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Critical and Strategic Minerals in Alaska

Cobalt, the Platinum-Group Metals, and Chromite

By James C. Barker, Jan C. Still,
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UNITED STATES DEPARTMENT OF THE INTERIOR

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UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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CRITICAL AND STRATEGIC MINERALS IN ALASKA

Cobalt, the Platinum-Group Metals, and Chromite

By James C. Barker,[1] Jan C. Still,[2] Thomas C. Mowatt,[3] and John J. Mulligan[4]

ABSTRACT

A uniquely mineralized area extends from northwestern Canada through Alaska into eastern Siberia. Some of the metals found there are relatively rare in the conterminous United States. Among these are cobalt, the platinum-group metals, and chromite. Geologic evidence suggests that cobalt and the platinum-group metals may be present in deposits that could constitute nationally important reserves. Chromite in potentially minable deposits is known, but it may be relatively less abundant. Limited reserves of these metals have been delineated, but most of the favorable terranes and reported occurrences throughout the vast expanse of Alaska remain unexplored.

As part of the mineral studies mandated under the Alaska National Interest Lands Conservation Act, the Bureau of Mines' Alaska Field Operations Center and the Bureau's research centers at Albany, Oreg., and Reno, Nev., are cooperating in a long-range program to investigate occurrences and delineate reserves of cobalt, the platinum-group metals, and chromite in Alaska. Studies of other critical and strategic minerals will be phased in during succeeding years, as ongoing projects are completed. This first in a series of annual reports summarizes available information about deposits and past production of cobalt, the platinum-group metals, and chromite, and describes current and planned Bureau investigations of these minerals.

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INTRODUCTION

One of the world's uniquely mineralized areas extends from northwestern Canada through Alaska and into eastern Siberia. Some minerals that are relatively rare in the conterminous United States occur there. Critical and strategic minerals normally imported from foreign sources have been produced in Alaska during the First and Second World Wars, the Korean and Vietnam conflicts, and other times of unusual shortage or demand. Alaska's contribution to U.S. industry has included tin, tungsten, the platinum-group metals, antimony, mercury, chromite, and minor amounts of asbestos.

As a major part of the mineral studies mandated under the Alaska National Interest Lands Conservation Act,[5] the Bureau of Mines' Alaska Field Operations Center (AFOC) is evaluating economic and subeconomic reserves of critical and strategic minerals in Alaska. Evaluations will include an estimate of the degree of certainty with which the reserves are known. Initial investigations during 1981 will include field reconnaissance of some potential sources of cobalt, the platinum-group metals, and chromite. Studies of other minerals will be phased in during future years, as currently ongoing projects are completed.

This is the first report on these Bureau of Mines investigations. It summarizes available information about deposits and past production of cobalt, the platinum-group metals, and chromite, which was obtained during investigations of these metals through May 1981. Subsequent reports will be issued annually to cover critical and strategic minerals investigations during the preceding field seasons, and the resultant laboratory and office studies.

ACKNOWLEDGMENTS

This report includes data compiled from referenced sources, data collected by the Bureau of Mines during the numerous mineral land assessments resulting from the Alaska Native Claims Settlement Act[6] and related legislation, and data resulting from investigations of mineral deposits containing platinum-group metals and chromite, made in cooperation with the Bureau's Albany (Oreg.) and Reno (Nev.) Research Centers.

The basic reference is "Mineral Terranes of Alaska" (*1*),[7] a series of 1:1,000,000-scale maps with explanatory text, prepared under Bureau of Mines contract J0199051 by the University of Alaska Arctic Environmental Information and Data Center, with the cooperation of the U.S. Geological Survey, the State of Alaska Division of Geological and Geophysical Surveys, and representatives of several mining and mineral consulting firms. Some additional data were acquired from U.S. Geological Survey mineral investigations resource maps (*5*). The mineral deposit location map (fig. 1, pocket) was adapted from topographic and land status maps of Alaska published by the U.S. Geological Survey. Historic production records were compiled by the Bureau of Mines State mineral specialist for Alaska. Data on reserves are from publications referenced or footnoted.

Platinum samples were preconcentrated at the AFOC and analyzed at the Reno Research Center. Metallurgical testing was done at the Albany Research Center. Petrographic analyses were performed at the AFOC, but quantitative analyses other than for platinum-group metals were usually made in commercial laboratories.

