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Strategic and selected critical minerals in Alaska summarized

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Introduction

Since the turn of the century, Alaska has added significant amounts of so-called 'strategic' and 'critical' materials to United States domestic mineral production during the First, Second, Korean, and Vietnam Wars as well as during times of unusual shortages caused by technological change or disruption of critical foreign sources. Alaska's contribution includes tin, tungsten, platinum-group metals, antimony, mercury, chromium, and minor amounts of asbestos (table 1). This paper defines what strategic and critical minerals are, summarizes Alaska's past strategic-minerals contribution and known reserve base, and discusses strategic and critical minerals availability with respect to lands open or closed to mineral entry and development.

'Strategic' vs 'Critical'

Not all mineral experts agree on the definitions of both 'strategic' and 'critical minerals,' and many view the two terms as synonomous. The best available general definitions have been provided by Thrush (1968):

> 'Strategic minerals are those commodities essential to the national defense for the supply of which, during war, we are wholly or in part dependent upon sources outside the national boundaries of the United States, and for which strict measures controlling conservation and distribution are necessary.
>
> 'Critical minerals are those essential to the national defense, the procurement of which in war, while difficult, is less serious than those of strategic minerals (because they can either be

domestically produced or obtained in more adequate quantities from reliable foreign sources) and for which some conservation measures may be necessary for nondefense uses.'

It follows that a 'strategic' mineral is one in which a chronic domestic shortage exists. On the other hand, potentially economic reserves of 'critical' minerals may be relatively abundant within the United States, but for social, economic, environmental, or political reasons, the country relies heavily on foreign sources of raw ore. Conservation and recycling of mineral materials could help alleviate the minerals supply problem and may reduce our dependence on foreign sources of materials in future years, but the United States has not been able to provide an adequate supply for defense. Also, many mineral uses are 'dissipative' and thus industrial consumption must always, to some degree, be supplemented by primary mineral extraction.

The lists for 'strategic' and 'critical' minerals have changed over time. In 1941, 'strategic' minerals were aluminum, antimony, chromium, manganese, optical mica, platinum, nickel, mercury, tin, and tungsten. Minerals important to space-age technology such as cobalt, niobium, cesium, and various rare-earth elements have been added to the list since World War II.

The 1975 Conference on Strategic and Critical Minerals held in Farley, Virginia listed 29 'critical' minerals, of which 17 are designated 'strategic' according to the definitions of Thrush (1968) adopted here. They are:

Optical mica	Asbestos
Niobium	Chromium
Cesium	Tin
Manganese	Fluorine
Tantalum	Nickel
Cobalt	Mercury
Bauxite	Tungsten
Platinum-group metals	Antimony
	Selenium

Fourteen of the 17 are found in varying amounts in Alaska. Also found in the 49th State are significant reserves and resources of seven selected critical minerals---cadmium, zinc, barium, titanium, gold, silver, and gypsum (table 2).

Established Reserves of Strategic Minerals Listed

Since World War II, private industry and limited federally subsidized exploration have delineated economic or 'near'-economic reserves of 10 of the 17 strategic minerals defined here: cobalt, nickel, tin, platinum-group metals, asbestos, mercury, fluorine, tungsten, antimony, and chromite. Of the rest, promising resources of selenium, optical mica, niobium, and tantalum are found in mineralized regions in Alaska; however, commercially viable reserves of bauxite (aluminum), manganese, and cesium are not known to exist anywhere in the state. Estimated reserve bases of strategic and critical minerals are summarized in tables 1 and 2; approximate locations of selected deposits are shown in figure 1.

A 63-million-lb proven reserve of cobalt metal contained within four deposits in the Southeastern Panhandle ---Brady Glacier, Yakobi Island, Mirror Harbor, and Funter Bay (52, 53, 54, 57; table 1)---amounts to about 3 years of annual U.S. cobalt consumption. If the inferred reserve---another 55 million lb---is included, the total would amount to 5-1/2 years of present U.S. consumption. The same four deposits contain an estimated 1.12-billion-lb (561,000-ton) proven reserve of nickel, equal to 2.1 years of current U.S. consumption; adding the inferred reserve increase the total amount to about 4 years of present domestic consumption.

