler Mesh Retained	Concentrate Weight Grams	Sink Fraction Grams	Float Fraction Grams	Sink Fraction %	Float Fraction %
-	10	37.0	1.2	35.8	3.1	96.9
10	14	103.0	15.8	87.2	15.3	84.7
14	20	234.0	74.9	159.1	32.0	68.0
20	28	823.5	356.6	466.9	43.3	56.7
28	35	432.0	239.8	192.2	55.5	44.5
35	48	1,037.5	740.8	296.7	71.4	28.6
48	65	103.0	73.9	29.1	71.7	28.3
65	100	71.4	54.5	16.9	76.4	23.6
100	150	28.6	20.2	8.4	70.8	29.2
150	Pan	4.5	3.0	1.5	66.6	33.4
Total or Average		2,874.5	1,580.7	1,293.8	55.0	45.0

Table 30

Zircon Distribution, Bristol Bay

Tyler Mesh		Non-Magnetic Fraction Grams	Zircon Recovery Grams	Zircon Distribution %	Weight % of Non-Magnetic Fraction
Passed	Retained				
-	10	134.0	0.0	0.0	0.0
10	14	228.0	0.0	0.0	0.0
14	20	446.0	Trace	0.0	0.0
20	28	1,151.0	3.6	26.9	0.3
28	35	503.5	1.3	9.7	0.3
35	48	677.5	3.9	29.1	0.6
48	65	74.2	2.1	15.7	2.8
65	100	42.5	1.7	12.7	4.3
100	150	22.2	0.8	5.9	3.6
150	Pan	50.5	-	-	-
Total or Average		3,329.4	13.4	100.0	0.4

Gold Distribution

During the process of zircon concentration and recovery, gold was noted in certain size fractions. Surprisingly the gold was fairly coarse for this type of deposit and was concentrated in the minus 20 plus 28 mesh size fraction. Table 31 indicates the distribution of gold and calculates the information to an ounce per ton basis. A value of 0.38 ounces per ton of non-magnetic material or 0.19 ounces per ton of total sample is indicated.

Conclusions

The results of these tests indicate the presence of beach concentrates of heavy minerals. It is unfortunate that a detailed investigation of those samples containing heavier concentrations of magnetite, zircon and gold could not be made. This would have been meaningless, however, without a record indicating from where the sample was obtained.

A composite sample analysis did dilute individual samples that would have shown higher values and therefore pinpoint specific areas that should be investigated further. It is suggested that further sampling would be beneficial, and that the individual samples be marked and the location noted. The presence of gold is noteworthy and would indicate further investigation. Areas containing higher concentrations of magnetite and zircon would be the logical starting points for further sampling.

Table 31

Gold Distribution, Bristol Bay

Tyler Mesh		Gold Recovery Mgs.	Non-Magnetic Fraction Grams	Ounces/Ton Non-Magnetic Fraction
Passed	Retained			
-	10	Nil	134.0	0.00
10	14	Nil	228.0	0.00
14	20	Nil	446.0	0.00
20	28	36.0	1,151.0	0.91
28	35	3.0	503.5	0.17
35	48	2.0	677.5	0.09
48	65	2.0	74.2	0.79
65	100	Trace	42.5	-
100	150	Trace	22.2	-
150	Pan	Trace	50.5	-
Total		43.0	3,329.4	0.38

COOK INLET AREA

Introduction

One sample of approximately 550 pounds was received by the Mineral Industry Research Laboratory of the University of Alaska. This sample was obtained from a submerged sand shoal in the Upper Cook Inlet, 2.9 miles due north of North Point; the most north-easterly point of Fire Island during exposure due to a minus four foot tide. The sample was taken from beneath the area of natural wave concentration and is assumed to be representative of the shoal.

A second sample consisting of 3,730 grams of beach sand was received from the North shore of Cook Inlet in the vicinity of the Tyonek reservation.

For purposes of clarity the samples will be designated Cook Inlet Shoals and Tyonek and will be discussed in that order.

Laboratory Procedure - Cook Inlet Shoals

Three representative samples were obtained from the original sample by means of a Jones Riffle Splitter. A screen analysis of sample one, Table 32, indicates the size distribution of the minus 35 mesh sand in each screen fraction as well as cumulative percentages retained and passing each mesh size. In order to determine the amount of heavy minerals present and recovery that might be expected, the samples were treated by sink-float analysis, gravity concentration, magnetic concentration, electrostatic concentration, and x-ray diffraction analysis. This procedure is illustrated as Figure 9.

Table 32

Screen Analysis, Cook Inlet Shoals

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
	35	9	0.2	0.2	100.0
35	48	706	15.8	16.0	99.8
48	65	2,283	51.2	67.2	84.0
65	100	1,077	24.1	91.3	32.8
100	150	216	4.8	96.1	8.7
150	200	85	1.9	98.0	3.9
200		88	2.0	100.0	2.0
Total		4,464	100.0		

