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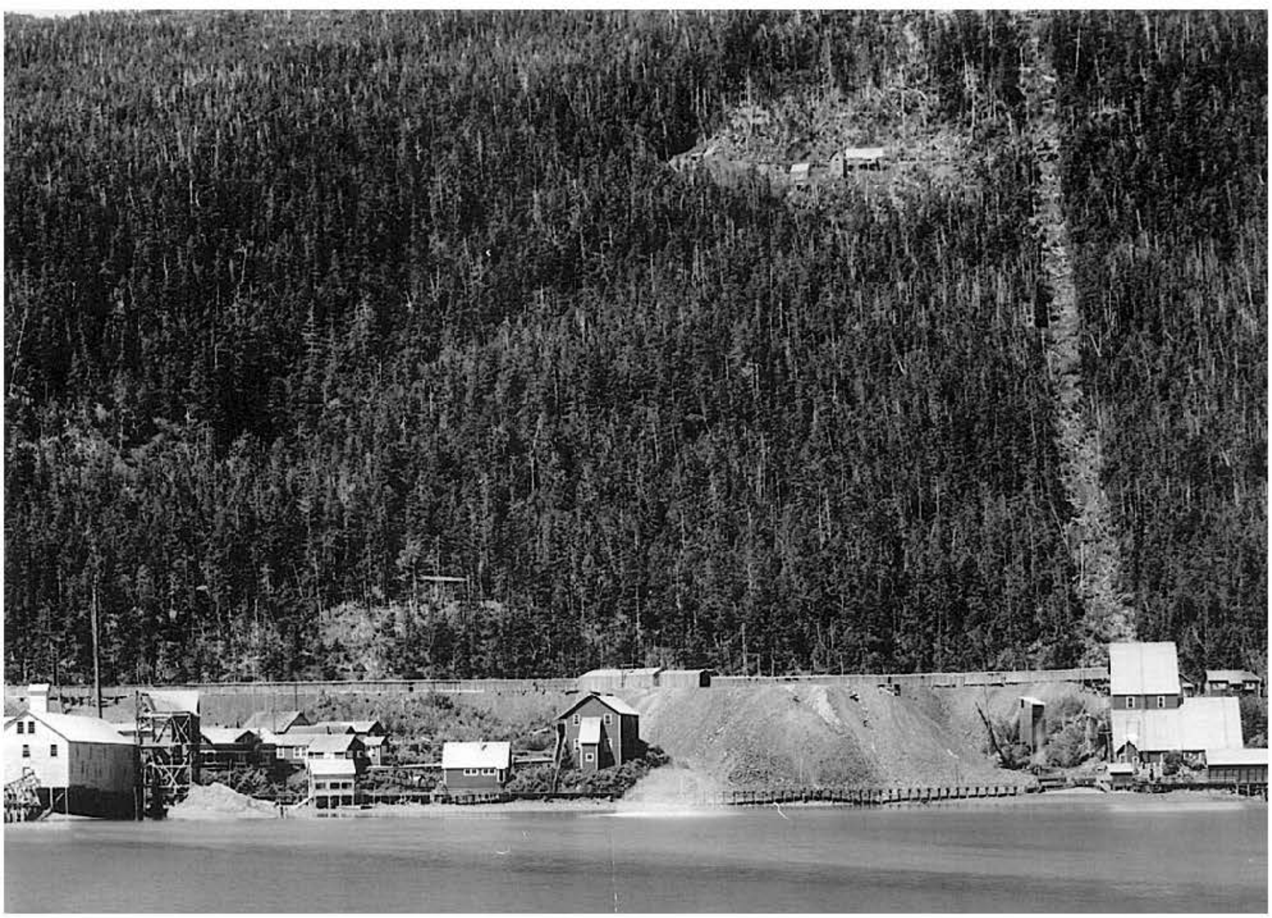
Economic Feasibility of Mining in the Chichagof and Baranof Islands Area, Southeast Alaska

James R. Coldwell



Author

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Cover Photo

Chichagof Mine, circa 1930, photograph by E. Andrews. From 1906-1942, the Chichagof Mine produced about 20,500 kg of gold from over 540,000 mt of ore. The mine closed in 1942 due to shortages of men and equipment created by World War II.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter
dpy	days per year
g	gram
g/mt	gram per metric ton
kg	kilogram
km	kilometer
lb	pound
m	meter
Mmt	million metric tons
mt	metric ton
mtpd	metric tons per day
mtpy	metric tons per year
ppm	parts per million
st	short ton
tr oz	troy ounce
yrs	years

METRIC TO ENGLISH CONVERSIONS

From	Multiply by	To
g/mt (= ppm)	0.02917	ounces/short ton
kg	2.2046	pounds
mt	1.1023	short tons
m	3.2808	feet
km	0.6214	miles
m^3	1.3080	cubic yards

Temperature conversion centigrade to fahrenheit:

$(^{o}C \times 9/5) + 32 = ^{o}F$

ECONOMIC FEASIBILITY OF MINING IN THE CHICHAGOF AND BARANOF ISLANDS AREA, SOUTHEAST ALASKA

by James R. Coldwell[1]

ABSTRACT

Mining and processing cost analyses were conducted on magmatic segregation and low sulfide vein gold deposit types that may be found in the Chichagof and Baranof Islands Area. Resources and recoverable metal values (RMV) needed to make these deposits economically viable were modeled. Methods for estimating ore grades and required RMV are presented.

Economic modeling for magmatic segregation deposits indicated the RMV necessary for a 15% Discounted Cash-Flow Rate-Of-Return (DCFROR) for a surface mine with an on-site mill ranged from $61/mt for a 5,051 mtpd operation to $236/mt for a 631 mtpd operation. A surface mine using off-site processing at an existing mill located near Hyder, Alaska would require an RMV of $148/mt for a 5,051 mtpd operation to $261/mt for a 631 mtpd operation. Off-site milling was more costly than on-site milling.

Economic modeling for low sulfide vein gold deposits indicated the RMV necessary for a 15% DCFROR for an underground shrinkage stoping mine, off-site milling operation ranged from $219/mt at 643 mtpd to $653/mt at 80 mtpd, and from $181/mt at 643 mtpd to $828/mt at 80 mtpd for an on-site milling operation. Off-site milling was less costly than on-site milling until production exceeded approximately 300 mtpd. Then, economies of scale reduced operating costs enough to offset the higher capital costs required for on-site milling.

