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J. A. KRUG, SECRETARY

BUREAU OF MINES
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INFORMATION CIRCULAR

ALASKA'S MINERALS AS A BASIS FOR INDUSTRY

BY

H. FOSTER BAIN

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By H. Foster Bain[2/]

CONTENTS

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2/ One of the consulting engineers, Bureau of Mines, U. S. Department of the Interior.

ILLUSTRATIONS

THE PROBLEM

Alaska, as has frequently been pointed out, has an area of 586,400 square miles, equal to about one-fifth of that of the continental United States, but according to the census of 1940, has a total population of only 72,524, after three-quarters of a century of American occupation following nearly one and a half centuries of Russian. Of the present population, approximately half is still composed of native races, Esquimo, Aleut, and Indian, with a low standard of living and limited buying power. The white population is increasing but slowly, despite the undoubted wealth of natural resources in the Territory.

Population growth in Alaska

Race	1880	1890	1900	1910	1920	1929	1939
White.....	430	4,303	30,507	36,400	27,883	28,640	39,170
Aleut.....	2,145	968)		1,491	2,942	Inc. in Indian	5,599
Esquimo...	17,617	12,784)	29,536	12,652	13,698	19,028	15,576
Indian....	11,478	9,522)		11,188	9,918	10,955	11,283
Other.....	1,756	4,218	3,549	2,625	595	655	896
Total	33,426	31,795	63,592	64,356	55,036	59,278	72,524

As was true of most of the States west of the Mississippi, Alaska pioneered by fur trappers and gold miners. Since it came into American possession its furs and fish have added more than a billion dollars to the national wealth and its mines more than three-quarters of a billion, the latter mostly in the form of gold. In the years immediately preceding World War II the Territorial fisheries were yielding approximately $60,000,000 a year, the mines $24,000,000, and the fur trade 2¼ million, yet the total population has hardly more than doubled in a half century.

Consider, by way of contrast, certain of our Western States which in general topography, climate, and character of resources are not entirely dissimilar. Montana may appropriately be taken as an example. This State has an area of 147,138 square miles of mountain and plain and in 1940 had a population of 4,150,003. It also was pioneered by fur trappers and gold miners. The fur traders were followed by cattlemen and farmers, and the gold seekers by miners of copper and other base metals. Smelters were built, power was developed, roads and railways were constructed, and industries in wide variety were developed. Between 1870 and 1940 the population increased from 315,358 to 4,150,003, and a great State having a soundly based and balanced economy has been developed (see figs. 1 and 1a).

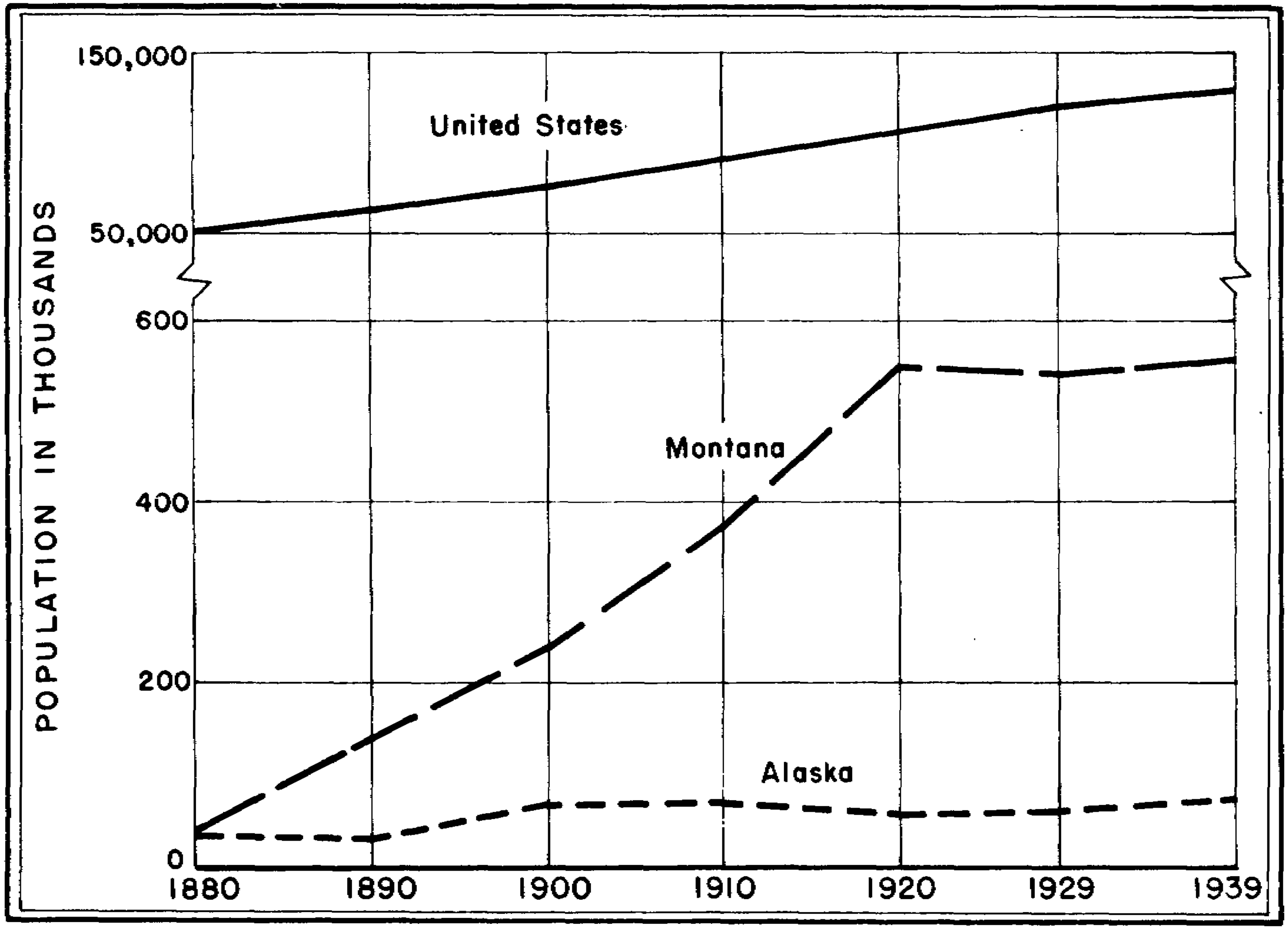

Figure I.- Growth of population in Alaska, Montana, and the United States.