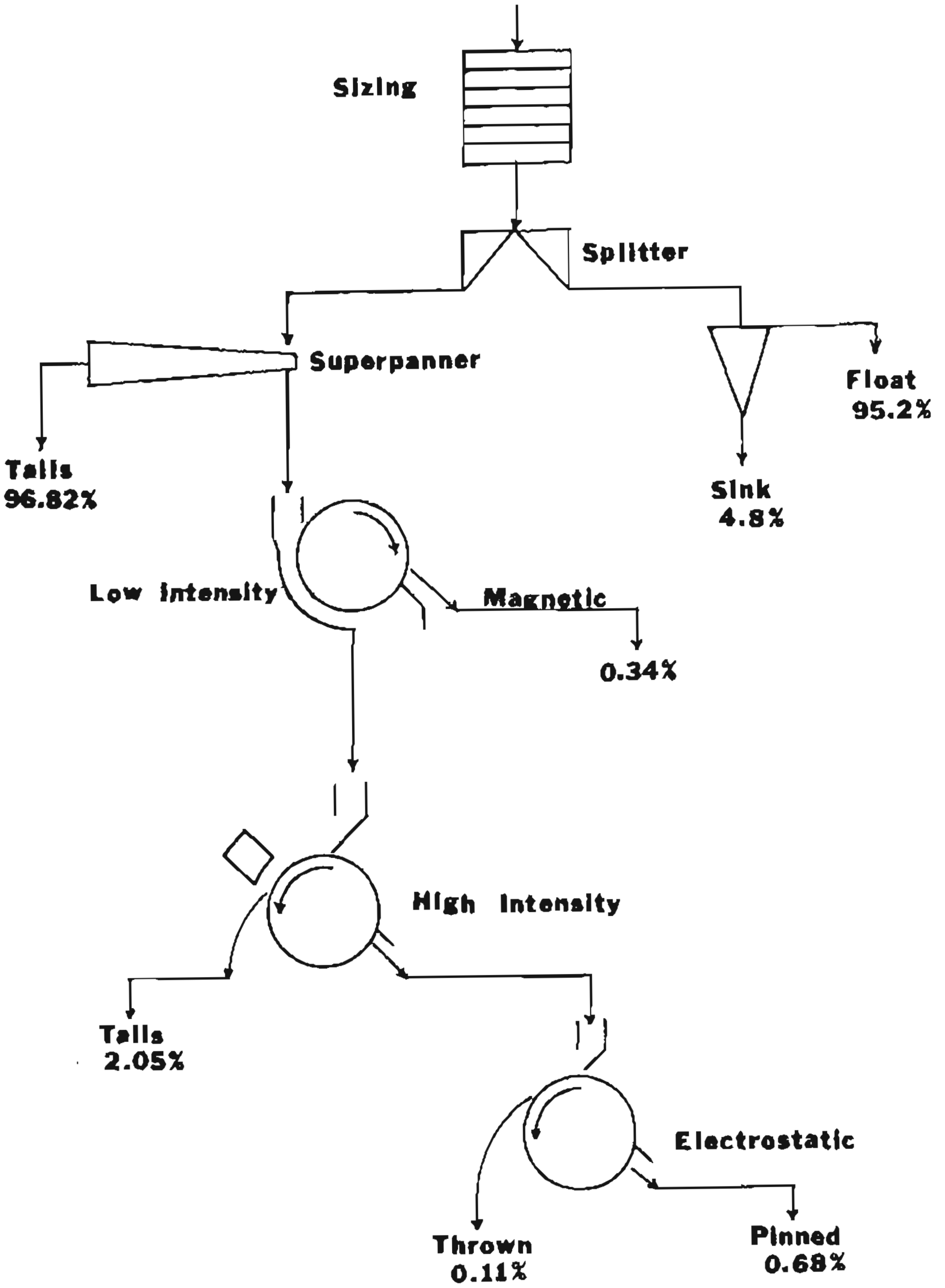
Table 33

Gravity Concentration, Cook Inlet Shoals

Tyler Mesh		Wt. (Grams)	
Passed	Retained	Feed	Concentrate
35	48	661.6	21.2
48	65	2,243.7	52.3
65	100	1,044.0	30.0
100	150	189.5	13.0
150	200	64.8	11.0
200		66.7	8.6
Total		4,270.3	136.1

Figure 9

COOK INLET SHOALS



Gravity Concentration - Cook Inlet Shoals

Sample number one was sized by screening and each size fraction treated as an individual sample. This aided the determination of the amount, type, and distribution of heavy minerals present. Gravity concentration was effected by a superpanner, no effort being made to produce a clean magnetite-ilmenite concentrate. This procedure insured maximum recovery of the heavy mineral concentrate. A ratio of concentration of 31.4 was obtained, indicating that 31.4 tons of sand would have to be mined to produce one ton of this concentrate. The concentration results are tabulated in Table 33.

Sink-Float Analysis - Cook Inlet Shoals

A small portion of each size fraction was split for sink-float analysis prior to gravity concentration. This procedure indicates the theoretical amount recoverable to gravity concentration and the amount of heavy mineral present. The samples were separated at a specific gravity of 2.96 using tetrabromoethane as the heavy liquid.

Analysis by x-ray diffraction indicated that the sink product, 4.76% by weight, was composed of principally magnetite, ilmenite, pyroxene and other rock forming minerals.

The results of the analysis, Table 34, indicate that the heavy minerals are concentrated in the finer size ranges. As an example, 97.73% of the heavy minerals are finer than 48 mesh.

Magnetic Separation - Cook Inlet Shoals

The distribution of magnetite was determined by processing each gravity

Table 34

Sink-Float Analysis, Cook Inlet Shoals

Tyler Mesh		Wt. Float Grams	Wt. % Float	Wt. Sink Grams	Wt. % Sink	Cumulative Wt. % Float		Cumulative Wt. % Sink	
Passed	Retained					Retained	Passed	Retained	Passed
35	48	44.2	25.13	0.2	2.27	25.13	100.00	2.27	100.00
48	65	39.1	22.22	0.2	2.27	47.35	78.87	4.54	97.73
65	100	32.5	18.48	0.5	5.68	65.83	52.65	10.22	95.46
100	150	22.7	12.91	3.8	43.18	78.74	34.17	53.40	89.78
150	200	16.2	9.21	4.0	45.45	87.95	21.26	98.85	46.60
200	-	21.2	12.05	0.1	1.15	100.00	12.05	100.00	1.15
Total		175.9	100.00	8.8	100.00				

concentrate through a Carpco Low Intensity Magnetic Separator. This separator operated at a field of 345 gauss utilizing rotating permanent magnets to concentrate ferromagnetic particles.