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INTRODUCTION

This report is one of a series produced in conjunction with the BLM's ongoing mineral assessment program. A mineral assessment includes surveying, mapping, and sampling historic mines, prospects, and occurrences as well as reconnaissance investigations of prospective mineralized areas. The main objective is to determine the type, amount, and distribution of mineral deposits, which assists in evaluating the area's mineral development potential.

Economic prefeasibility studies were conducted on typical mineral deposit types that are found in the Chichagof and Baranof Islands Area. Two factors were addressed in this study: (1) the magnitude of resource that would have to exist, and (2) the recoverable metal value (RMV) that would be necessary to make a deposit economically feasible to mine. The RMV is the combined dollar value of all salable products from a given mineral deposit expressed in $/mt, and is equal to the amount of revenues required before all expenses including royalties, mining and milling capital and operating costs, off-site transportation costs, base smelting charges, and taxes are deducted. The interrelation between these factors is shown in tabular and graphical form.

In order to make these economic assessments for the magmatic segregation and low sulfide vein gold deposit types, existing mineral deposit information was used whenever possible. Mineral deposit grades and supporting background information were furnished by the BLM's Mineral Assessment personnel. Additional information was retrieved from the Minerals Availability System (MAS) database. Results of field work and analytical results from the 1995-96 investigations of the Chichagof and Baranof Islands Area were published in two open-file reports (4,9).

Detailed deposit characteristics such as depth, thickness, orientation, and volume have not been determined for the partially explored deposits used as examples in this study, so assumptions were made. These assumptions are discussed at the beginning of each deposit characteristics section.

Location and Access

The following descriptions of location and access, and land status were modified from Maas, Bittenbender, and Still (9). The study area consists of the land area west of Chatham Strait and south of Icy Strait, and includes Inian, Lemesurier, Yakobi, Chichagof, Baranof, Kruzof and the smaller islands scattered along the Pacific coast (fig. 1). This area is depicted on parts of the 1:250,000-scale USGS quadrangle maps for Mt. Fairweather, Juneau, Sitka, and Port Alexander. Population centers in the district include the City and Borough of Sitka, the city of Hoonah, and Tenakee Springs, Pelican, Elfin Cove, Baranof, and Port Alexander.

The area is characterized by rugged topography with peaks in excess of 1,400 m high. The steep terrain inhibits foot access in most cases. Numerous inlets and bays cut through the area providing rock exposure along shorelines that can be accessed by boat. Extensive logging-road networks traverse the northeastern portion of Chichagof Island and can be accessed from Hoonah and are located on Forest Service and Native Corporation land. Logging roads also provide access to the Sitkoh Bay-Basket Bay areas. A short paved-road network surrounds Sitka proper. The Alaska Marine Highway System (ferry) provides service to Sitka, Hoonah, Tenakee, and Pelican. Fixed-wing and helicopter support can be obtained from Sitka. Sitka is the largest population center in the district and offers some supplies and services. Juneau can also be used for logistical support.

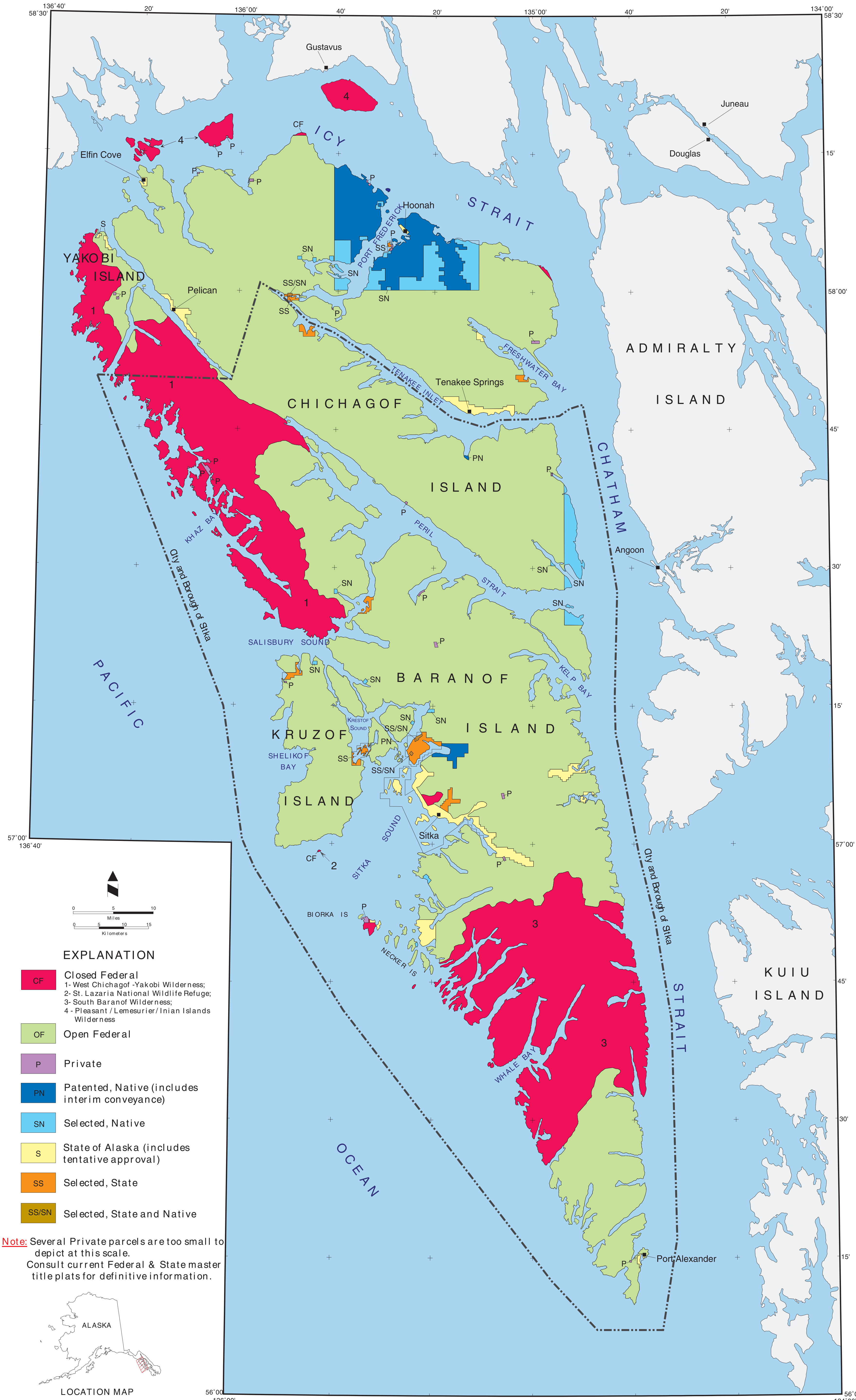


Figure 2. - Generalized land status map (Maas and others, 1996)