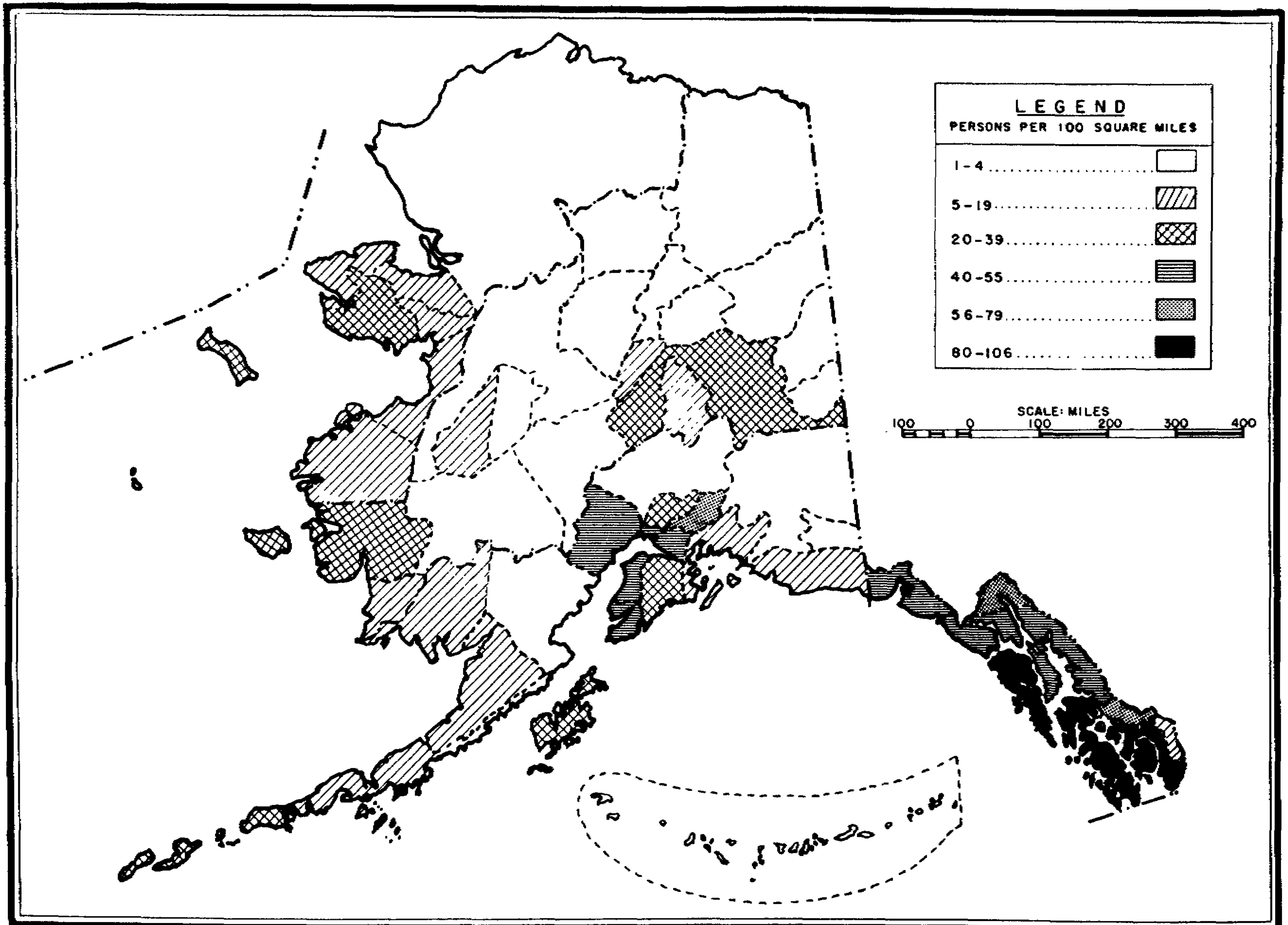

Figure IA.- Distribution and density of population in Alaska in 1939 (Source: United States Bureau of the Census).

A similar story could be related of Colorado and other Western States though the parallel with Alaska would be less close, primarily because of climatic differences. The settlers in each of the States had, however, to overcome the effects of distance and isolation. From the point of view of time of travel necessary, Alaska has long had the advantage, since its contact with its principal market center, Seattle, has been by ocean steamer, whereas Montana had for many years to depend on slow-moving covered wagons to connect with Chicago. Actually the first machinery to work the mines at Butte was hauled in on oxcarts, and the first shipments of ore were transported to railhead by the same means of transportation. From railhead they made the further long journey by rail and ship to Swansea, Wales, yet Montana has developed at a rapid pace and Alaska has not. What does Montana have that Alaska lacks?

Probably the first thought would be climate, but the differences are not as great as commonly supposed. Any country as large as Alaska is bound to have a wide variety of climates. They range, for example, from a winter low at Sitka which corresponds with that at Meridian, Miss., and Tallahassee, Fla., to a winter temperature in the Tanana Valley which is approximately the same as in Yellowstone National Park. The high and low extremes in the Matanuska Valley correspond fairly well to those in northern Minnesota and parallel latitudes west. In central Alaska the winter and summer temperatures similarly compare with those of North Dakota and northern Minnesota. The most significant climatic difference is the shorter growing season in Alaska. This is somewhat ameliorated by the greater number of daylight hours in Alaska's summer time. While the winters over much of the Territory are long and severe in the interior and on the Arctic coast, southern Alaska has a year-around climate that may properly be characterized as mild. Certainly the climate over much of Alaska is not more unfavorable than in large parts of the United States that have been pioneered and settled without undue hardship.