The recovery of magnetite, Table 35, indicates that the magnetite is concentrated in the minus 48 mesh fraction with 97.95% being finer than 65 mesh.

Distribution of ilmenite was determined by processing the tailings from low intensity separation through a Carpco High Intensity Magnetic Separator. Concentration was produced by the attraction of paramagnetics to a rotating induced roll operated at a field of 3,460 gauss with a ¼" air gap between the poles.

A bulk paramagnetic concentrate containing ilmenite, pyroxene and other iron containing silicate minerals was produced. This enabled more efficient concentration of the ilmenite by electrostatic separation. The tailings (diamagnetic particles) were composed primarily of quartz with minor amounts of zircon.

Electrostatic Separation - Cook Inlet Shoals

The concentrates from high intensity magnetic separation were treated by a Carpco High Tension Electrostatic Separator. Concentration is effected due to differences in the conductive capabilities of minerals when passed through an electric field. Good conductors are thrown from a rotating roll with in the field and poor conductors such as the silicates are pinned to the roll. Results from this analysis, Table 36, show that 97.87% of the ilmenite is contained in the minus 65 mesh fraction with 87.23% being finer than 100 mesh; 76.59% of this contained in the 100/200 mesh fraction.

Table 35

Magnetite Distribution, Cook Inlet Shoals

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
35	48	0.1	0.68	0.68	100.00
48	65	0.2	1.37	2.05	99.32
65	100	1.0	6.85	8.90	97.95
100	150	6.8	46.58	55.48	91.10
150	200	5.1	34.93	90.41	44.52
200		1.4	9.59	100.00	9.59
Total		14.6	100.00		

Table 36

Ilmenite Distribution, Cook Inlet Shoals

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
35	48	0.0	0.00	0.00	100.00
48	65	0.1	2.13	2.13	100.00
65	100	0.5	10.64	12.77	97.87
100	150	2.0	42.55	55.32	87.23
150	200	1.6	34.04	89.36	44.68
200		0.5	10.64	100.00	10.64
Total		4.7	100.00		

Bulk Sample Tests - Cook Inlet Shoals

As a check on the laboratory results, two bulk tests were split from the remaining sand, and designated as samples two and three. Sample two, 8,285.5 grams, was processed in the same manner as the laboratory sample except that gravity concentration was effected by a Wilfley Table instead of by a Superpanner. The ilmenite concentrate was produced by selective high intensity magnetic concentration instead of by electrostatic concentration. Sample three, 199.62 pounds, was processed as a check on the two smaller samples; was concentrated on the Wilfley Table and processed in the same manner as sample one. Flowsheets of these tests are shown as Figure 10 and 11 respectively.

The results are tabulated as follows:

Sample Two

Unit	Feed Grams	Concentrate Grams	Tailings Grams	Ratio of Concentration
Table	8,285.5	582.0	7,703.5	14.24
Low Intensity Magnetic	582.0	32.0	550.0	18.19
High Intensity Magnetic	550.0	11.3	538.7	48.67

Sample Three

Unit	Feed (lbs.)	Concentrate (lbs.)	Tailings (lbs.)	Ratio of Concentration
Table	199.62	20.81	178.81	9.59
Low Intensity Magnetic	20.81	0.75	20.06	27.75
High Intensity Magnetic	20.06	9.62	10.44	2.08
Electrostatic	9.62	0.37	9.06	25.65