HISTORY AND PRODUCTION

COBALT

No cobalt is known to have been produced in Alaska. The available information on cobalt was compiled almost entirely from data gathered during the exploration of mineral deposits for other metals, mostly in southeastern Alaska. The low prices that prevailed—because cobalt could be imported from south-central Africa—have until recently resulted in a general lack of interest in Alaskan deposits.

PLATINUM AND PLATINUM-GROUP METALS

Platinum was recognized in the placer gravels at widely scattered places throughout Alaska during the early years of this century. About 96 percent of the reported Alaskan production of platinum-group metals was from the placers of Salmon River and its headwater tributaries about 15 miles south of Goodnews Bay on the west coast of Alaska

[5]Public Law 96-487, Dec. 2, 1980, title X, sec. 1010.
[6]Public Law 92-203, Dec. 18, 1971.
[7]Italicized numbers in parentheses refer to items in the list of references at the end of this report.

Table 1.—Estimated production of platinum-group metals, ounces

Source	PGM[1] (crude)	Platinum	Palladium	Iridium	Ruthenium
Placer mines:					
Goodnews Bay:[2]					
1927-34	3,000	2,580	30	70	30
1934-75	[3]641,000	551,000	6,000	14,000	6,000
Miscellaneous (1900-41)	3,500	3,000	30	ND	ND
Total, placer mines	647,500	556,580	6,060	14,070	6,030
Lode mine: Salt Chuck (1918-21, 1924-26, 1935-41)	14,271	ND	[4]14,271	ND	ND
Grand total	661,771	556,580	20,331	14,070	6,030

ND Not determined.
[1]Platinum-group metals.
[2]Estimated data for Goodnews Bay are derived from references *4* and *12*.
[3]Actual production data (*13*).
[4]From unpublished Bureau of Mines data; reference *11* suggests that this total may include platinum and other platinum-group metals.

(fig. 1). The known placer reserves of platinum-group metals are also in this area. About 3 percent of the Alaskan production of platinum-group metals was from the Salt Chuck Lode Mine about 10 miles north of the head of Kasaan Bay on Prince of Wales Island, southeastern Alaska. The remaining 1 percent was recovered as a byproduct from gold placer mines in many areas, including the Koyuk area, the Ruby-Poorman area, the Tolstoi area, the Snow Gulch area, several headwater tributaries of the Yentna and Kahiltna Rivers, headwater tributaries of the Chistochina River, and Lituya Bay in the Glacier Bay National Park. Production statistics are summarized in table 1.

CHROMITE

Chromite production from 1917 to 1957 is shown in table 2. No production has been recorded since 1957. All production was from near Seldovia on the Kenai Peninsula. Despite the sporadic production, there has been relatively little exploration for chromite in Alaska.

Table 2.—Chromite production[1]

Source	Production, long tons	Grade, pct Cr_2O_3	Ratio, Cr:Fe
Star 4 Claim (Red Mountain)	21,435	[2]48	2.9:1
Chrome Queen Claim (Red Mountain)	[3]6,500	ND	ND
Reef Mine, Claim Point (Seldovia)	[3]2,000	44	ND

ND Not determined.
[1]Data are from reference *19*.
[2]Hand-sorted, metallurgical grade.
[3]Approximate.

DESCRIPTION OF DEPOSITS

TYPES OF DEPOSITS

Table 3 is a listing of the types of deposits of cobalt, platinum-group metals, and chromite that are either known or believed to exist in Alaska. The deposits or areas from which production of platinum or chromite has been reported, and the deposits listed as typical examples under "Selected known deposits or prospects" are identified by name on figure 1. The reported or suspected occurrences that will be the objective of reconnaissance investigations are also shown on the map (by symbol), but most are not identified by name.