Land Status

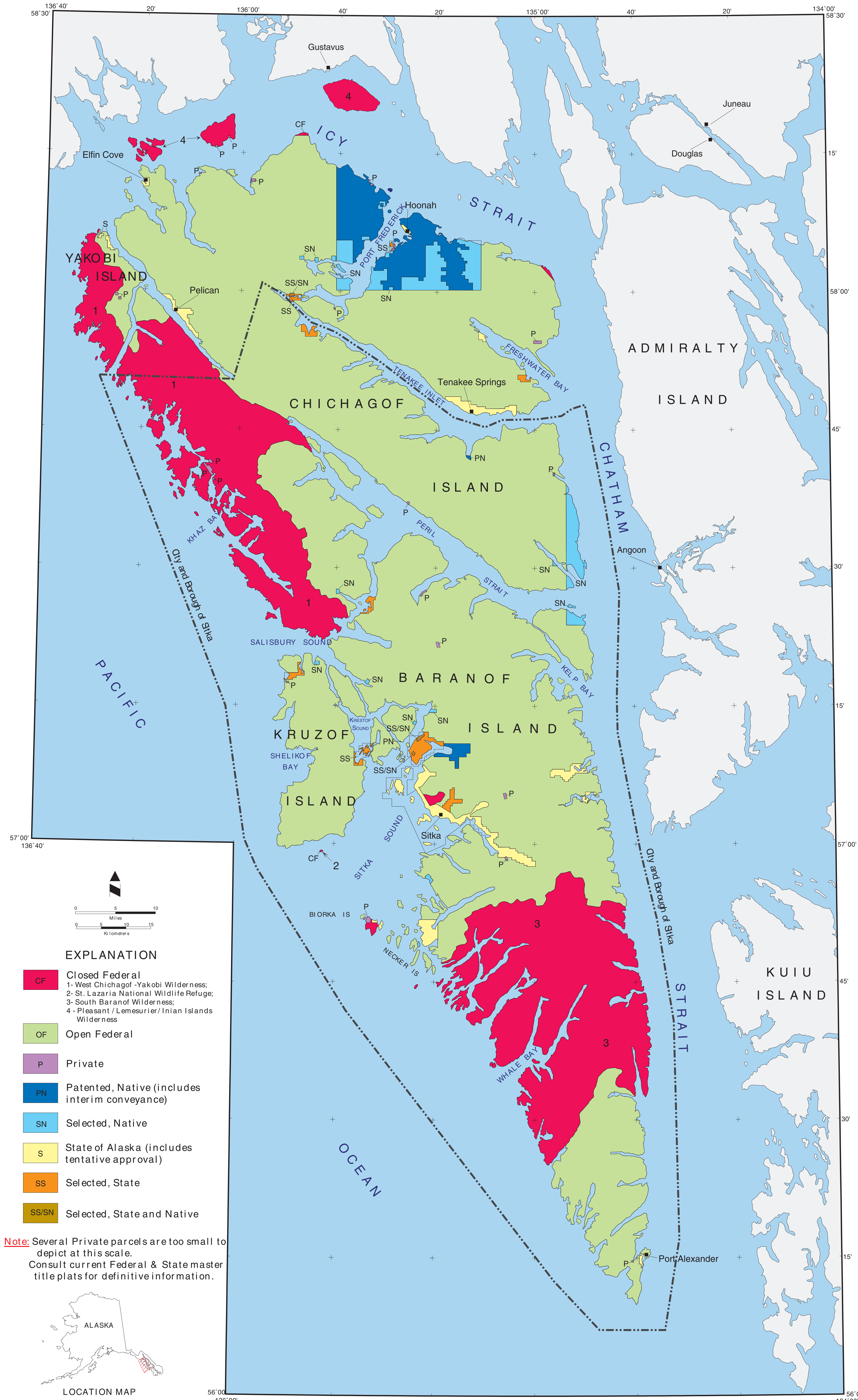
Land management responsibilities in the study area are divided among the Forest Service, Native regional and village corporations, the State of Alaska, and private entities (fig. 2). Most of the land on Baranof Island and the adjacent islands is administered by the Forest Service and is open to mineral location and development. Several lakes on the east side of Baranof Island, including Baranof, Kasnyku, Carbon, Antipatr, Deer and Betty Lakes, have been withdrawn as potential power sites. This classification does not preclude mineral entry, but there may be specific restrictions placed on mining-related activities due to this classification. The townsite of Port Alexander is an exclusion within the City and Borough of Sitka boundary. A large portion of Baranof Island (127,000 hectares) is included within the South Baranof Wilderness created by the Alaska National Interest Lands Conservation Act (ANILCA). St. Lazaria National Wildlife Refuge, a small island managed by the Fish and Wildlife Service, is located south of Kruzof Island. Both wilderness parcels are closed to mineral entry, subject to valid existing rights. A small parcel of land north of Sitka proper is included within an enacted municipal watershed classification (PL 78-262) that precludes mineral entry.