If climate is to bear any large part of the blame for the slow development of Alaska, it must be coupled with the fact that American life in recent years has become so easy that we do not have the same proportion as formerly of hardy pioneers willing to endure hardships in order to secure land and make homes of their own. With the great growth of industry, the avenues of opportunity have so multiplied and diversified that the majority of our people no longer live on farms, and the farmer's boy has now a wider choice than to follow his father in clearing a tract in the wilderness or breaking original sod on the prairies. With this change has come a lessening of attachment to the particular locality in which each of us was born and where each passed his early years. We have, as a nation, become detached from our home localities as well as from our parental vocations. While this has strengthened our nomadic instincts it has dampened the ardor to win a home from the wilderness which was the dominant motive in the spread of our people from the Atlantic to the West coast. This is probably a factor, possibly a considerable one, in the slower movement of population into Alaska than into the Western States settled earlier.

There is plenty of land to be had in Alaska, though it is of unequal value, as is true elsewhere. It is sometimes charged that it is locked up by the Government and unavailable to settlers, a charge not entirely sustained by examination of the figures. It is true that more than 98 percent of the area is still in the hands of the Federal Government. It is difficult to obtain an exact figure of how much land is really still so held since, to cite one difficulty, unpatented mining claims, so long as the miner files the necessary annual affidavits as to assessment work (which by no means always reflect the true facts), are withdrawn from entry by anyone else and even from resumption of ownership by the Federal Government, so that Uncle Sam is in the strange position of not always knowing what land he owns and what he has sold or given away. However, of the total acreage in Alaska less than 15 percent (53,490,414) at the end of 1936 had been reserved for any public purpose whatever. Nearly 325,000,000 acres were then still unappropriated and unreserved. The figures for today probably would be slightly, but only slightly, different. During the war several large temporary reserves have been created, but it is not expected that much if any of the land so covered will be permanently held. In addition to the 53,000,000 acres reserved by the Federal Government, 21,455,209 acres have been given to the Territory, mainly to support schools. The Territorial title to this land attaches as rapidly as surveys cover it. Obviously much the larger part of the Territory is open to settlement under the general land laws, and included in this open land is much that is good for one purpose or another.

Since this land is available in quantity and the natural resources of the Territory are large and varied - as they are - and since the climate does not differ greatly from that in areas we have already pioneered and settled, and access is at least as easy as it was to the Far West when the long immigrant trains wound their way into and across it, the question remains as to why Alaska is filling up so slowly.

There are undoubtedly many reasons, and the final answer lies in a combination of them rather than in any one. The major reason probably is to be found in the change that has taken place in American life since colonial days. If, when the stream of settlers moved west across the Appalachian Mountains, there had existed in New England and the Atlantic States the numerous opportunities to make a living and get ahead by going into industry that now exist in those areas, pressure of population on land would hardly have been felt, and it would have been only the spirit of adventure that would have called men to face the Indians and other dangers in the lands beyond the mountains. In those times, however, our East had only been industrialized to a very limited extent. Agriculture was almost the only industry men there knew. Now, vastly more men and women find a livelihood off the farm than on it and feel no necessity to move far away and endure unaccustomed hardship to secure land on which to raise food for themselves and their children. Despite periods of depression when, for some reason or another, thousands are thrown out of work for a time, there is no major permanent movement back to the land and no large migration. When the Okies swarmed into California it was in search of jobs, not of land. As a matter of fact, the larger part of those unemployed in business depressions have been so conditioned by their life, as units of industry, that they are not prepared to profit from the land, even when moved onto it and provided in advance with facilities and help which were unknown