COBALT

The cobalt reserves presently known in Alaska are associated with large nickel-copper deposits in southeastern Alaska. On Yakobi Island, the Bohemia Basin deposit (fig. 2) contains cobalt reserves of 14 million pounds together with 85 million pounds of copper and 140 million pounds of nickel.[8] On the west coast of Chichagof Island at Mirror Harbor, a nickel-copper deposit has inferred reserves of 960,000 tons of ore[9] containing some cobalt.[10] On Admiralty Island, the Funter Bay deposit contains proven reserves of 0.82 million pounds of cobalt, 4.8 million pounds of copper, and 5.39 million pounds of nickel (*8*). On Prince of Wales Island, cobalt is known in a variety of deposit types, but no reserves have been calculated. In Glacier Bay National Park, the nickel-copper deposits under Brady Glacier apparently contain cobalt that may be recoverable as a byproduct of copper-nickel mining. The deposit is estimated to contain 100 million tons of ore, containing some cobalt in the proven ore body, and perhaps an equal amount in the inferred extensions (*20*).

Cobalt occurs in a wide variety of geologic environments (*21*). Most well known in Alaska are associations of cobalt with copper and nickel sulfides in ultramafic rocks, such as the deposits mentioned above. Carbonate deposits of copper, lead, or zinc can contain cobalt, as exemplified by the deposits in the Mississippi Valley region. The large copper deposits at Bornite on the south slopes of the Brooks Range are known to contain associated cobalt, but testing is still in progress. No figures on cobalt reserves have been released by the owners. Other carbonate sulfide deposits in Alaska have not been evaluated for cobalt. The vast carbonate terrane of the Brooks Range and the sequences alined along the Tintina-Kaltag fault systems are considered to warrant investigation.

The other forms of cobalt deposits described in table 3 also warrant investigation. No reports were found that indicate exploration for them by either the Government or prospectors.

PLATINUM-GROUP METALS

Alaska's measured and indicated reserves of platinum-group metals are 500,000 ounces of platinum and platinum-group metals (*13*) near Goodnews Bay on the western Alaska coast and less than 1,000 ounces at Salt Chuck on Prince of Wales Island in southeastern Alaska.[11] Reported resources of unknown economic tenor include 6.8 million ounces in the Goodnews Bay area, 7.5 million ounces in the Klukwan deposit, and 4.5 million ounces in the Snettisham deposit (*3*). These resource estimates must be considered very tenuous because mining costs and the percentage of metallurgically recoverable platinum-group metals remain unknown.

Platinum-group metals are known in Glacier Bay National Park. Recent work by Czamaske (*7*) has indicated that platinum may be recovered as a byproduct from the proven Brady Glacier nickel-copper ore body. Platinum has been reported elsewhere in the park, and very small amounts of platinum-group metals were produced from beach sands near Lituya Bay (*12*).

Palladium and platinum occasionally have been produced as a byproduct of gold placer operations. With the recent dramatic increase in placer gold mining, it is possible that some platinum-group metals will be produced, although no production has been reported to date.

Platinum and other platinum-group metals are believed to occur throughout Alaska, associated with ultramafic-mafic complexes. The most extensive of these are in the western Brooks Range. Present information on grade ranges from limited to nonexistent. There is potential for both lode and placer deposits.

[8]Public release by Inspiration Development Co., March 1978.
[9]Inspiration Consolidated Copper Co. Letter to S. P. Wimpfen, Mar. 15, 1977.
[10]Johnson, B. R. (U.S. Geological Survey); A. L. Kimball, and J. Still (U.S. Bureau of Mines). Mineral Resource Potential of the Western Chicagof-Yakobi Islands Wilderness Study Area, Southeastern Alaska. U.S. Geol. Survey Bull. in press; for information, contact A. L. Kimball, Bureau of Mines, Juneau, Alaska.

[11]Fox, P. E. Salt Chuck Cu-Au-Pd Deposit. Unpublished examination report, Apr. 22, 1980, 16 pp. For information, contact J. J Mulligan, Bureau of Mines, Juneau, Alaska.