Proven and inferred reserves of 938,000 oz of platinum-group metals at Goodnews Bay, Brady Glacier, Yakobi Island, and Salt Chuck (36, 52, 53, 67; table 1) amount to about 6 months at present rates of U.S. consumption. Except for the Stillwater complex resources in Montana, Alaska has the largest economic reserves of platinum-group metals in the U.S.

The most obvious land-use conflict

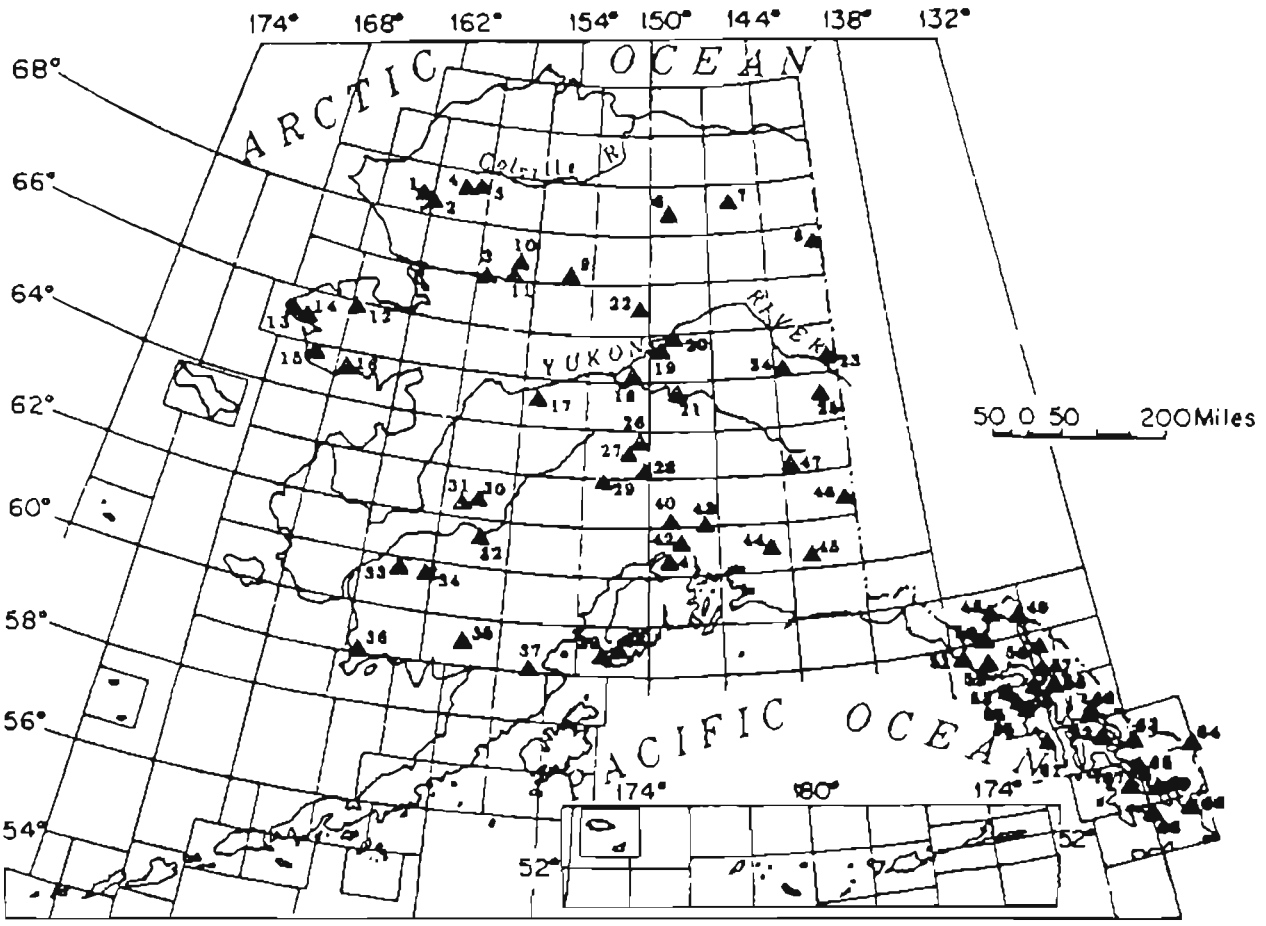

Figure 1 Locations of selected strategic and critical mineral deposits in Alaska

with respect to strategic minerals in Alaska is found in the nickel-cobalt-copper-platinum group metal deposits of the Southeastern Panhandle. Ninety-eight and one-half percent of the Alaska's cobalt reserves (equivalent to one-sixth of U.S. reserve base), 99.4 percent of Alaska's nickel reserve (equivalent to one-fifth of the U.S. reserve base) and 50 percent of Alaska's platinum-group metal reserve (one-fourth of the nation's known economic platinum reserves) are located either in Glacier Bay National Monument or section 204 withdrawals in the Tongass National Forest (West Chichagof-Yakobi Wilderness proposal). Insufficiently evaluated reserves at Spirit Mountain (45, table 1) and Bornite (11, table 1) are in Wrangell National Monument and on state-selected lands, respectively.

Alaska has 131 million lb (66,500 tons) of proven and inferred reserves of tin in deposits on the western Seward Peninsula, in the Manley-Tofty area, and at the Purkey Pile prospect in the southern Alaska Range (13, 14, 18, 29, table 1), which are the largest known reserves of primary tin in the U.S.; this amounts to about 1 year of current U.S. usage. Most of Alaska's known tin reserves are outside existing national monuments or lands withdrawn from mineral entry, but three promising tin belts---the Chulitna, Sithylemenkat, and the Old Crow-Bear Mountain areas (28, 8, 22, table 1)---lie partly within Denali National Monument, in a small portion of Lake Clark National Monument, in southern additions to the Arctic National Wildlife Refuge, and in part of the proposed Kanuti National Wildlife Refuge.

Inferred reserves of antimony in the Fairbanks and Kantishna districts (21, 26, 27, table 1) amount to about 55,000 tons of metal (contained in low-

Table 1. Production and reserve base of selected strategic minerals in Alaska[1]

Mineral	1979 U.S. net import reliance (%)	Major foreign source	Past production	Proven reserve	Inferred reserve	Major Alaskan deposits or districts with past production, reserves, or promising resources[2]	Remarks	Major industrial uses[3]