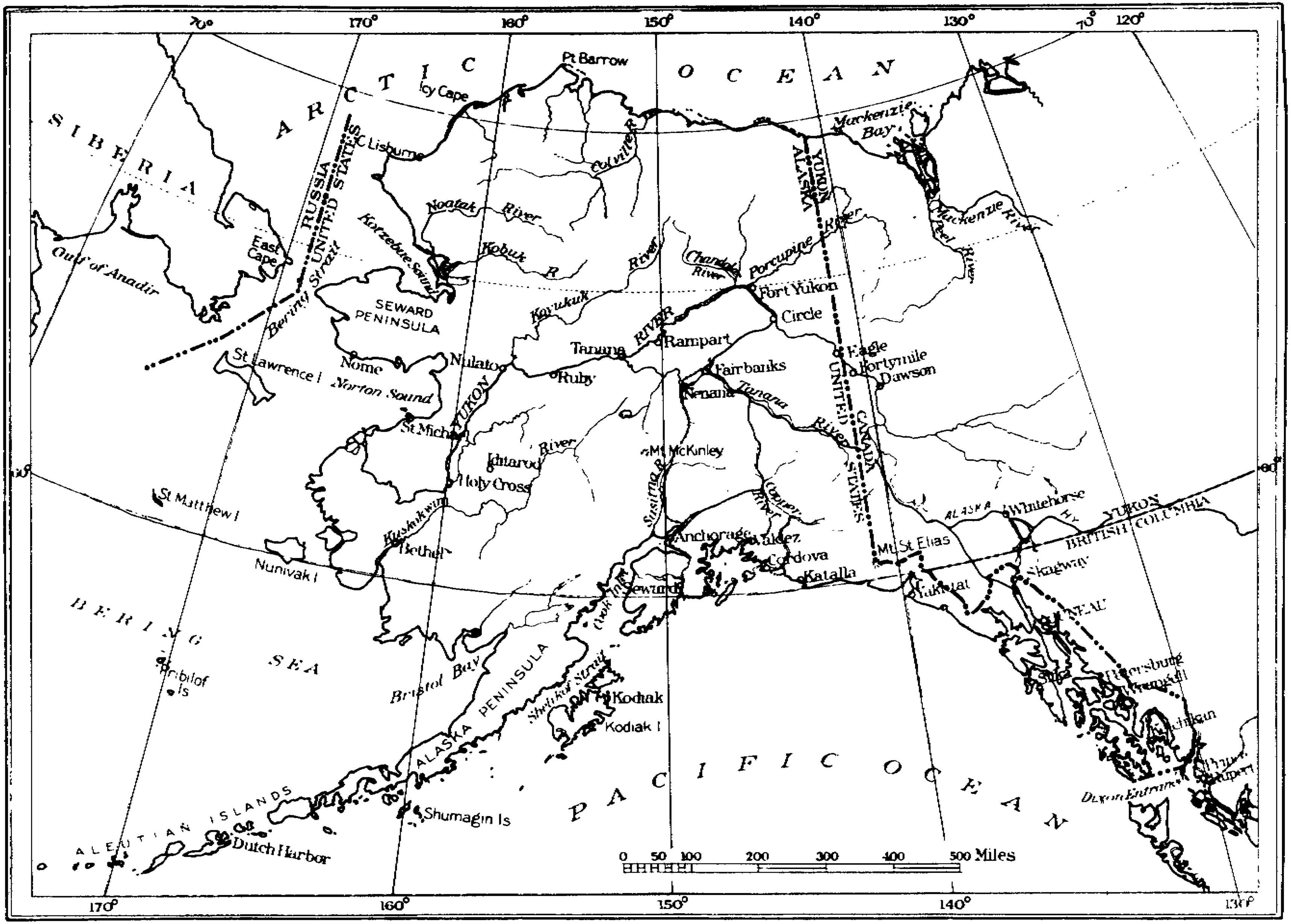

Figure 2.- Index map of Alaska from the Geological Survey.

to their pioneer ancestors. The history of the Matanuska settlement proves this abundantly. There most of the settlers originally moved in by Federal aid have drifted away. The present flourishing community is made up of successors - men who came of their own initiative. The early experience of the Reclamation Service, and indeed of many efforts in many parts of the world to give to misfits in the cities opportunities on wild land, prove clearly that such artificially stimulated migration is no sure method of inducing rapid and successful settlement. Men who for one reason or another make a failure of life in an environment with which they are familiar do not often make a success in one of which they know little or nothing. It takes more than land, barns, and a few animals to make a successful farm. The motives which, through so many years, led Americans to move farther and farther west from the seacoast strip they won in Colonial days and to build up, one after another, the magnificent States of our West, no longer dominate American life. The pioneer instinct has changed form and the frontier that attracts young men today is not geographic but industrial. If, after the Civil War, jobs at $5 per day and up had been available in the automobile factories at Detroit, few indeed of the returning soldiers would have homesteaded and fought grasshoppers and prairie fires to win even the rich corn and wheat lands of Kansas and Nebraska. It is in these psychological factors that much of the answer to Alaska's puzzle lies.

Economics, however, as well as psychology enters into the problem. People must be able to make a living, or they cannot remain in any area. Practically, too, they must have or think they have a chance to better themselves by emigrating, or they stay where they are. Subsistence farming is not an attractive occupation, and so far as agricultural life is concerned anything beyond that depends on opportunity to sell farm produce at some profit rather than merely to produce them. A market is as necessary as the land, and it connotes the presence of nonfarmers engaged in productive or service industries. Since the latter are nonagricultural dependent industries, some form of industrial production is necessary to a balanced and expanding industry. Historically the mines have most often been the basis for initiating and sustaining industry in a new country. There is a growing disposition to depend on chemistry to transmute surplus farm crops into industrial materials, but it is still true that it is the mines which supply the materials for the machinery of modern civilization, that furnish more than half the materials transported in commerce, and that truly form the backbone of our economic set-up today. For that reason, this special inquiry as to the part minerals have played and may play in the development of Alaska was undertaken in the summer of 1945.

THE COUNTRY

Alaska is a large peninsula with adjacent islands, at the northwest corner of the North American Continent (see fig. 2). It extends from 130° west to 173° east in longitude, stretching as far west of San Francisco as the latter is west of New York. In latitude it lies between 51° and 72° north, roughly the same as from London to Iceland. Despite its northern position, it is by no means the land of snow and ice that it was long popularly pictured, nor is the larger part of it really an Arctic country. Sitka parallels Edinburgh, and southeastern Alaska, where most of the people of Alaska live, parallels and is not greatly different from Scotland, although the mountains are higher. Geographically the country consists of two mountain belts with a plateau between and an Arctic plain to the north. The southern of the two mountain belts, the Pacific mountain system, is the extension to the north of the Coast Range of Oregon, Washington, and British Columbia. The international boundary runs along its crest to Mountain St. Elias, where the boundary turns north while the mountains continue northwest then southwest and the system swells out to form the Alaskan Range on the north and Chugach Mountains along the coast, with the Copper River Basin between. The Chugach Mountains also turn southwest around Prince William Sound and extend through the Kenai Peninsula and Kodiak Island out under the ocean. The Alaska Range, beginning with the Nutzotin Mountains near the international boundary, culminates in Mount McKinley and then swings to the southwest into the Aleutian Range which forms the backbone of a great peninsula and chain of islands extending nearly to Japan and dividing Bering Sea from the Pacific.

Beyond the Pacific mountain system and extending north to the Brooks Range is the Central Plateau region, which occupies an intermountain position similar to that of the Great Basin country of Utah and Nevada. This region is dominated by two great rivers, the Yukon and the Kuskokwim, and extends into Seward Peninsula to within 60 miles of Siberia. North of it, and trending in Alaska westward, is the Brooks Range, including the Endicott Mountains, Brooks Range, Baird Mountains, and DeLong Mountains. North of this, in turn, is the Arctic plain, which slopes from the mountains to the ocean at Point Barrow, the most northerly point on the mainland.

Glaciers and snowfields occur in the Pacific and Endicott Mountain areas, but are absent in the interior. The lower parts of the valleys in the Coast Range and of the Chugach Mountains are forested, and the interior and the south slopes of the mountains are covered with scattered timber; but the Arctic slope, most of Seward Peninsula, and large areas in the interior are tundra, covered with moss and low bushes, and set with many small lakes and pools. These, in summer, become breeding places for clouds of mosquitoes.

For purposes of discussion the Territory may be divided into six districts: (1) Southeastern Alaska; (2) South Central Alaska; (3) Southwestern Alaska; (4) the Interior; (5) Seward Peninsula; (6) Northern Alaska.

Southeastern Alaska is the most accessible region and the one best known to visitors. It is a rugged mountain area rising abruptly from the sea to 2,000 to 3,000 feet, but with crests rising 5,000 to 10,000 feet and in Mount Fairweather to 15,300 feet. This district lies between Canada and the Pacific, is cut by channels of the sea into numerous islands and peninsulas, and is a land of great scenic beauty and potential wealth in minerals, timber, and marine products.