Figure 10

COOK INLET SHOALS

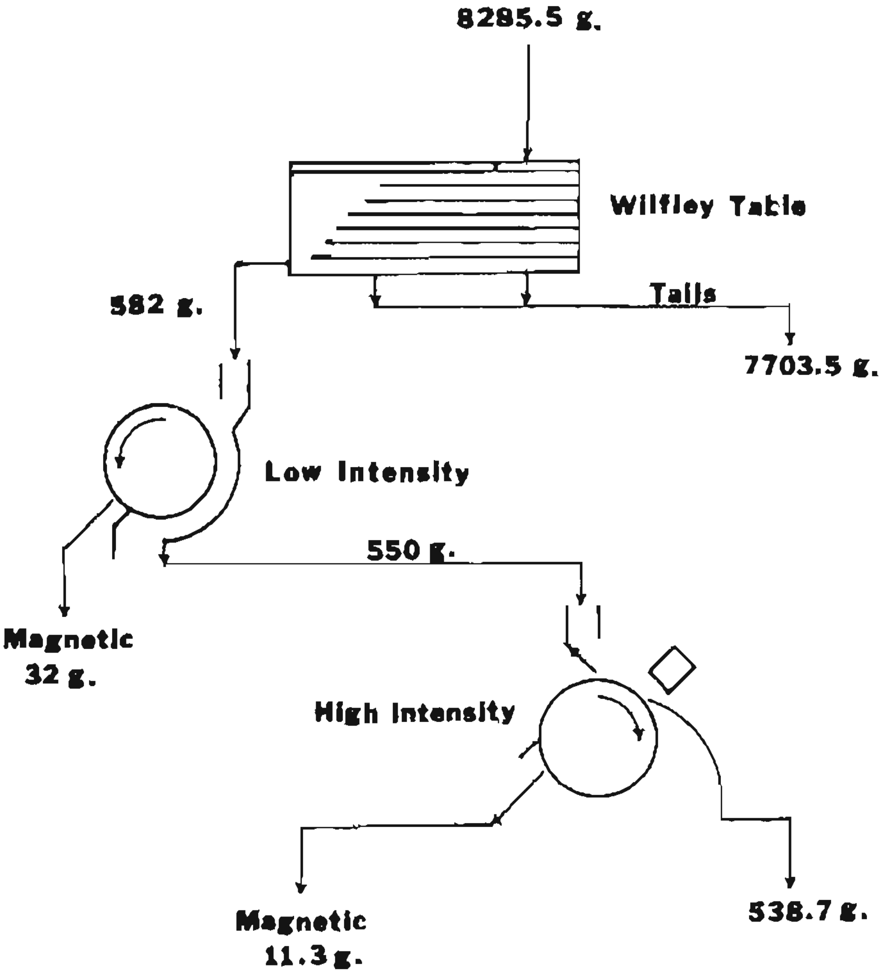
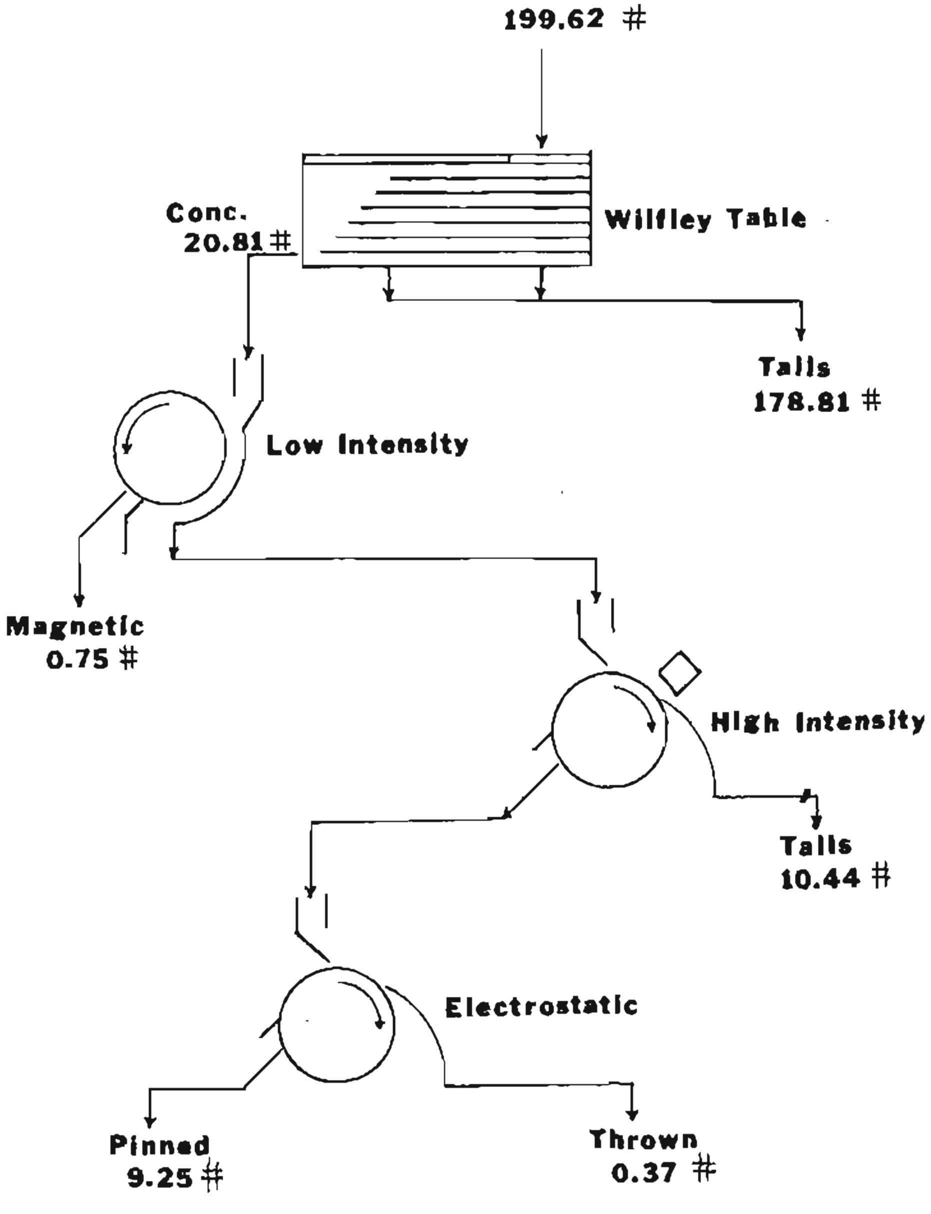


Figure 11

COOK INLET SHOALS



Conclusions - Cook Inlet Shoals

The tests conducted on individual size fractions indicate that the heavy minerals present are concentrated in the minus 48 mesh fraction. They may conveniently be recovered by a combination of sizing, gravity, magnetic and electrostatic concentration. The amount of heavy minerals present is, however, to low to be of any economic significance at the present time. The sands contain 15.9 pounds of magnetite and 5.2 pounds of ilmenite on a cubic yard basis.