A large portion of Chichagof Island is managed by the Forest Service and is open to mineral exploration and development. However, significant acreage has been designated as LUD II by the Tongass Land Management Plan and subsequent updates resulting from ANILCA and the Tongass Timber Reform Act. This designation restricts certain activities and provides for the area to be managed in a roadless state for most uses. Roads supporting mineral exploration and development activities in LUD II designated areas may be allowable as specifically authorized uses. The West Chichagof/Yakobi Wilderness occupies over 107,000 hectares on West Chichagof and Yakobi Islands, and is closed to mineral location and development, subject to valid existing rights. The newly created Pleasant/Inian/Lemesurier Islands Wilderness is also closed to mineral entry, subject to valid existing rights.

The Hoonah-Totem Village Corporation owns a large tract of land on northeastern Chichagof Island, centered around Hoonah and adjacent to Port Frederick. Mineral rights on this native corporation land are managed by Sealaska Corporation, the Native regional corporation for Southeast Alaska. Sealaska also has title to several parcels of subsurface estate in the same general vicinity. Several parcels in this area are still in selection status. Shee-Atika Corporation owns land on Alice and Charcoal Islands as well as a small parcel in Katlian Bay. Kootznoowoo Corporation has selected land along Chatham Strait from Little Basket Bay south to Point Thatcher. Most Native corporation lands are available for mineral exploration and development as long as this use does not conflict with traditional, cultural, and subsistence uses. Lease arrangements must be made with the appropriate Native corporations prior to any activity.

State and municipal land is found adjacent to Sitka, Tenakee Springs, Pelican, and Port Alexander. Other small conveyances are scattered throughout the west half of the study area. The City and Borough of Sitka developed a draft comprehensive plan for lands within its jurisdiction in February, 1995. A general provision affecting the mining industry states, "any uses that can potentially degrade the natural habitat will be reviewed and monitored on a case-by-case basis (5)." Users are encouraged to provide information to the Borough very early in the permitting process.

Figure 2. - Generalized land status map (Maas and others, 1996)



Active mining claims and patented claims are present within the study area. Patented mining claims are present in the following locations: 1) Lemesurier Island, 2) in Bohemia Basin, 3) in Kimsham Cove - Hirst-Chichagof Mine, 4) in Klag Bay - Chichagof Mine, 5) Iyoukeen Cove at Gypsum, 6) at Rodman Bay, 7) in Silver Bay - Stewart Mine, and 8) in Pande Basin. Ownership information for these claims can be obtained from the assessors office in Sitka. Records for unpatented claims are kept by the BLM and are available at the Forest Service offices in Sitka and Juneau, and the BLM offices in Anchorage and Juneau.

Private parcels are scattered throughout the study area but most are too small to depict at the scale of figure 2. Consult the Forest Service, BLM or State of Alaska to obtain more precise, up-to-date information on these parcels.

Environmental and Socioeconomic Issues

This preliminary study does not address environmental and socioeconomic concerns in a direct manner. For each model the acquisition cost represents the cost of mine permitting activities, environmental studies such as baseline data collection, water quality sampling and monitoring, wildlife studies, preparation of permit applications to the required local, State, and Federal agencies and other related activities. Environmental issues that may arise during the course of mineral development in Southeast Alaska may include but are not limited to potential land status conflicts, impacts on recreational opportunities, fishery habitat, water quality, marine environment, technical and economic feasibility, and regional population centers (23).

Socioeconomic concerns may include but are not limited to potential impacts on the population (e.g. population increase, movement, or relocation in response to the project), public services and facilities, housing supply, employment, education (e.g. student population increase), local, state and Federal tax revenues and expenditures, transportation, and quality of life (3).

Mitigation measures and associated costs developed during the permitting process are unique for each mineral development project. It is difficult to estimate these costs without benefit of public scoping and at least a preliminary environmental and socioeconomic assessment for the proposed mineral development project. These issues and the associated costs of mitigation are beyond the scope of this preliminary study, and are not addressed in the economic models.

ECONOMIC MINE PREFEASIBILITY STUDIES

Economic prefeasibility studies for two mineral deposits types were conducted to establish the recoverable metal value (RMV) per metric ton necessary to meet a 15% discounted-cash-flow rate-of-return (DCFROR). The definition of RMV as given by Baggs and Sherman in previous U.S. Bureau of Mines (USBM) feasibility studies was used (1,13).

The RMV is the combined dollar value of all salable products from a given mineral deposit expressed in $/mt. The RMV was used to reduce the individual effects of commodity grades, recoveries, and metal prices to a common base so that a single curve relating ore value of the deposit to DCFROR could be created. See Appendix B for further information and a sample calculation of RMV.

This pre-feasibility report considers a number of factors controlling the feasibility of mineral development including physical attributes and geographic location of the deposit, metallurgical attributes of the minerals, metal markets, and infrastructure availability. Results presented here should be considered preliminary. Additional factors such as perceived risk, political and economic climate, environmental constraints, and corporate policy may be present but aren't considered.

Capital and operating costs for the models were determined using the U.S. Bureau of Mines' Cost Estimation System (USBM CES 2.3) . Cost estimates were escalated using the USBM's Alaska Mineral Industry Cost Escalation Factors (AMICEF) of 1.51 for operating labor, 1.58 for capital labor, 1.10 for capital costs, and 1.73 for electricity to reflect higher costs in the Chichagof and Baranof Islands Area. These factors are a set of calculated values that are used to escalate itemized capital and operating costs for mining and milling operations from the central front range of the Rocky Mountains (Denver vicinity) to any point in Alaska. The Denver vicinity is used as the base for CES (2).

Published cost information from permitting documents, environmental impact statements, and private reports were also used (23-26). All cost estimates are expressed in January, 1997 dollars.

Using the estimated capital and operating costs, economic models were compiled using cash flow analysis techniques. The RMV and DCFROR were computed. See Appendix A for the economic models and Appendix B for the inflation adjusted twenty-year and thirty-year commodity price averages.

Magmatic Segregation Model

The magmatic segregation deposit models are based on the geology and mineralization present at the Bohemia Basin, Mirror Harbor, and Snipe Bay copper-nickel-cobalt deposits. Maas, Bittendbender, and Still rated the Bohemia Basin property with a medium to high mineral development potential (9). The deposit is hosted in Tertiary norite and locally contains pyrrrhotite, pentlandite, and chalcopyrite. The magmatic segregation mine models assume that the structural characteristics of the orebody favor the use of surface mining methods. Exploration expenditures range from $25-45 million, increasing as the size of the resource increases from 1.56 to 25 Mmt.