South Central Alaska is similar, in general, to Southeastern Alaska, with Prince William Sound affording numerous good harbors. The timber in the

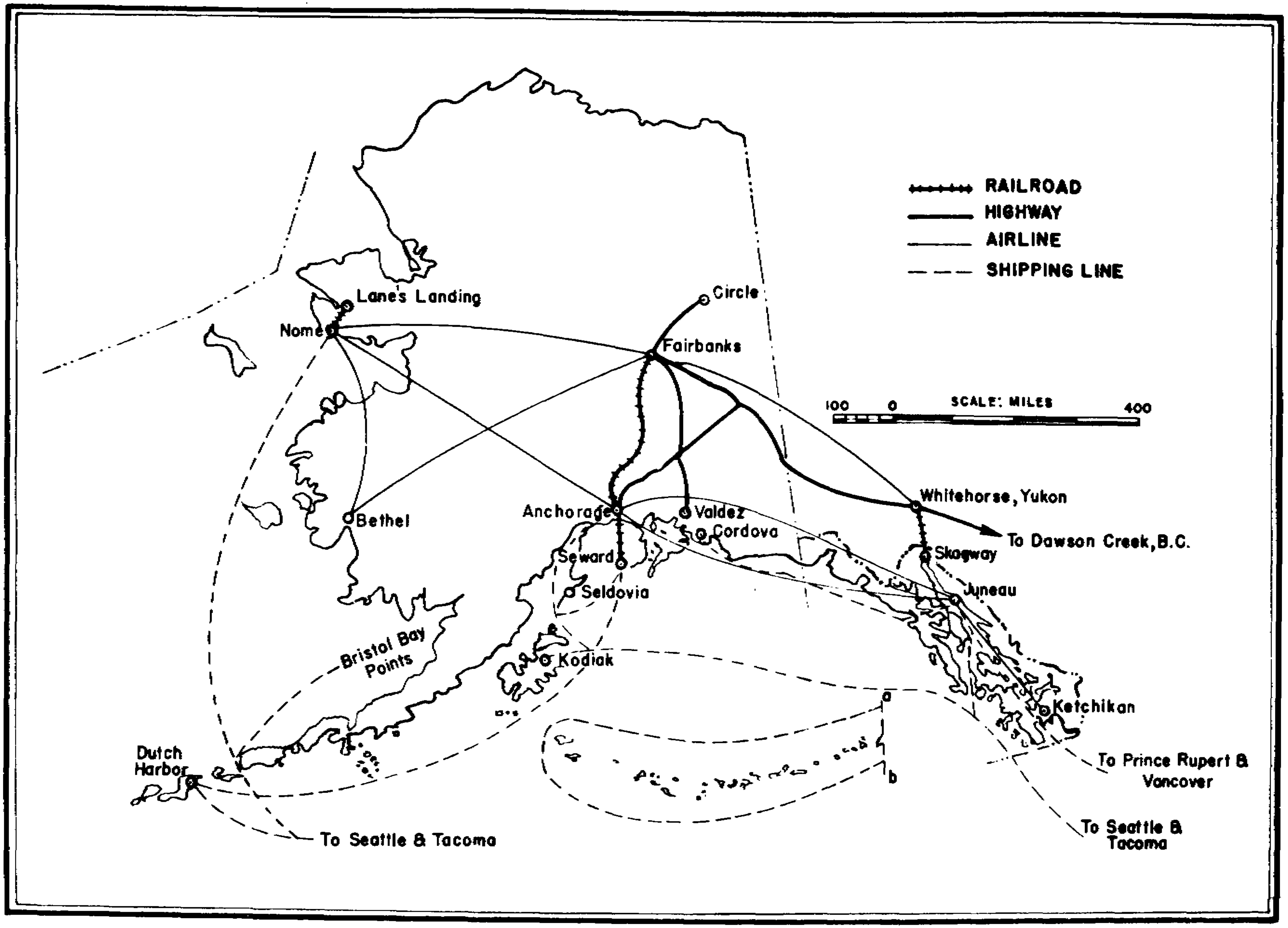

Figure 3.—Principal transportation routes to and in Alaska.

Chugach Mountains differs in character from that in Southeastern Alaska and is not so close-set. The mineral wealth is varied and, in particular, includes coal and potential oil fields.

Southwestern Alaska is little known, despite its being the area first occupied by the Russians. It stretches out into a series of wind-swept islands closed in by frequent fogs and is sparsely inhabited. Fishing is now almost the only industry, and Bristol Bay, on the inner side, is one of the great salmon-canning centers.

The Interior district of Alaska is dominated by the Yukon River, one of the first routes of access, now supplemented by the Alaska Railroad from Fairbanks to Seward on the Kenai Peninsula, the Richardson Highway to Valdez, and recently the Alaska Military Highway route to Whitehorse and points farther south in Canada. It is a country ranged by caribou and other wild life, with scattered areas of agricultural land and is now devoted to hunting, fishing and mining, especially placer mining.

The Seward Peninsula, which juts into Bering Sea north of the Yukon, includes some mountains but is mainly a low windswept tundra country, with important placers and a little lode mining. Fishing and hunting are native industries. Nome is the principal settlement and has steamer connection in summer with Puget Sound and, as is true of nearly all of Alaska, now has year-around air-transport connection as well. There is, in fact, through daily plane connection between Seattle and Nome, the time consumed being from morning to midnight (see fig. 3).

Northern Alaska is suitable for reindeer and is inhabited mainly by Esquimos, who generally live along the coast andrivers and who trap, hunt, fish, carve ivory, and are now finding occasional seasonal employment in varied industries such, for example, as driving trucks and caterpillars on land and motor boats along the coast and on the rivers. There are a few local coal mines and trading posts, as well as schools and other Government institutions. The Esquimos are not a tribal people but individual citizens and proud of their status. They are drifting into new occupations and are a potential asset of the Territory. On the Arctic Plain there are oil seeps and possible oil fields are now being explored by the Navy. Coal is found at a number of places.