Columbite (niobium)	100	Brazil, Canada, Thailand, Malaysia	- - -	- - -	- - -	Bokan Mt. (68), Rapid River (8), Lost River (14), Tofty Tin Belt (18), and Ruby (17) contain potentially recoverable niobium	- - -	MHD generators; energy converters, biological research
Optical and sheet mica	100	India, Brazil, Madagascar	- - -	- - -	- - -	Promising resources at Sitkan Island (66), Silver Bay (61), and general Seward Peninsula	- - -	Electronics
Manganese	98	Gabon, Brazil, Australia, S. Africa	- - -	- - -	- - -	Sinuk deposits (15), Nation River area (23), central Alaska Range all contain unevaluated manganese resources	Not now important	Steel alloys, batteries, chemicals
Tantalum	96	Thailand, Canada Brazil, Malaysia	- - -	- - -	- - -	Tofty Tin Belt (18), Lost River (14), Bokan Mtn. (68), Rapid River (8), Ruby placers (17) all contain unevaluated resources	Tantalum could be recovered at Tofty today	Electronics, miscellaneous machinery, alloys
Cobalt	90	Zaire, Zambia	- - -	63,600,000 lb	55,703,400 lb	Brady Glacier (52), Yakobi Island (53), Mirror Harbor (54), Funter Bay (57), Spirit Mtn. (45), Bornite (11)	18% of U.S. reserve base, potential for reserve-base expansion in Panhandle deposits and at Bornite	Aerospace, electrical, catalysts, classified military uses
Chromium	90	S. Africa, USSR, Turkey	36,849 tons (38%-42% Cr_2O_3) 1944-58, 1976)	215,530 tons (23%-42% Cr_2O_3)	127,930 tons (12%-36% Cr_2O_3)	Red Mtn. (38), Claim Point (39), Bernard Mtn (44), Kanuti River (22), De Long Mts (4), Eklutna (41-42), Union Bay (65)	Potential nationally significant resources statewide; present reserve not important	Metallurgical industry, construction, refractories, transportation
Platinum-group metals	89	S. Africa, USSR	569,500 oz (dominantly platinum) (1928-76)	760,000 oz	171,895 oz	Goodnews Bay (36), Brady Glacier (52), Salt Chuck (67), Yakobi Is (53), Mirror Harbor (54), zoned mafic-ultramafic rocks in SE and SW AK, misc. placer camps statewide (as by-product of gold mining)	Past production largest in the U.S., 50% of U.S. recoverable reserves found in Alaskan deposits (except for platinum resource of Stillwater complex). Potential for significant reserve-base expansion in Panhandle deposits	Catalysts, electronics, dental, chemical
Asbestos	85	Canada, S. Africa, Turkey	3,000 lb tremolite asbestos (1942-44)	Not released	Not released	Doyon's Slate Creek (25), Shungnak (5), Nyac (33), Eastern Alaska Range (47)	Doyon's Slate Creek asbestos deposit one of the largest in the U.S.	Fireproof cement, friction products, gaskets, textiles