Ten surface mine models were developed. Five use an on-site mill, and five use the existing Westmin Premier Mill located approximately 19 km north of Hyder, Alaska. Off-site milling was evaluated to determine if it would prove to be a less costly option. It was assumed a flotation circuit would be added to the existing mill, and based on a comparison of flotation and carbon-in-leach milling costs, the custom milling fee was estimated at $53 per metric ton of ore, regardless of milling requirements. The stripping ratio was assumed to be 2.5:1, based on data available for the Bohemia Basin deposit.

The on-site mill scenario requires building and maintaining an 8.0 km road from the mine site to the port and trucking concentrates year round for shipment to a smelter assumed to be located in Japan. The off-site scenario requires building and maintaining the same road, trucking ore 8.0 km, barging the ore 400 km to Stewart, British Columbia, off-loading it, trucking it an additional 19 km to the existing Westmin Premier Mill, and then trucking the concentrates 19 km back to the port for shipment to Japan.

Material handling requirements were almost twenty times larger under the off-site mill scenario as compared to the on-site mill scenario. As an example, the 1.56 Mmt model had an annual ore production rate of roughly 221,000 mtpy, and a concentrate production rate estimated at 10,800 mtpy.

Surface mine models incorporate the use of rotary drills and explosives to drill and blast ore and overburden. Front end loaders and trucks would be used to excavate, load, and haul ore and overburden from the mine to its appropriate location. After processing, approximately 95% of the daily ore production would be sent to the tailings pond for disposal, with the remaining volume reporting to the concentrates.

The work force would commute from Sitka (113 km), Pelican (14 km), Hoonah (96 km), or Haines (240 km) to the site. Based on these assumptions, transportation costs will be higher than that usually found in the contiguous U.S. The project would produce its own electric power using diesel powered generators. Employees would be housed at a permanent complex built on-site.

Employees would work a 4-weeks-on, 2-weeks-off schedule, year-round. One-third of the employees would be on their scheduled days off at anytime. Two-thirds would be on-site for their scheduled work assignments. Employees would be transported to the mine site via two catamaran ferries under a time charter arrangement (11).

Two concentrate storage buildings are included in the on-site model, one at the mill-site and one at the port-site, each capable of storing six weeks of production. The off-site model would not have concentrate storage buildings. Concentrates produced at the on-site or off-site mill would be shipped out to a smelter, assumed to be in Japan. Fuel storage facilities capable of supplying the operation year-round are located at the port-site and mill-site areas.

The difference in RMV under the off-site mill scenario varied. Average RMV required for the off-site mill models was 36% higher (ranging from 10% to 59%) than the equivalent on-site model. The difference in RMV increases as resource size increased from 1.56 Mmt to 25 Mmt of resources. Cost savings from the elimination of the mill, tailings pond, concentrate storage buildings, and reduction of power generation, employee transportation, and housing costs were not enough to offset the higher costs of trucking and barging ore to the off-site mill. The custom milling fee was another significant cost. All costs generated for each mine model are listed in Appendix A, Table A-1. In each mine model, the associated mill uses flotation to process the ore.

Figure 3 graphically presents the results for the magmatic segregation deposit mine models. The downward sloping curve illustrates the cost advantage larger deposits achieve through economies of scale. Table 1 summarizes the results of the various models. The RMV per metric ton of minable ore required to achieve a 15% DCFROR ranges from $261/mt for a 631 mtpd (1.56 Mmt) mine using an off-site mill, to a low of $61/mt for a 5,051 mtpd (25 Mmt) mine using an on-site mill.

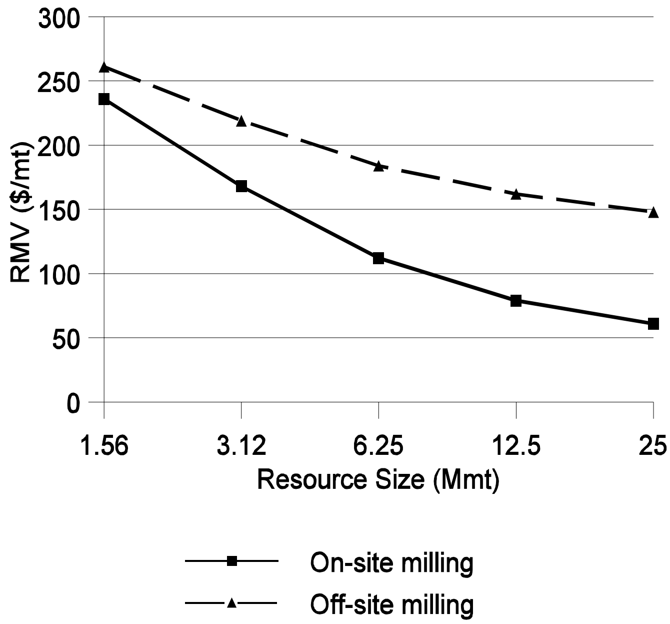


Figure 3 - RMV vs. resource size, magmatic segregation surface mine models, 15% DCFROR

Table 1. - Summary of cash flow analysis for magmatic segregation models

Deposit Type	Deposit size (Mmt)	Mining rate (mtpd)	RMV On-site mill 15% ROR ($/mt)	RMV Off-site mill 15% ROR ($/mt)
magmatic segregation	1.56	631	$236	$261
magmatic segregation	3.12	1062	168	219
magmatic segregation	6.25	1786	112	184
magmatic segregation	12.5	3003	79	162
magmatic segregation	25.0	5051	$61	$148

Low Sulfide Vein Gold Models

The low sulfide vein gold deposit models are based on the geology and mineralization present at the Chichagoff Mine. Maas, Bittendbender, and Still rated the property with a high mineral development potential (9). The vein deposits are hosted in Sitka Graywacke with ore shoots ranging from 0.5 m to 5.0 m in width, with an average width of 1 to 2 m. The low sulfide vein gold mine models assume that the structural characteristics of the orebody favor the use of underground shrinkage stoping mining methods. Exploration expenditures range from $5-25 million, increasing as the size of the resource delineated increases from 100,000 mt to 1.6 Mmt.