The results of both bulk tests were comparable to those obtained by the small scale laboratory tests. Each of the fractions were checked for equivalent uranium, resulting in trace amounts only. A tabulation of test results is listed below:

Test	% Magnetite	% Ilmenite
Sample One	0.34	0.11
Sample Two	0.33	0.14
Sample Three	0.28	0.12

Laboratory Procedure - Tyonek

The sample, as received, represented a good wave concentration. It was, therefore, not necessary to use gravity techniques prior to further concentration of the constituents present. A screen analysis, Table 37, indicates the size distribution of the minus 35 mesh in each screen fraction, as well as, the cumulative percentages retained and passing each mesh size. In order to determine the amount and type of heavy minerals present and the recovery that might be expected, the samples were treated by magnetic and electrostatic concentration, as shown in

Table 37

Screen Analysis, Tyonek

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
	35	165.0	4.44	4.44	100.00
35	48	421.5	11.33	15.77	95.56
48	65	1,225.7	32.95	48.72	84.23
65	100	1,185.0	31.86	80.58	51.28
100	150	630.0	16.94	97.52	19.42
150	200	91.5	2.46	99.98	2.48
200		1.0	.02	100.00	.02
Total		3,719.7	100.00		

Figure 12.

Magnetic Separation - Tyonek

The distribution of magnetite, Table 38, was determined by processing each screen fraction through a Carpo Low Intensity Magnetic Separator. This separator operated at a field of 345 gauss utilizing rotating permanent magnets to concentrate ferro-magnetic particles. The average grade of the 105.5 grams magnetite recovered was 61.0% iron, indicating that the sample contained 1.49% iron as received, or 2.44% magnetite. Of this, 99.05% is concentrated in the 48 mesh fraction with 90.04% being finer than 65 mesh.

Distribution of ilmentite was determined by processing the tailings from low intensity separation through a Carpo High Intensity induced roll. Paramagnetics, including ilmenite, were attracted to the induced roll which was operated at a field of 3,460 gauss with a $\frac{1}{4}$" air gap between the poles.

Electrostatic Separation - Tyonek

The concentrates from high intensity magnetic separation were processed through a Carpo High Tension Electrostatic Separator. Concentration is effected due to differences in the conductive capabilities of minerals when passed through an electric field. Results from this analysis, Table 39, show that 99.80% of the ilmenite is contained in the minus 48 mesh fraction with 98.40% being finer than 65 mesh. The majority of the ilmenite 87.00% passes the 65 mesh seive and is retained on the 150 mesh seive.

Figure 12

TYONEK

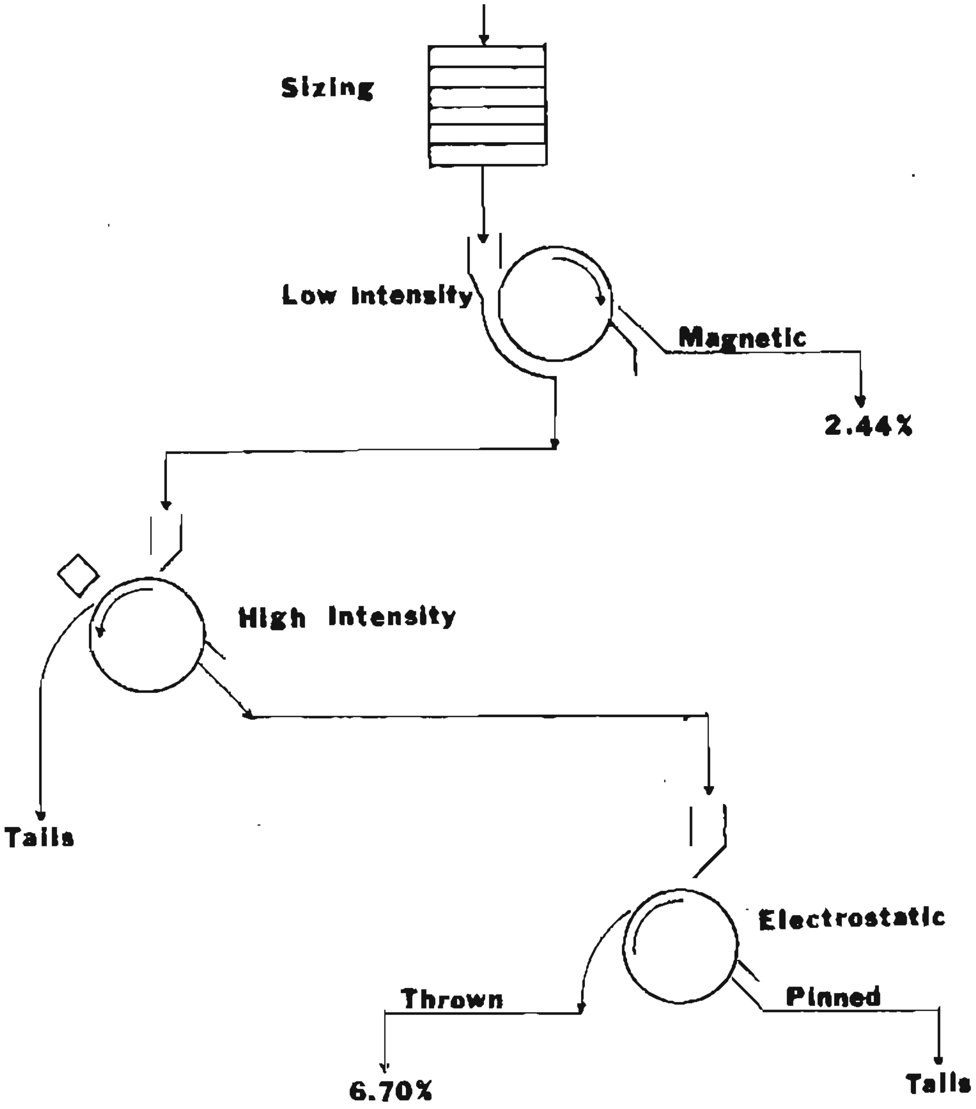


Table 38

Magnetite Distribution, Tyonek

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
	35	0.0	0.0	0.00	100.00
35	48	1.0	0.95	0.95	100.00
48	65	9.5	9.01	9.96	99.05
65	100	21.6	20.49	30.45	90.04
100	150	51.8	49.15	79.60	69.55
150	200	21.5	20.40	100.00	20.40
200		0.0	0.00		
Total		105.4	100.00		