Mineral	1979 U.S. net import reliance (%)	Major foreign source	Past production	Proven reserve	Inferred reserve	Major Alaskan deposits or districts with past production, reserves, or promising resources[2]	Remarks	Major industrial uses[3]
Tin	81	Canada, S. Africa, Indonesia, Bolivia	4,556,157 lb (1905-79)	125,973,000 lb	5,046,000 lb	Western Seward Pen (13, 14), Taffy belt (18), Boulder Creek (Purkey Pile) (29), Rapid River (8), Chulitna belt (28), Sithylemenkat (22)	80% of U.S. reserve base, excellent chance for reserve-base expansion at Lost River (14). General Alaskan tin potential is excellent	Containers, electronics, construction, solder, bronze
Fluorine	81	Mexico, S. Africa, United Kingdom, Italy, Spain	- - -	4.94 million tons	- - -	Lost River (14), Porcupine Lake (7), Groundhog-Glacier Basin (63), Sinuk deposits (15),	25% of U.S. reserve base; excellent chance for reserve-base expansion at Lost River	Steel industry, hydrofluoric acid
Nickel	77	Canada, Norway, New Caledonia, Dominican Rep.	- - -	1,123 million lb	950,561,500 lb	Brady Glacier (52), Yakobi Is (53), Mirror Harbor (54), Hunter Bay (57), Spirit Mtn (45)	20% of U.S. reserve base (one of the largest nickel-sulfide reserves in U.S.)	Electroplating, batteries, stainless steel
Mercury	62	Algeria, Spain, Italy, Canada	2,300,000 lb (1942-74)	Unknown	1,500,000 lb	Red Devil (32), Cinnabar Cr (34), White Mtn, De Coursey Mtn (31), numerous other prospects in SW Alaska	During 1930s, Alaskan miners contributed 10% of U.S. production; reserves difficult to block out in mercury deposits. Alaskan production could resume with high prices.	Scientific control instruments, batteries, chloro-alkali industry, medicine
Tungsten	99	Canada, Rep. Korea, Bolivia	276,000 lb WO_3 (1916-58, 1973-79)	19,545,560 lb WO_3	34,008,000 lb WO_3	Lost River (14), Gilmore Dome (21), Hyder (64), Big Hurrah (16), Chichagof (55), Majoria Glacier (50, Kanuti River, Upper Hodzana (22), Golden Horn (30), misc. placer districts (by-product), Chatley River-Circle area (24), Willow Creek (40), Chulitna (28)	20% of U.S. reserve base. By-product production from Lost River very significant; Upper Hodzana-Kanuti River, Chatley River and Circle areas are important tungsten provinces	Nuclear, space, and aircraft 'super alloys,' electronics, tool steel
Antimony	43	China, Mexico, Bolivia, Yugoslavia	10,493,360 lb (1915-78)	Not released	110 million lb	Scrattord (Treasure Cr (21), Stampede (26), Slate Cr (27), Sawtooth Mtn (19), Stibnite Cr (47), Wiseman, and Nome areas, Chulitna (28), Red Devil (32)	Past production = 18% of all historical U.S. production. Inferred reserves (30% of U.S. reserve base) are largely low-grade ores	Fire retardant, babbitt, solder, batteries, refractories