The models assume ore is mined by shrinkage stoping methods using stopers for drilling and jacklegs for rock bolting. Stopes, stope raises, laterals, and crosscuts necessary for production are developed using drilling and blasting methods. The ore is milled using carbon-in-leach processing.

Electric power will be produced by on-site diesel generators.

Employees would work a 4-weeks-on, 2-weeks-off schedule, year-round. One-third of the employees would be on their scheduled days off at anytime. Two-thirds would be on-site for their scheduled work assignments. Employees would be transported to the mine site via two catamaran ferries under a time charter arrangement (11).

A primary ferry equipped with multiple backup systems for both safety and reliability and a smaller ferry available on standby would be used for transportation. The work force would commute from Sitka (80 km), Pelican (64 km), Hoonah (154 km), or from Haines (320 km) from the site. Based on these assumptions, transportation costs will be higher than that usually found in the contiguous U.S. Employees would be housed at a permanent accommodation complex built on-site.

The power plant cost for the off-site mill scenario would be 40% of the comparable on-site mill scenario. The milling fee for the off-site mill scenario is assumed to be $42.57/mt regardless of the milling rate (8). It is assumed the Westmin Premier Mill could process the ore.

Table 2 summarizes the results of the analysis for the various models. The RMV per metric ton of minable ore required to achieve a 15% DCFROR range from $828/mt for an 80 mtpd (0.1 Mmt) mine using an on-site mill, to a low of $181/mt for a 643 mtpd (1.6 Mmt) mine using an on-site mill.

Figure 4 graphically presents the relation between RMV per metric ton and deposit size for the low sulfide gold deposit mine-models. This graph illustrates that sending ore to the Westmin Premier Mill is an advantageous alternative for the smaller models. An on-site mill is more cost-effective for larger deposits.

Table 2.- Summary of cash flow analysis for underground shrinkage stoping gold models

Deposit Type	Deposit Size (Mmt)	Mining rate (mtpd)	RMV On-site mill 15% ROR ($/mt)	RMV Off-site mill 15% ROR ($/mt)
Vein Gold	0.1	80	$828	$653
Vein Gold	0.2	135	623	539
Vein Gold	0.4	227	402	384
Vein Gold	0.8	382	274	289
Vein Gold	1.6	643	$181	$219

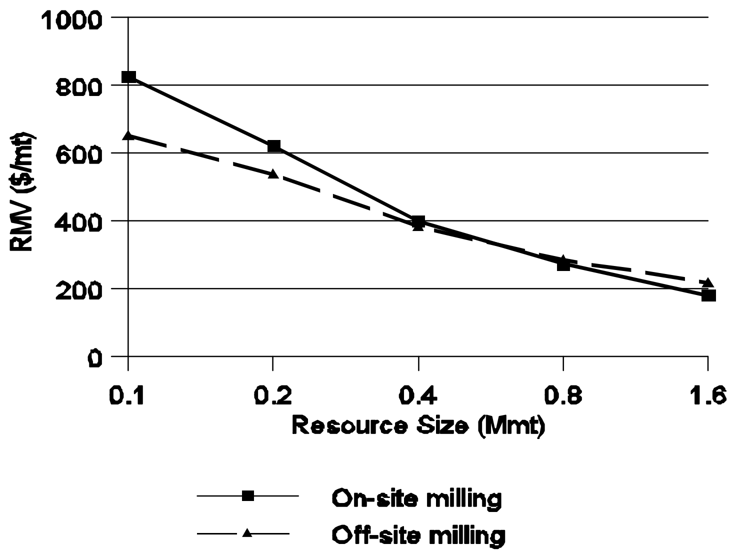


Figure 4 - RMV vs. resource size, underground shrinkage stoping models, 15% DCFROR

Klag Bay Tailings

Mineral development potential exists for reworking tailings from the Chichagoff Mine. It is estimated that 453,900 mt grading 4.8 g/mt gold are present in Klag Bay (6). The model is based on a development scenario proposed by a mining company in the late 1980s (10). The model consists of a suction dredge equipped with on-board processing, recovering gold as its only product. Tailings would be pumped through a large hose to a disposal site on land. Estimated captial costs are approximately $9,450,000 with $20.79/mt operating costs. The operation would employ about 30 people. At a mining rate of 900 mtpd, the mine life would be about 1.4 years. Based on these assumptions, RMV is estimated at $41.50/mt.

The proposed operation was not permitted due to possible impacts on salmon spawning. The company considered a seasonal operation during non-spawning periods, but found that intermittant operations were detrimental to project economics. Consequently, the project did not proceed.

SUMMARY AND CONCLUSIONS

Mining prefeasibility investigations were conducted for magmatic segregation and low sulfide vein gold deposit types that are found in the Chichagof and Baranof Islands Area, Southeast Alaska. Mine models were developed for application to the mineral deposit models. Capital and operating costs for the models were determined using the USBM's Cost Estimation System (CES 2.3) (18)

Published cost information drawn from industry publications, permitting documents, and environmental impact statements were also used. All costs were escalated by factors which reflect the higher cost of labor, transportation, and electricity in Alaska.

The cost data for each mine model were used to perform a cash flow analysis for each mine model, and the DCFROR was calculated. The goal of the prefeasibility study was to determine the RMV per metric ton of minable ore that would provide a 15% DCFROR to each of the mine models.

The modeling indicated the RMV required to achieve a 15% DCFROR for a magmatic segregation surface mine ranges from $61/mt for a 5,051 mtpd (25 Mmt) operation to $236/mt for a 631 mtpd (1.56 Mmt) operation using on-site milling. On-site milling was less costly than off-site milling.

Economic modeling for low sulfide vein gold deposits indicated the RMV necessary for a 15% DCFROR for an underground shrinkage stoping mine, using off-site milling operation ranged from $218/mt at 643 mtpd (1.6 Mmt) to $653/mt at 80 mtpd (0.1 Mmt), and from $181/mt at 643 mtpd (1.6 Mmt) to $828/mt at 80 mtpd (0.1 Mmt) for an on-site milling operation. Off-site milling was less costly than on-site milling until production exceeded approximately 300 mtpd. Then, economies of scale reduced operating costs enough to offset the higher capital costs required for on-site milling.