The geological section in Alaska ranges from the pre-Cambrian and Paleozoic through Triassic, Jurassic, Cretaseous, and Tertiary to the Quaternary gravels so extensively worked for placer gold. The Devonian and Silurian contain nonmetallic resources of probable importance, the Jurassic, Cretaceous, Triassic, and Tertiary and are the potential source of petroleum, and the Tertiary includes most of the coal beds. In many localities the rocks have been repeatedly intruded by both acid and basic eruptives and have been widely metamorphosed. Igneous activity has taken place a number of times extending into the present, and in this circumstance of wide mingling of sedimentary and eruptive rocks lies the most hopeful prospect of a widespread and growing industry based on finding and mining metallic ores in rich variety.

The geography and geology of Alaska are mainly known through the work of the Federal Geological Survey, which began sending field parties into the Territory almost as soon as its own foundation in 1879. Among the geologists who contributed to the early knowledge of Alaska's geology may be mentioned, especially, W. H. Dall, I. C. Russell, C. W. Hayes, J. E. Spurr, W. C. Mendenhall, Alfred Brooks, and F. C. Schrader. In 1903 the Alaska Division was set up as a separate Branch of the Survey under the direction of Dr. Alfred H. Brooks, who long continued in charge and who became the first and undisputed authority on the region. He was succeeded by Dr. Phillip S. Smith, who but recently retired. In 1904 a map of the country was compiled from results from previous explorations. In 1906 Dr. Brooks published a general report on the geography and geology of Alaska[3], which remains standard for many districts and has been largely used in preparing the brief summary given above. In the years since, the survey has been pushed as rapidly as funds available have permitted. According to a memorandum prepared by Dr. John C. Reed, assistant chief Alaskan geologist, for use of a Congressional committee visiting Alaska in the summer of 1945, the progress in mapping has been as summarized below:

> Approximately half of Alaska has been mapped on reconnaissance standards by the Geological Survey during the past half century in connection with its investigations of the Territory's mineral resources. The annual appropriations for all such investigations have been very small and the suballotments for topographic mapping were necessarily extremely limited. However, a very effective, though small, staff of reconnaissance mapping experts was developed under this sustained program. This personnel, together with their special techniques and instruments, formed the nucleus of a large charting organization which was developed in 1941-42 by the Survey to supply terrain data throughout the world for the Army Air Forces. In connection with this program the greater part of Alaska has been photographed from the air, and aeronautical charts have been compiled therefrom.
>
> Because of the acute need for general Alaska maps, the Survey has recently started and expects to continue to use a small portion of its productive capacity in the preparation of a new general map of Alaska on the scale of 40 miles to the inch (see fig. 4). This project will incorporate on the new map the data now available from trimetrogon aerial photography and will provide for the first time a uniformly reliable general map of the whole of Alaska. Although it is hoped that this new map will be available for distribution within a period of months, and that good progress can be made on supplemental editions including contours and relief shading and on general maps of other scales, actual progress will depend on the funds that can be squeezed from an exceedingly limited budget that must also finance other high-priority projects.

3/ Brooks, A. H., The Geography and Geology of Alaska, a Summary of Existing Knowledge: Geol. Survey Prof. Paper 45, 1906, 327 pp.