[1]Proven and inferred reserves and resources based on definitions supplied by Thrush (1968, p. 378, 872, 914). Reserves for each commodity have been lumped to avoid disclosure of confidential information derived from unpublished private-industry data. Other strategic minerals---cesium, bauxite, and selenium---are judged not to be significant in Alaska.
[2]Numbers in parentheses denote locations in fig. 1.
[3]Uses derived from USBM 'Commodity Summary - 1980' and 'Metals Week.'

grade ores) and represent about 14 months of U.S. consumption. Roughly one-third to one-half of Alaska's potential antimony resources are contained in mines in Denali National Monument (Kantishna Hills); the Fairbanks deposits are largely on lands where mineral development is permitted.

The proven and inferred reserves of tungsten at Lost River, Big Hurrah, Hyder, Gilmore Dome, and Majorie Glacier (14, 16, 64, 21, 50, table 1) amount to about 1 year of annual U.S. consumption of WO_3. Most of Alaska's known economic[1] tungsten reserves are on lands open to mineral development; however, areas showing promise of being important tungsten provinces are in withdrawn areas such as the upper Hodzana River-Kanuti River trend, the Charley River drainage in the Yukon-Tanana Uplands, and the Old Crow-Bear Mountain area in east-central Alaska.

The inferred reserve of high-grade chromite ore and concentrates in deposits near Seldovia, equal to about 300,000 tons of 28 percent Cr_2O_3 (38, 39, table 1), amounts to about 6 weeks of present U.S. consumption. These reserves are on state and federal lands open to mineral entry; however, most of the remaining Alaskan chrome resources have been withdrawn from mineral entry. We judge that the best potential chromite belts in Alaska, besides the Seldovia-Eklutna trend, are, in descending order: 1) the Caribou Mountain occurrences (part of Kanuti National Wildlife Refuge proposal), 2) the Bernard Mountain trend (partly in Wrangell National Monument), and 3) the Baranof Island occurrences in Southeastern Alaska (partially in a section 204 withdrawal) (22, 44, 58, table 1). Although the De Long Mountain deposits (Noatak National Monument) are judged to be too remote to be viable today, the potential chrome resources there appear to be very large (4, table 1).

The most promising Alaskan asbestos deposit is on lands explored by Doyon, Inc. near Eagle (25, table 1), and is open to development. Many other asbestos occurrences in the state are also on lands where development is allowed.

Alaska's 4.94 million tons of fluorite, contained mainly in high-grade ores on the Seward Peninsula (14, table 1), amounts to 5 years of present U.S. consumption. The possibility of expanding Alaskan fluorite reserves, which represent one-fourth of the U.S. reserve base, is excellent. The fluorite prospects on the Seward Peninsula are primarily on lands open to mineral entry. However, significant fluorite shows to the east of the Pipeline Haul Road, near Porcupine Lake in the eastern Brooks Range (7, table 1), are located in proposed additions to the Arctic National Wildlife Refuge.

There are almost no areas of conflicts regarding Alaska's mercury reserves or resources; none of the significant past producing mines in the Kuskokwim River region (31, 32, 34, table 1) are in federal conservation units.

Much of the state's known potential for optical and sheet mica is included in the Misty Fiords National Monument and in a section 204B withdrawal in the Tongass National Forest, both in the Southeastern Panhandle of the state (61, 66, table 1).