Table 39

Ilmenite Distribution, Tyonek

Tyler Mesh		Weight	Weight	Cumulative Weight %	
Passed	Retained	Grams	%	Retained	Passed
	35	0.0	0.00	0.00	100.00
35	48	0.5	0.20	0.20	100.00
48	65	12.5	5.00	5.20	99.80
65	100	66.5	26.60	31.80	98.40
100	150	151.0	60.40	92.20	68.20
150	200	19.5	7.80	100.00	7.80
200		0.0	0.00	100.00	0.00
Total		250.0	100.00		

Conclusions - Tyonek

The tests conducted indicate that the principle potentially valuable minerals present are magnetite, ilmenite and zircon. These minerals are present in the 48 x 0 mesh fraction and may be conveniently recovered by a combination of sizing and dry magnetic and electrostatic methods. The mineral euxenite, a source of columbium, tantalum and thorium, was found in minor amounts. The principle constituents are tabulated below on the basis of weight percent per cubic yard of sand.

Heavy Mineral Content

	Weight %	Lbs. Per Yard^3
Ilmenite	6.70	411.5
Zircon	0.60	36.8
Magnetite	2.44	149.9

SUMMARY AND CONCLUSIONS

The Mineral Industry Research Laboratory, University of Alaska, has aided individuals in the evaluation of the mineral constituents of beach sand samples taken from the Nome, Bristol Bay, Cook Inlet, Gulf of Alaska, and Southeastern Alaska areas. These samples, with the exception of those taken at Yakataga, have not represented sampling programs with the purpose of delineating reserves, consequently, the results must be viewed with this in mind. The Yakataga samples, although more systematic in covering a broader area, were taken by hand methods and, consequently, did not give the desired information as to depth of sands and a true evaluation per unit of volume.

Deposits of this type are difficult to evaluate because the minerals are in a liberated state and the somewhat eratic forces of nature have worked and reworked them in the processes of transportation and reconcentration by wave and current action along the shoreline. Consequently, the deposits may vary in composition and extend within comparatively narrow boundaries. The result is a non-homogeneous deposit that requires a careful and systematic sampling procedure to evaluate its economic potential.

On the other hand, the conditions which lead to difficulty in evaluation make the deposits attractive from mining and beneficiation viewpoints. The valuable minerals have been liberated by the forces of nature and the expense of crushing and grinding is eliminated. A degree of sizing and concentration has also been accomplished and a substantial amount of the coarser material can be immediately eliminated as containing no valuable mineral constituents.

The mineral compositions of these deposits are similar in that they contain those minerals that are hard and resistant to weathering. Because of the sorting and concentrating actions they have been subjected to the heavier minerals such as magnetite, ilmenite, zircon, rutile, chromite, garnet and precious metals, gold and platinum are found predominantly in the minus 28 mesh size fractions.

Beach deposits along the Gulf of Alaska have been worked erratically for their precious metal content since prior to the turn of the century, but only in the early part of this period when deposits were mined in the vicinities of Yakataga and Lituya Bay has ther been any record of production.

Other beach areas have been prospected for gold, and substantial amounts of this precious metal have been produced from the Nome beaches of the Seward Peninsula. The gold and platinum in these deposits usually occur in fine, thin scales that are difficult to save in conventional gold recovery systems. The particles may also have a tarnished surface which makes amalgamation difficult. These problems have contributed to the spasmodic manner in which these deposits have been prospected and worked over the years for their precious metal content.

Interest in mineral constituents other than the precious metals has been either slight or entirely neglected. In most cases their presence was a source of aggravation to prospectors and operators, because the high specific gravity of these minerals caused interference with recovery of gold values. However, if a stable and profitable industry is to be developed by exploiting the submerged and exposed beach deposits, it must be based on the total content of minerals having economic value. This must include both the present and the foreseeable future demands for the minerals recovered.

A careful and systematic study of Alaska's submerged and exposed beach placers are needed to evaluate the potential of these deposits. Four general areas of consideration are suggested to give the desired information: (1) Development of improved sampling techniques to guarantee accurate appraisal of overall deposit grade; (2) analysis of mining systems best suited for both submerged and exposed deposits; (3) concentration of valuable minerals to eliminate waste and separation of concentrate into its various constituents; and (4) economic studies of mining, processing, transportation and marketing aspects.

Because these deposits are not homogeneous and the mineral constituents are in a liberated form, samples should be taken at fairly close intervals by a coring method that will give reliable information concerning the volume measured. Analysis of gold and other minerals should not be by a method that involves taking a further representative sample containing a representative portion of all liberated constituents. The total core sample is more appropriately separated into its individual mineral components by a combination of screening, magnetic, electrostatic and gravity processes. This is a more lengthly procedure, but gives more reliable results for evaluation purposes.