Table 3.—Types of known and potential deposits of cobalt, the platinum-group metals, and chromite

General geologic setting[1]	Known or probable commodities[2]	Selected known deposits (d) or prospects (p)		Sites recommended for evaluation[4]
		Location	Map[3]	
Mafic-ultramafic igneous rocks.	Ni, Cu, Co, PGM, Cr.	Brady Glacier (d), Bohemia Basin (d), Mirror Harbor (d).	17–19	Fairweather, Crillon-La Perouse, and Astrolabe-De Langle mafic-ultramafic complexes in Glacier Bay National Park.
Do	Ni, Cu, Co, PGM, Cr.	Spirit Mountain (d)	13	The Spirit Mountain deposit in the Chugach Range, the Rainbow Mountain prospects north of Paxson in the Alaska Range, and the Salcha prospects in the Yukon-Tanana Uplands.
Do	Ni, Cu, Co, PGM, Cr.	Blashke Island (p), Salt Chuck Mine (d), Duke Island Ultramafic (p) and Yellow Hill (p).	24, 26 28	Salt Chuck Mine, Poor Man Mine, and numerous other mines and prospects in the vincinity. Other prospects in southeastern Alaska at Funter Bay, Yellow Hill, Blashke Island, Duke Island, Snettisham, Klukwan, Windham Bay, Snipe Bay, and Union Bay.
Do	Cr, PGM (and probably other commodities).	Western Brooks Range (p)..	1	Western Brooks Range—chromite and PGM were noted in samples obtained by the Bureau of Mines in 1975 and 1976. Additional mapping has been undertaken by the U.S. Geological Survey recently. More detailed investigation is needed.
Do	Cr	Kanuti River area (d), Seldovia-Red Mountain (d), Eklutna-Chugach trend (p).	3, 11–12	The southwestern extension of the Kanuti ultramafic belt and the Eklutna-Chugach trend.
Do	Cr	Red Bluff Bay (p), Mt. Burnett (p).	22, 25	Red Bluff Bay and Hill prospects and vicinity on Baranof Island; Mt. Burnett prospect and vicinity on Cleveland Peninsula, southeastern Alaska.
Stratabound-hydrothermal replacement.	Co associated with Cu, Pb, Zn.	Bornite-Ruby Creek (d)	2	Extensions of the Bornite-type mineralization are possible. Other copper-lead-zinc deposits of the western Brooks Range should be investigated for cobalt. Preliminary Bureau of Mines data from the Mt. Schwatka area of central Alaska and the copper occurrence north of Arctic Village in the eastern Brooks Range indicate a cobalt association.
Do	Co associated with Cu, Pb, Zn.	Orange Point (p)	16	Near the Orange Point deposit is similar geologic terrane that may have similar deposits. The Sumdum, Jingle-Jangle, and Sweetheart ridge deposits south of Juneau, the Glacier Basin and Groundhog Basin deposits east of Wrangell, and the massive sulfide deposits of the Alaska Range should also be evaluated for cobalt potential.
Hydrothermal vein type.	Cu, Co, As	None	...	There are very limited unpublished Bureau of Mines data on a copper-cobalt-arsenic vein south of Livengood, in the Yukon-Tanana Uplands.
Do	Cu, Zn, Au, Ag, PGM.	...do	...	Portage Mountain prospect and vicinity on Kupreanof Island, southeastern Alaska. Vein-type copper-gold deposits in the area near the Salt Chuck mine on Prince of Wales Island may include cobalt and PGM.
Contact metasomatic type.	Cu, Fe, Co	Sultana (p)	27	There are numerous contact-type iron-copper mines and prospects on Prince of Wales Island, including the Jumbo and Green Monster mines that may also contain cobalt and PGM. Contact deposits near Chandalar on the south slopes of the Brooks Range may contain cobalt.
Stratiform sedimentary—red beds.	Fe, Mn, Cu, Co ..	None	...	Very limited unpublished Bureau of Mines data indicate a possibility for cobalt association with the iron-rich red beds of eastern Alaska near Eagle, and of copper-zinc-manganese-cobalt enrichment of shales east of Arctic Village.
Stratiform sedimentary—manganese nodule-bearing marine shales.	Mn, Co, Cu	...do	...	Manganiferous shales with nodule horizons and occurrences of copper and lead sulfides of the central Arctic National Wildlife Refuge may be favorable for cobalt. The stratigraphy was mapped by the U.S. Geological Survey, but no sample analyses have been reported to date.
Stratiform sedimentary—laterites.	Ni, Co	...do	...	Cenozoic deep weathering of some interior Alaska mafic-ultramafic complexes (e.g., Christian Complex in the eastern Brooks Range) may be favorable for laterites.

See footnotes at end of table.