Significant niobium and tantalum resources exist at Bokan Mountain in Southeastern Alaska, in the Manley-Tofty district, in the Ruby mining camp, and at Lost River on the Seward Peninsula; all are open to mineral development (68, 18, 17, 14, table 1). Two areas with reported niobium anomalies have been withdrawn from mineral entry: Serpentine Hot Springs (Bering Land Bridge National Monument) and the Old Crow area (proposed addition to the Arctic National Wildlife Refuge) (12, 8, table 1).

On the basis of present geological knowledge, the potential for development of the remaining strategic commodities---cesium, manganese, bauxite, and selenium---are judged to be not affected by federal lands withdrawn from mineral entry.

[1] Majorie Glacier by-product tungsten reserve in Glacier Bay National Monument is judged to be subeconomic.

Table 2. Production and reserve base of selected critical minerals in Alaska

Mineral	1979 U.S. net import reliance (%)	Major foreign source	Past production	Proven reserve	Major deposits or districts with past production, reserve base or promising resources	Remarks	Major industrial uses
Rutile or ilmenite (titanium)	100	Australia, Japan, India	- - -	- - -	Lituya Bay (beach placers) (51), Klukwan (49), Snettisham (60), Kemuk Mtn (35)	Millions of tons, titanium metal in low-grade iron ore are potential nationally significant resource. Lituya Bay placers contain significant by-product platinum and gold as well	Jet engines, airframes, classified missile uses
Zinc (includes cadmium)	62	Canada, Honduras, Mexico, Spain, Germany	520,000 lb zinc metal (intermittently since [illegible] majority as a by-product	6,900,000 tons zinc metal	Mahoney Creek (69), Lik (1), Red Dog (2-3), Arctic (10), Sun (9), Ho & Udall (20), Greens Creek (58), Glacier Creek (48), Kantishna (26-27), Alaska Range, numerous areas statewide	15% of U.S. reserve base; significant by-product cadmium production possible. Alaskan zinc potential very large	Galvanization, alloys, brass, electrical equipment
Gold	56	Canada, USSR	30,150,336 oz (1867-1979)	1,500,000 oz	Greens Creek (58), Berners Bay (56), Fairbanks (21), Willow Creek (40), Ambler mineral belt (9-11), Iliamna Belt (37), Chulitna (28), numerous camps statewide	Current reserve 2% of U.S. reserve base, 1979 production of 65,000 ounces was 6% of U.S. production	Electronics, dental, jewelry, arts
Silver	45	Canada, Mexico, Peru, U. Kingdom	20,084,510 oz	192,500,000 oz	Greens Creek (58), Ambler mineral belt (9-11), Noatak deposits (1-2), Kantishna (26-27), Ruby (18), other camps statewide	13%-15% of U.S. reserve base. Alaskan mines could account for 30% of current U.S. production by 1992	Electronics, electroplating, solder, photography, brazing alloys
Barite	40	Mexico, Peru	750,000 tons (1915-16; 1964-79)	- - -	Petersburg (62), Lime Point (69), Red Dog (2), Atigun (6), Glacier Creek (48)	'Millions of tons' of barite in western Brooks Range	Well-drilling mud, numerous other uses
Gypsum	33	Canada, Mexico, Jamaica	510,000 tons (1905-26; 1950s)	650,000 tons 25% ($CaSO_4 \cdot 2H_2O$)	Iyoukeen Cove (59), Sheep Mtn (43), Bewltoft (16)	Past production significant, however, present reserves <0.5% of U.S. reserve base	Portland cement, various agricultural uses

Selected Critical Minerals in 49th State

Significant reserves and resources of seven critical minerals---titanium, zinc, cadmium, barium, gold, silver, and gypsum---are known to in Alaska.

Although there are no measured titanium reserves in Alaska, resources in low-grade titanium-iron deposits in the Southeastern Panhandle and in southwestern Alaska (49, 60, 35, table 2) and in beach placers at Lituya Bay (51, table 2) contain an in-place resource of millions of tons of titanium metal. The latter placers are in Glacier Bay National Monument, whereas the former deposits are both inside of and outside of federal conservation units.