As submerged and exposed shoreline placers of economic value may be contiguous, considerations for mining systems should involve both possibilities. This would probably mean a floating dredge of either suction or bucket type in which a separation by size or a rough concentrate could be made on the floating plant. By economic necessity this would probably involve a dredge capable of handling thousands of cubic yards of sand per day. Considerations involving stormy weather and high seas would be necessary in design and operating functions of this type of unit.

The recovery of valuable minerals from a deposit will normally involve a flowsheet designed for the particular minerals and gangue material present and processing can, therefore, vary drastically from one type of deposit to another. As the mineral constituents of beach sand deposits are quite similar, varying mainly in grade of valuable constituents and particle size, it is possible to design a flowsheet suitable for many deposits. This can be accomplished with only minor variations in design.

Primary sizing of the original material in the area of 28 mesh will result in a large percentage of the sand being discarded as waste material containing no valuable mineral commodities. This can be accomplished on the dredge followed by a rougher concentration of heavy minerals containing precious metals. As heavy minerals usually amount to from 3-10% of the total sand content these processes can result in a concentration ratio in the neighborhood of 20:1.

As some sand deposits contain fine gold not ameanable to gravity or amalgamation processes consideration may have to be given to an initial flotation step for the recovery of precious metals. This can then be followed by a conventional gravity process for the recovery of associated heavy minerals such as ilmenite, zircon, monazite, magnetite, rutile, chromite, cassiterite, etc.

Most heavy minerals in these types of deposits can be readily recovered by processes that utilize the magnetic and electrical properties of the minerals. However, this must be proceded by drying the gravity concentrate prior to processing.

It is extremely doubtful that each individual sand deposit would warrant the capital expenditure necessary for erection of a dry processing plant. One centrally located plant could, however, serve to process wet concentrates from many locations along the coastline. Abundance of natural gas in the Cook Inlet area makes this a natural location for drying concentrates with water transportation available for shipping products to and from the dry plant. Figures 13 and 14 illustrate generalized flowsheets for the separation of minerals typical of beach sand deposits.

Analysis of the economic aspects of transportation, mining, processing and world markets for individual mineral constituents is of vital importance in determining the feasibility of working deposits of this nature. Studies of this type can be accomplished either after tenor of deposits have been established or it is possible, knowing mineral associations and market conditions, to project a necessary grade and magnitude for profitable exploitation.

The past few years has shown increasing interest in alluvial mineral deposits along the Alaska coastline as evidenced by the number of prospecting permite and mineral leases issued by the State Division of Lands. At the time of this writing, 1,539 prospecting permits covering 3,521,826 acres and 8 leases covering 27,405 acres are in effect. These permits and leases are located in the general areas of Seward Peninsula, Kotzebue Sound, Norton Sound, Norton Bay, Goodnews Bay, Cook Inlet, Kodiak, Yakataga and Icy Bay.

Unfortunately, with some exceptions, these permits and leases may not be productive due to the high cost of accurately evaluating their potential as mineral deposits. Continued studies concerning methods of evaluation, mining, processing and marketing are needed before the potential of these reserves can be determined.