Table 3.—Types of known and potential deposits of cobalt, the platinum-group metals, and chromite

General geologic setting[1]	Known or probable commodities[2]	Selected known deposits (d) or prospects (p)		Sites recommended for evaluation[4]
		Location	Map[3]	
Stream placers .	Au, PGM, Ti, Fe . .	Goodnews Bay (d)	8	Major deposits occur on Salmon River south of Goodnews Bay; additional reserves are likely. There are numerous, generally unverified reports of placer PGM associated with placer gold deposits. Reports of placer platinum north of Paxson near Rainbow Mountain on the south slopes of the Alaska Range may be significant. Placers may be associated with the western Brooks Range ultramafics. In all cases, further work is needed.
Marine placers .	Au, PGM, Ti, Fe . .	Beach sands north and south of Lituya Bay (p).	14	The beach sands near Lituya Bay are very extensive, but major concentrations of minable grade have not been reported despite reported production of small amounts of gold and PGM, and sporadic exploration for many years. Occurrences of PGM in the beach sands also have been reported on the western shores of Kodiak Island. South of Goodnews Bay are coastal beach sands, both of present day and ancient formation, reported to contain PGM.

[1]This list of geologic settings is not intended to represent a classification of Co, PGM, and Cr deposit types, but to indicate those settings for which present data indicate favorability for occurrence.
[2]Arsenic (As), chromite (Cr), cobalt (Co), copper (Cu), gold (Au), iron (Fe), lead (Pb), manganese (Mn), nickel (Ni), platinum-group metals (PGM), silver (Ag), titanium (Ti), zinc (Zn).
[3]Numbers refer to locations on figure 1.
[4]Deposits and occurrences recommended for evaluation may not be listed on figure 1, but the commodity location is indicated by symbol.

Figure 2.—Takanis Peak, Yakobi Island, southeastern Alaska. The low hill in the foreground is the north end of the Bohemia Basin copper-nickel-cobalt deposit.

CHROMITE

The area near Seldovia, from which chromite has been produced in the past, is at present being explored by industry. Other potential chromite belts in Alaska include the Kanuti River occurrences (fig. 3), the Eklutna-Chugach trend, the occurrences at Red Bluff Bay, Baranof Island, in southeastern Alaska, and the western Brooks Range deposits.

Chromite has also been reported at other Alaskan locations, but present information on these occurrences is inadequate to suggest a level of favorability or even the type of source rocks. Further exploration certainly is warranted in the Goodnews Bay area, the Kuskokwin region, and on Prince of Wales Island in southeastern Alaska.

Published data on metallurgical characteristics are limited to the Seldovia deposits. Preliminary metallurgical testing has just been completed by the Bureau of Mines on the Kanuti chromite deposits, and a report is being prepared that includes field descriptions and the results of metallurgical tests.[12]

Chromite is rather unique in nature in that only two types of deposits are mined—stratiform and podiform—both associated with ultramafic rocks. Stratiform deposits contain most of the world's reserves, but the podiform deposits are generally of higher grade, and have been and continue to be important sources of production (*16*). In the United States, podiform deposits have been intermittently mined to meet wartime needs. The known chromite deposits in Alaska are of the podiform type. The widespread occurrence of chromite-bearing ultramafic rocks in Alaska and the unusually large size of the ultramafic bodies in the western Brooks Range indicate that there is an opportunity to develop nationally valuable reserves. However, present information suggests that these will not be major occurrences on the world scale.

Figure 3.—Massive chromite lenses in podiform deposits of the Kanuti River region.

BUREAU OF MINES INVESTIGATIONS

Since 1978, the AFOC has made limited studies, including literature review, fieldwork, and cost evaluations, specifically directed toward reserves of cobalt, platinum-group metals, and chromite (*14-15*). The Albany Research Center (ALRC) has been performing metallurgical analyses of bulk samples, principally directed toward platinum-group elements but including associated metals. Evaluation of nonultramafic cobalt ore samples is planned for next year. A report jointly authored by the AFOC and the ALRC, on chromite (and associated platinum-group elements) in the Kanuti area, is now in preparation.[13] The Reno Research Center has been and will continue evaluating platinum-bearing samples. It is anticipated that this cooperative approach will be continued and that other research centers with special expertise may also participate.