Economic and near-economic reserves of zinc metal in Alaska exceeds 6.9 million tons, equivalent to about 15 percent of the U.S. reserve base. Several copper-zinc deposits in the Ambler mineral belt in the western Brooks Range (3, 10, 11, table 2) are outside federal withdrawals, but one major deposit in this belt, the Sun (Picnic) ore body (9, table 2), is partially within the Gates of the Arctic National Monument. Large zinc reserves at the Lik deposit north of Kotzebue are outside of federal conservation withdrawals, but the highly regarded Red Dog and Drenchwater deposits are in proposed additions to Noatak National Park (1, 7, 5, table 2). The zinc reserve at Greens Creek is in Admiralty Island National Monument. An unmeasured but significant by-product reserve of cadmium could be recovered from many of the zinc deposits.

Significant barite reserves in the Southeastern Panhandle (including a producing mine near Petersburg) are on lands where mineral development is permitted. There are also large resources of barite in the western Brooks Range, but they are mostly within areas that are not only withdrawn from mineral entry and development, but extremely remote (62, 69, 1, 2, 48, table 2).

Many promising and productive gold-silver mining regions throughout the state are on lands where mineral

development is permitted. Notable exceptions include the metal reserves at Greens Creek (Admiralty Island National Monument), which amounts to more than 20 million oz of gold-silver bullion; parts of the Chulitna and all of the Kantishna gold-silver mineral belts (Denali National Monument); the newly discovered Iliamna mineral belt (part of proposed addition to Katmai National Monument and Iliamna National Wildlife Refuge of HR39); and the major reserve of silver at the Sun deposit in the Ambler Mineral Belt, on the western boundary of Gates of the Arctic National Monument (58, 28, 26, 27, 37, 9, table 2). The Stanford Research Institute (Staff, 1978) included the Greens Creek and Sun deposits in their evaluation and calculated in their mine development model that Alaska could annually produce over 12 million ounces of silver and 90,000 oz of gold by 1992, equal to about 31 percent and 9 percent of current U.S. annual production, respectively.

Unmeasured but significant resources of former producing gypsum deposits on Chichagof Island (59, table 2), in the Southeastern Panhandle are on lands open to mineral development. An estimated 650,000 tons of 25- to 30-percent gypsum ore grade at Sheep Mountain west of Glennallen are partially within state lands classified for critical Dahl sheep habitat. An unevaluated gypsum occurrence at Baultoff in the northern Wrangell Mountains (46, table 2) is within Wrangell National Monument.

Discussion

It has been said many times and is worth saying again---Alaska has not been adequately explored for mineral resources.

Moreover, recent public land classifications in Alaska have not only withdrawn nationally significant reserves of strategic and critical minerals but have also discouraged or prohibited mineral entry and development in several promising mineral belts throughout the state.

According to a University of Alaska Mineral Industry Research Laboratory report (Metz, et al 1978), only 17 percent of the public domain in Alaska (federal, state, and municipal) is open to mineral entry. Other strategic and critical mineral deposits on lands open to mineral entry could not be developed during a national emergency or critical shortage in less than the better part of a decade.

Strategic and critical mineral production should be encouraged on lands where economic development is permitted. Additionally, it would be prudent to inventory all Alaskan strategic and critical mineral deposits in terms of the national interest---even within federal conservation units ---as well as on state and federal lands open to mineral entry.

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[2]Editors note: This paper is a condensed version of a DGGS individual report on Strategic and Critical Minerals in Alaska written for John Katz's use in the state's position on D-2 lands legislation. In that report the authors used 78 publications from both government and private sources that deal with strategic and critical mineral deposits in Alaska. This bibliography is available from the DGGS editor.

"The country is moving toward a system....in which business is flogged by government officials and regulators until it proves itself innocent---by reason of failure."---George Gilder, Harper's Magazine, Nov. 1979.