Economic modeling for the Klag Bay tailings deposit indicated a RMV necessary for a 15% DCFROR for a dredging operation at $41.50/mt for a 900 mtpd operation. Deposit grades required to achieve the necessary RMV for a 15% DCFROR with the development scenarios modeled in this report can be calculated based on information found in Appendix B.

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APPENDIX A. - CAPITAL AND OPERATING COSTS FOR MINE MODELS

The tables in this appendix give the mineral deposit type and mine model descriptions; and capital and operating costs for the Chichagof and Baranof Islands Area models. Capital costs are categorized into six groups which include acquisition, exploration, infrastructure, mine, mill, and working capital costs for each model. Operating costs are categorized into six groups which include general and administrative, infrastructure, mine, mill, smelting, and transportation.

A ten-year preproduction period is assumed for each model. The models assume exploration will take ten years, permitting will take five years, and three years will be needed for construction. These activities would operate concurrently.

Table A-1. - Mineral deposit and mine model descriptions

Deposit type	Deposit size (Mmt)	Mine model	Mining rate (mtpd)	Mine life (yrs)[2]	Mill type
Magmatic segregation	1.56	Surface	631	7	Flotation
Magmatic segregation	3.12	Surface	1,062	8	Flotation
Magmatic segregation	6.25	Surface	1,786	10	Flotation
Magmatic segregation	12.5	Surface	3,003	12	Flotation
Magmatic segregation	25.0	Surface	5,051	14	Flotation
Low sulfide vein gold	0.1	Shrinkage stoping	80	8	CIL Plant
Low sulfide vein gold	0.2	Shrinkage stoping	135	9	CIL Plant
Low sulfide vein gold	0.4	Shrinkage stoping	227	11	CIL Plant
Low sulfide vein gold	0.8	Shrinkage stoping	382	13	CIL Plant
Low sulfide vein gold	1.6	Shrinkage stoping	643	16	CIL Plant

[2] Mine life estimate is based on 350 days per year.

TABLE A-2. - Capital and operating costs - magmatic segregration on-site mill models

Model Description					
Resource size (Mmt)	1.56	3.12	6.25	12.5	25
Mining rate (mtpd)	631	1,062	1,786	3,003	5,051
Capital Costs ($ millions)					
Acquisition	$4.54	$5.29	$6.30	$7.66	$9.23
Exploration	25.00	30.00	35.00	40.00	45.00
Infrastructure	20.04	23.56	28.80	36.55	46.71
Mine	9.07	10.33	12.51	16.19	22.37
Mill	19.22	21.35	24.99	30.03	33.56
Working Capital	4.15	5.11	6.47	8.43	11.30
Reclamation	4.39	5.11	6.10	7.43	8.99
TOTAL	$86.41	$100.75	$120.17	$146.29	$177.16
Operating costs ($/mt)					
Infrastructure	$16.50	$12.40	$9.50	$7.41	$5.90
Mine	18.45	13.37	10.06	7.84	6.31
Mill	35.99	25.71	18.68	13.89	10.60
Smelting[3]	12.30	12.30	12.30	12.30	12.30
Transportation	2.04	2.04	2.04	2.04	2.04
TOTAL	$85.28	$65.82	$52.58	$43.48	$37.15

TABLE A-3. - Capital and operating costs - magmatic segregation off site mill models

Model Description					
Resource Size (Mmt)	1.56	3.12	6.25	12.5	25
Mining rate (mtpd)	631	1,062	1,786	3,003	5,051
Capital Costs ($ millions)					
Acquisition	$3.14	$3.82	$4.76	$6.08	$7.32
Exploration	25.00	30.00	35.00	40.00	45.00
Infrastructure	19.31	23.24	30.14	41.32	48.83
Mine	5.75	7.60	10.74	15.86	23.20
Mill	0.00	0.00	0.00	0.00	0.00
Working Capital	6.39	9.29	13.74	20.72	27.70
Reclamation	3.19	3.95	5.05	6.63	8.13
TOTAL	$62.78	$77.90	$99.43	$130.61	$160.18
Operating costs ($/mt)					
Infrastructure	$15.71	$11.67	$8.98	$6.34	$4.63
Mine	18.92	13.66	10.22	7.94	6.37
CustomMill Fee & Smelting	65.39	65.39	65.39	65.39	65.39
Transportation	47.97	49.91	49.91	49.91	49.91
TOTAL	$147.99	$140.63	$134.50	$129.58	$126.30

[3] Includes base smelter charges of $252.10/mt copper concentrate, RMV includes smelter recovery and all price and assay adjustments which reduce the smelter payment (14).

TABLE A-4. - Capital and operating costs - vein gold on-site mill models

Model description					
Resource Size (Mmt)	0.1	0.2	0.4	0.8	1.6
Mining rate (mtpd)	80	135	227	382	643
Capital Costs ($ millions)					
Acquisition	$1.92	$2.44	$3.02	$3.74	$4.66
Exploration	5.00	10.00	15.00	20.00	25.00
Infrastructure	14.47	15.41	16.52	18.25	20.82
Mine	1.39	2.02	2.94	4.29	6.27
Mill	10.91	12.50	14.69	18.01	23.21
Working Capital	0.67	0.88	1.20	1.69	2.48
Reclamation	1.84	2.31	2.85	3.53	4.41
TOTAL	$36.20	$45.56	$56.23	$69.50	$86.85
Operating costs ($/mt)					
Infrastructure	$33.52	$25.20	$18.84	$14.23	$10.89
Mine	32.85	31.50	30.32	29.58	28.37
Mill	26.35	15.83	9.55	5.53	3.54
TOTAL	$92.72	$72.53	$58.71	$49.04	$42.80

TABLE A-5. - Capital and Operating costs - vein gold off-site mill models

Capital Costs ($ millions)					
Resource size (Mmt)	0.1	0.2	0.4	0.8	1.6
Mining rate (mtpd)	80	135	227	382	643
Capital Costs ($ millions)					
Acquisition	$1.21	$1.59	$1.98	$2.40	$2.86
Exploration	5.00	10.00	15.00	20.00	25.00
Infrastructure	12.82	13.39	14.02	14.92	16.29
Mine	2.04	2.31	2.68	3.23	4.08
Working Capital	0.79	1.23	1.94	3.10	5.00
Reclamation	1.17	1.52	1.90	2.33	2.85
TOTAL	$23.03	$30.04	$37.52	$45.99	$56.08
Operating costs ($/mt)					
Infrastructure	$26.50	$19.90	$14.90	$11.28	$8.71
Mine	34.08	32.24	30.77	29.53	28.52
Custom Mill Fee	42.67	42.67	42.67	42.67	42.67
Transportation	49.23	49.23	49.23	49.23	49.23
TOTAL	$152.48	$144.04	$137.57	$132.71	$129.13

APPENDIX B. - ECONOMIC ASSUMPTIONS

This appendix includes information regarding the development of the economic models. It notes all major assumptions for income tax rates, depletion, depreciation, commodity prices, exploration and permitting costs, working capital, salvage value, and reclamation expense.