The results of the Bureau's studies can be found in the reports that are summarized in table 4 and in the Minerals Availability System property evaluations that are listed in table 5.

The investigations of Alaskan critical and strategic metals are planned as a combined evaluation of geologic parameters, deposit grades and dimensions, metallurgical characteristics, and recovery costs. Because of the lack of previous exploration, field investigations frequently begin witn a search to determine if the reported deposit or suspected occurrence actually exists. Future work will include the following:

1. Onsite investigations of deposits and reported or suspected occurrences of cobalt, platinum-group metals, and chromite.

2. Analyses of samples of other mineral deposits that may contain cobalt or platinum-group metals recoverable as byproducts. These metals have not always been analyzed for in the past.

3. For deposits found to contain cobalt, platinum-group metals, or chromite, ascertaining the mode of mineralization and geologic character, and estimating dimensions of the deposits. The implications of associated geologic structures in estimating extensions of the deposit or additional deposits are particularly important in this phase of the investigation.

4. Determination of deposit grade and, if size and grade warrant, determination of metallurgical characteristics from bulk samples. Estimation of recovery costs.

5. Monitoring the results of industry exploration for cobalt, platinum-group metals, and chromite.

6. Possible recommendation of specific deposits for more detailed evaluation by geophysical exploration, drilling, or other methods.

Reconnaissance of some of the known occurrences began in 1981 and will continue into the succeeding years. It is anticipated that more detailed evaluations of specific

[12]Foley, J. Y., M. McDermott, D. C. Dahlin, L. L. Brown, and J. J. Kinney. Podiform Chromite Deposits in Central Alaska. Unpublished BuMines report; for information, contact J. Y. Foley, Bureau of Mines, Fairbanks, Alaska.

[13]Work cited in footnote 12.

Table 4.—Selected Bureau of Mines reports on cobalt, the platinum-group metals, and chromite

Summary of information	*References*
Statewide review of mineral terranes, mapped at 1:1,000,000 scale	1
Analyses of 2,000 mineral samples collected in 1978	17
Analyses of 2,000 mineral samples collected in 1979	18
Delineation of areas with high potential for nickel-copper, cobalt, platinum-group metals, and chromite in Glacier Bay National Monument	2
Evaluations of the Bohemia Basin and Mirror Harbor nickel, cobalt, and copper deposits	([1])
Baseline information on chromite potential in select areas of the western Brooks Range	9-10
Initial delineation of the trend of chromite deposits in the Kanuti River region	6
Additional investigation of the trend of chromite deposits in the Kanuti River region	([2])

[1]Johnson, B. R. (U.S. Geological Survey); A. L. Kimball, and J. Still (U.S. Bureau of Mines). Mineral Resource Potential of the Western Chicagof-Yakobi Islands Wilderness Study Area, Southeastern Alaska. U.S. Geol. Survey Bull. in press; for information, contact A. L. Kimball, Bureau of Mines, Juneau, Alaska.

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Table 5.—Minerals Availability System evaluations of deposits of cobalt, the platinum-group metals, and chromite

Commodity	Deposit evaluated	Sequence No.
Cobalt	Yakobi Island (Bohemia Basin).	0021140017
	Mirror Harbor	0021140068
	Funter Bay	0021120072
Platinum-group metals.	Salt Chuck Mine	0021190135
	Salmon River (Goodnews Bay area).	0021230004
Chromite	Red Mountain	0021040001
	Claim Point (Seldovia).	0021040002
	Red Bluff Bay	0021160001

deposits can begin in 1982. These will include engineering and economic studies to update the Bureau's Minerals Availability System, if the estimated grade and tonnage of a deposit warrant.

In the reconnaissance phase, priority will be given to occurrences reported by the U.S. Geological Survey in quadrangles completed under the Alaska Mineral Resource Assessment Program.[14] Priority for the more detailed investigations will be given to occurrences in areas closed to mineral entry. To avoid duplication of effort, low priority will be given to deposits or areas where industry is currently exploring or likely to explore. However, a subprogram will be initiated to review industrial exploration and analyze gold placer concentrate samples or other selected mineral samples that may be donated by mine operators.

[14]A continuing program to map geology and mineral information on 1:250,000-scale quadrangle maps.

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