Figure 13

GENERAL FLOWSHEET WET PLANT

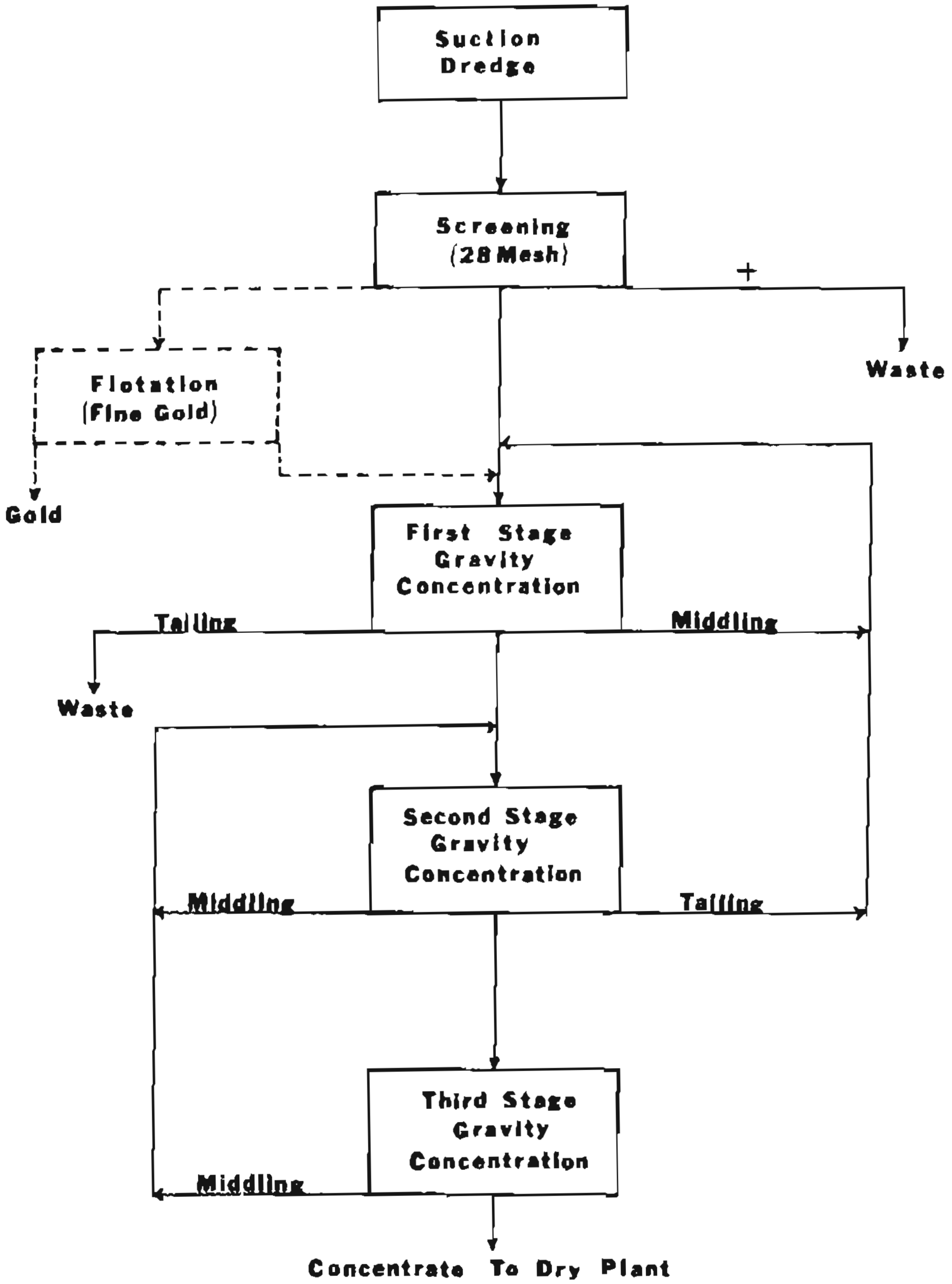
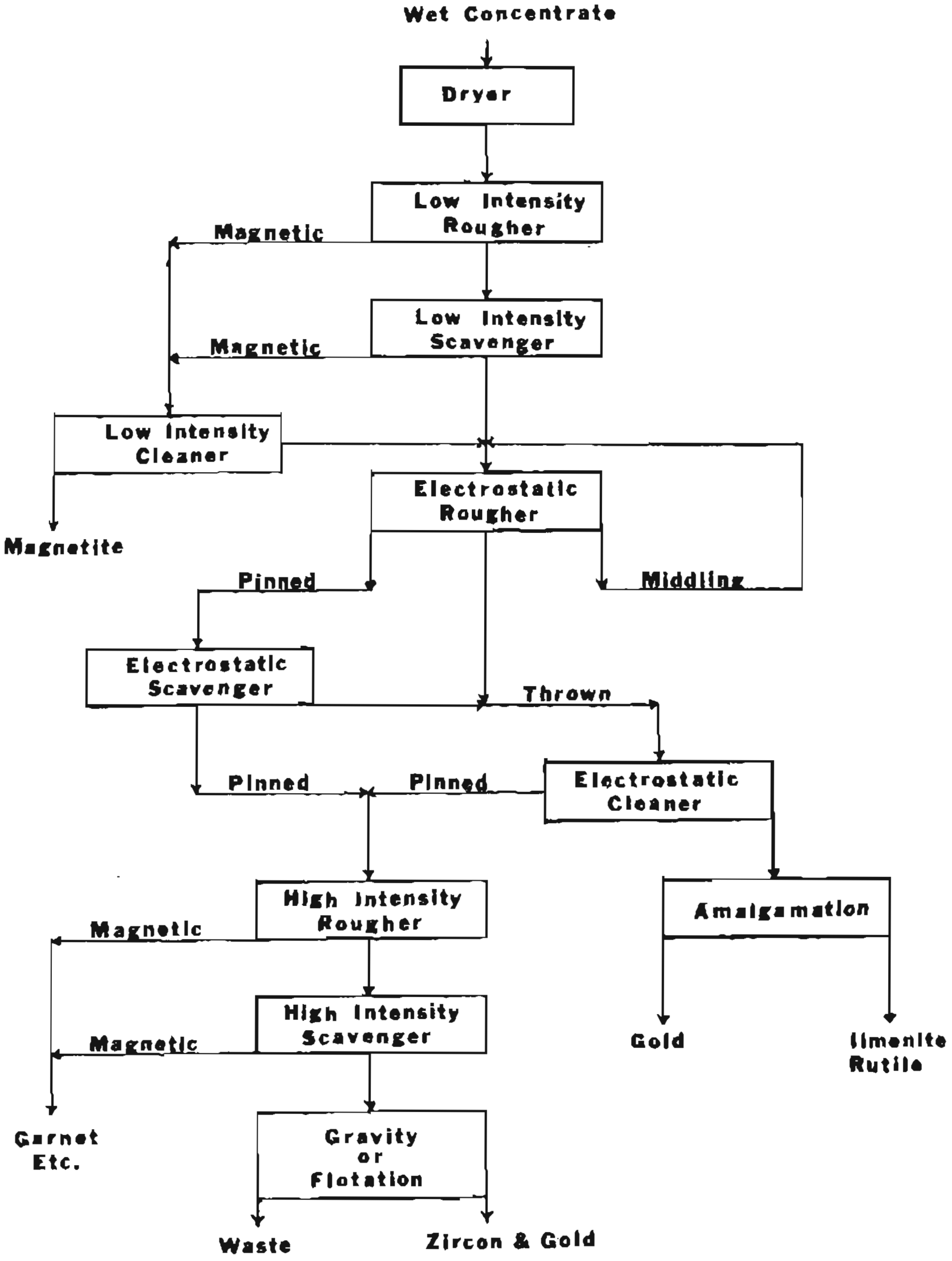


Figure 14

GENERAL FLOWSHEET DRY PLANT



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