Economic Factors

It is important to emphasize that the mine models described in this report are based on hypothetical mining and milling scenarios. The models are not meant to represent a feasibility analysis of specific deposits. This would be inappropriate since such an analysis requires more precise data than that available for this report.

The models do not include proprietary company data which, if available, would probably change the outcome of the evaluation. When applicable, cost information from developing or producing mines in Alaska was used in constructing the models. Alaska Mineral Industry Cost Escalation Factors (AMICEF) of 1.51 for operating labor, 1.58 for capital labor, 1.10 for capital costs, and 1.73 for electricity were used to reflect higher costs in the Chichagof and Baranof Islands Area. These factors are a set of calculated values that are used to escalate itemized capital and operating costs for mining and milling operations from the central front range of the Rocky Mountains (Denver vicinity) to any point in Alaska (2).

A number of factors control the feasibility of mineral development, including physical attributes of the deposit, metallurgical attributes of the minerals, metal markets, infrastructure availability, political climate, environmental constraints, and corporate policy. Any forecast of the development potential should weigh all of these factors. Results presented here are preliminary.

Cash Flow Assumptions

All RMV ($/mt) are equal to the amount of revenues required before all expenses including royalties, mining and milling capital and operating costs, off-site transportation costs, base smelting charges, and taxes are deducted. Base smelter charges are estimated at $252/mt copper concentrate. RMV includes smelter recovery and all price and assay adjustments which reduce the smelter payment (14). The magmatic segregation model assumes all concentrates would be sent to Japan.

Federal income tax, Alaska corporate income tax, and mining license tax rates are simulated with a 41% tax rate during the first 3 years of production, 43% in the 4th year, and 45% thereafter. All projects were assumed to be equity financed by a single corporate producer that expensed tax due against other income. Modified Accelerated Cost Recovery System (ACRS) depreciation and percentage depletion were utilized.

Exploration costs were considered for all models. Acquisition capital cost represents the direct cost of permitting, and were estimated at 4% of the total project cost (12). Reclamation costs were included in the magmatic segregation and vein gold models. Mine and mill reinvestment were not considered for the magmatic segregation or vein gold models. Working capital for both models equals 90 days of operating costs less smelting costs and was recovered in the last year of the project.

Calculation of RMV

Assume mill feed with grades of 11% zinc, 396.5 g/mt silver, 3% lead, and 3.6 g/mt gold was mined from a deposit. Mill recoveries were estimated at 90% for zinc, 85% for silver, 81% for lead, and 71% for gold. Smelter recoveries were estimated at 75% for zinc, 87% for silver, 80% for lead, and 55% for gold. The RMV ($/mt) equals $237.

The equation used in calculating RMV for a deposit is:

$$\sum_{I=1}^{n} GiRiSiVi,$$

where

Gi = mill feed grade of commodity I,
Ri = mill recovery of commodity I,
Si = smelter recovery of commodity I,
Vi = $/unit of commodity I,
and n = total number of commodities.

The calculations are shown in the worksheet below.

CALCULATION OF RECOVERABLE METAL VALUE						
Commodity	**Grade (decimal)**	**Mill Recovery (decimal)**	**Smelter Recovery (decimal)**	**Unit**	**Price**	**RMV**
	Gi	**Ri**	**Si**		**Vi**	**(GiRiSiVi)**
Zinc	0.11	0.90	0.75	mt	$1,420	$107
Silver	396.5	0.85	0.87	g	$0.30	88
Lead	0.03	0.81	0.80	mt	$1,120	25
Gold	3.6	0.71	0.55	g	$12.18	17
TOTAL						$237

How To Use Worksheet

1. Estimate minable resource size, and resource commodity grades to be evaluated.

2. Refer to Figure 3 or 4, select appropriate graph line representing nearest estimated minable resource size. Read RMV ($/mt) from y-axis. This is the minimum value per metric ton of minable resource adjusted for mining recovery, dilution, mill and smelter recovery required to yield a 15% DCFROR using the mining and milling scenario described in the report.

3. To translate this value into a gross in place value (GIPV), back calculate value using assumed mill recoveries or pilot testing results if available, and appropriate smelter recoveries. Suggested commodity prices shown in Table B-1 may be used or other prices as desired.

Commodity Prices

Commodity prices provided for individual metals were determined by using an inflation adjusted thirty-year average for the years 1967-96. Prices for 1967-96 from various Bureau publications were escalated to 1996 dollars using U.S. Department of Commerce Gross National Product implicit price deflators and then averaged (16-22).

Ten (1987-96), twenty (1977-96), and thirty year (1967-96) average prices are shown for the commodities of interest. All prices shown in Table B-1 are given in 1996 dollars.

Table B-1. - Ten, twenty, and thirty year average commodity prices (1967-1996)

	English Units				Metric Units			
Commodity	**30 YR AVG**	**20 YR AVG**	**10 YR AVG**		**30 YR AVG**	**20 YR AVG**	**10 YR AVG**	
Copper	$1.46	$1.29	$1.27	lb	$3.21	$2.84	$2.80	kg
Gold	425.58	517.69	441.98	tr oz	13.68	16.64	14.21	g
Cobalt	16.14	19.91	17.89	lb	35.58	43.89	39.44	kg
Nickel	$4.36	$4.20	$4.33	lb	$9.61	$9.26	$9.54	kg