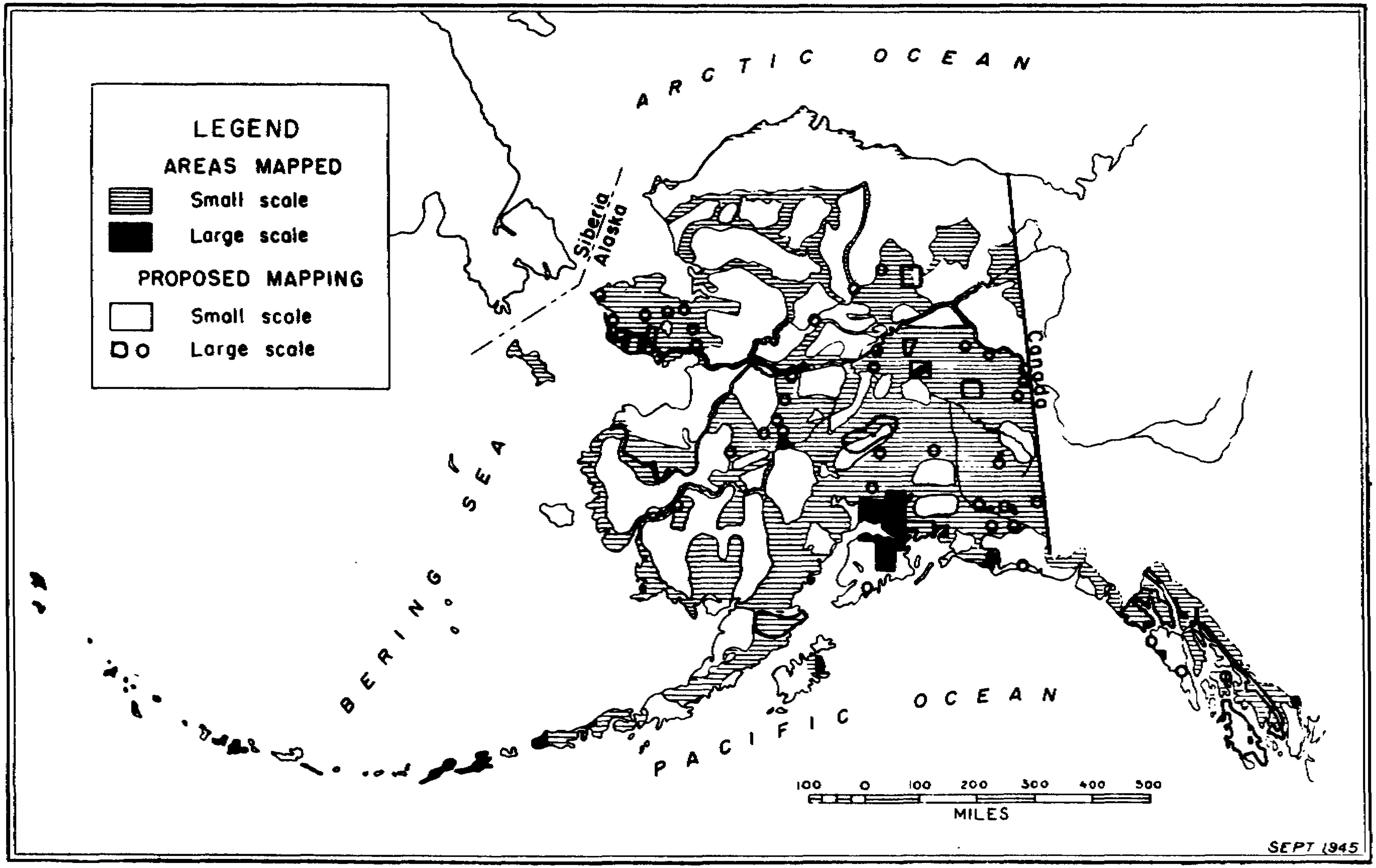

Figure 4.- Status of topographic mapping in Alaska

It will be noted in the attached diagram showing the present status of topographic mapping in Alaska, that approximately half of the Territory is still unmapped on the standard required for the most effective mineral investigations, general planning and development studies, utilization of forests, water power and other natural resources and the myriad activities for which a knowledge of the features of the land surface is essential.

It is hoped that, by the end of the current fiscal year, requirements of the War Department for chart production will have been alleviated to the extent of enabling the Geological Survey to assign personnel to resume its topographic mapping program for Alaska and that financial arrangements for supporting the program can be made. Because of the available aerial photography and the work accomplished by the Survey in connection with its worldwide charting program, the reconnaissance coverage could be completed within a few years, and a complete series of maps on a scale of 4 miles to an inch with 200 foot contours made available for public distribution and use.

Topographic maps on scales of 1 mile to an inch or ½ mile to an inch, with 10 to 100-foot contour intervals depending on local needs, should be made available as soon as possible for certain critical areas. The ultimate needs in Alaska for such large-scale maps, to facilitate the intensive development of areas of special importance, can not yet be estimated accurately. Such detailed maps must be supplied, during the first post-war years, for the most urgent projects and, subsequent to the completion of the Alaska reconnaissance maps, should be supplied for other areas as the needs arise.

The Survey geologists have issued some 600 separate reports and in them have covered, in some degree of detail, virtually all the districts in which there are mines or deposits of potential value. These reports and maps have been most useful and have been in such demand that a large number are out of print, though they still afford the best basis for any attempt at development in the areas covered. In many cases later work in adjacent areas would permit considerable revision and refinement of the maps, and geological questions unsettled when the report was written have since been resolved.

MINERAL RESOURCES

It has already been stated that in the years since the United States purchased Alaska its mines have poured more than three-quarters of a billion dollars worth of wealth into the national economy. Of this, much the largest part has been in the form of gold, which was mined to some limited extent from the first but which jumped into prominence as a source of wealth at about the turn of the century. The record of output of minerals as a whole is given in the following table:

Total value of mineral production of Alaska, 1880-1944[1/]

Year	Value	Year	Value	Year	Value
1880.......	$ 6,826	1903.......	$ 9,088,564	1926.......	$ 17,606,890
1881.......	15,000	1904.......	9,627,495	1927.......	14,402,440
1882.......	23,000	1905.......	16,490,720	1928.......	14,024,489
1883.......	67,146	1906.......	23,501,770	1929.......	15,946,830
1884.......	72,000	1907.......	20,840,571	1930.......	13,707,235
1885.......	425,000	1908.......	20,092,501	1931.......	12,371,057
1886.......	540,000	1909.......	21,140,810	1932.......	11,526,387
1887.......	657,000	1910.......	16,875,226	1933.......	12,681,071
1888.......	667,181	1911.......	20,866,122	1934.......	19,578,971
1889.......	847,490	1912.......	22,732,947	1935.......	18,811,544
1890.......	873,276	1913.......	19,645,498	1936.......	23,737,714
1891.......	1,014,211	1914.......	19,177,051	1937.......	27,927,958
1892.......	1,019,493	1915.......	32,854,011	1938.......	28,796,753
1893.......	1,104,982	1916.......	48,521,513	1939.......	25,673,566
1894.......	1,339,332	1917.......	40,710,655	1940.......	28,724,221
1895.......	2,588,832	1918.......	28,217,407	1941.......	26,809,380
1896.......	2,885,029	1919.......	19,616,909	1942.......	20,094,260
1897.......	2,539,294	1920.......	23,396,114	1943.......	9,055,000
1898.......	2,329,016	1921.......	17,041,057	1944.......	7,032,000
1899.......	5,425,262	1922.......	19,506,610	Total.......	902,557,000
1900.......	7,995,209	1923.......	20,241,137		
1901.......	7,306,381	1924.......	17,361,834		
1902.......	8,475,813	1925.......	18,286,320		

1/ Source of figures, as follows - 1880-1910: Bulletins on Mineral Industry of Alaska, prepared and issued by Alaskan Branch of Geological Survey; 1911-44: Mineral Resources of the United States and Minerals Yearbook, prepared and issued by Geological Survey (1911-23) and Bureau of Mines (1924-44).

Gold Mining

Approximately two-thirds of the total mineral production of Alaska has come from the gold mines, and of the total again roughly two-thirds has been won from placer ground. Details of gold production from 1880 to 1944 are given in the following table:

Gold produced in Alaska, 1880-1944

Year	Fine ounces	Total	Value Placer mines	Lode mines
1880-99...	1,153,889	$ 23,853,000	$ 8,692,000	$ 15,161,000
1900......	381,921	7,895,000	5,623,000	2,272,000
1901......	348,300	7,200,000	4,980,000	2,220,000
1902......	403,206	8,335,000	5,887,000	2,448,000
1903......	423,185	8,748,000	6,010,090	2,738,000
1904......	440,938	9,115,000	6,025,000	3,090,000
1905......	776,550	15,846,000	12,340,000	3,506,000
1906......	1,066,030	22,036,794	18,607,000	3,429,794
1907......	936,043	19,349,743	16,491,000	2,858,743
1908......	933,290	19,292,818	15,888,000	3,404,818
1909......	987,417	20,411,716	16,252,638	4,159,078
1910......	780.131	16,126,749	11,984,806	4,141,943
1911......	815,276	16,853,256	12,540,000	4,313,256
1912......	829,436	17,145,951	11,990,000	5,155,951
1913......	755,947	15,626,813	10,680,000	4,946,813
1914......	762,596	15,764,259	10,730,000	5,034,259
1915......	807,966	16,702,144	10,480,000	6,222,144
1916......	834,068	17,241,713	11,140,000	6,101,713
1917......	709,049	14,657,353	9,810,000	4,847,353
1918......	458,641	9,480,952	5,900,000	3,580,952
1919......	455,984	9,426,029	4,970,000	4,456,029
1920......	404,683	8,365,560	3,873,000	4,492,560
1921......	390,558	8,073,540	4,226,000	3,847,540
1922......	359,057	7,422,235	4,395,000	3,027,235
1923......	289,539	5,985,314	3,608,500	2,376,814
1924......	304,072	6,285,724	3,564,000	2,721,724
1925......	307,679	6,360,281	3,223,000	3,137,281
1926......	324,450	6,707,000	3,769,000	2,938,000
1927......	286,720	5,927,000	2,982,000	2,945,000
1928......	331,140	6,845,000	3,347,000	3,498,000
1929......	375,438	7,761,000	4,117,000	3,644,000
1930......	410,020	8,476,000	4,837,000	3,639,000
1931......	459,900	9,507,000	4,842,000	4,665,000
1932......	493,860	10,209,000	5,522,000	4,687,000
1933......	469,286	9,701,000	5,152,000	4,549,000
1934......	457,343	16,007,000	8,955,000	7,052,000
1935......	445,429	15,940,000	9,703,000	6,237,000
1936......	526,660	18,433,000	11,328,000	7,105,000
1937......	582,085	20,373,000	12,655,000	7,718,000
1938......	662,000	23,170,000	14,897,000	8,273,000
1939......	665,114	23,279,000	16,058,000	7,221,000
1940......	747,943	26,178,000	18,852,000	7,326,000
1941......	692,314	24,231,000	16,861,000	7,370,000
1942......	487,657	17,068,000	12,329,000	4,739,000
1943......	99,583	3,485,405	2,021,535	1,453,870
1944......	49,296	1,725,360	1,173,245	552,115
Total.....	25,671,689	608,623,765	399,310,780	209,302,985

Employment in the mines in recent years, as reported by B. D. Stewart, Commissioner of Mines, has been as below:

Year	Placers	Lode mines and mills	Coal and other mines	Total
1939..	3,928	1,986	229	6,143
1940..	4,240	1,974	149	6,363
1941..	3,965	1,805	218	5,988
1942..	2,175	1,065	249	3,489
1943..	556	581	321	1,449
1944..	658	489	393	1,540

Lode mining has so far been much less important than placer mining, with the exceptions of two properties, the Treadwell group and the Alaska Juneau,4/ from each of which very large returns have been won from very low grade ore by applying mass production methods involving heavy investment of capital and most skillful direction. Each of these mines was notable in turn for mining at a profit the lowest-grade gold ore in the world. Success in each constituted a monument to the persistent effort, indomitable will, and great skill of the late Fred W. Bradley of San Francisco, with whom were associated from time to time, some of the ablest men of the mining profession. Through the years 1885 to 1922, inclusive, the Treadwell group of mines produced $67,253,948 from ore averaging $2.34 per ton as mined. The mines received a death blow in 1917 when movement along a fault plane gave the sea access to the lower workings, though production was continued until 1922 in the Ready Bullion mine which, fortunately, was not flooded.

The Treadwell group of mines was owned by three companies operating on one great lode. The Alaska United, one of these companies, owned two properties - the 700-Foot mine, between the Alaska Treadwell and the Alaska Mexican, and the Ready Bullion, at the south end of the lode. The companies were owned largely by British shareholders, though there was a considerable American interest in them. Since there was a strong community of ownership among the three companies and the properties were adjacent, the management was early consolidated, and when the mines became flooded steps were in progress to amalgamate the companies themselves.

The complete record of production is so unusual that the figures are given in some detail below. They were kindly compiled for that purpose by the staff of the Alaska Juneau Gold Mining Co., which took over the residual properties of the Treadwell Co., and are presented here through the courtesy of P. R. Bradley, chairman of the board.

4/ For a general description of the geology, see especially Spencer, A. C., The Juneau Gold Belt: Geol. Survey Bull. 287, 1906, pp. 1-137. For further description of geology and mines of Southeastern Alaska see Geological Survey Bulletins 236, 259, 284, 314, 345, 442, 446, 504, 692, 739, and 783 and Professional Papers 1, 64, 87, and 120.

Tonnage and value of Treadwell output

ALASKA TREADWELL

	Tons milled	Value per ton	Total value
August, 1885-Dec. 31, 1915, inclusive	15,678,285	$2.4339	$38,159,038.63
Year 1916:..........................	671,378	1.99	1,337,305.53
Jan. 1-Apr. 21, 1917:...............	126,959	2.54	322,569.13
Total production:...............	16,476,622	$2.4166	$39,818,913.29

ALASKA MEXICAN

Jan. 1, 1894- Dec. 31, 1915, inclusive	4,270,331	$2.6526	$11,327,647.05
Year 1916:..........................	175,476	1.57	275,022.53
Jan. 1-April 21, 1917:..............	28,840	2.15	62,127.01
Total production:...............	4,474,647	$2.6069	$11,664,796.59

ALASKA UNITED (700-FT. MINE)

Apr. 15, 1899-Dec. 31, 1915, inclusive	2,138,018	$2.0918	$ 4,472,247.99
Year 1916:..........................	262,850	1.74	456,319.92
Jan. 1-April 21, 1917:..............	80,640	2.33	188,050.05
Total production:...............	2,481,508	$2.0619	$ 5,116,733.02

ALASKA UNITED (READY BULLION MINE)

Nov. 15, 1898-Dec. 31, 1915, inclusive	3,681,057	$2.0801	$ 7,657,095.47
Year 1916:..........................	286,078	2.11	602,194.31
Year 1917:..........................	201,943	2.18	439,514.44
Year 1918:..........................	191,342	2.26	432,270.68
Year 1919:..........................	266,111	1.81	482,201.85
Year 1920:..........................	298,914	1.87	558,930.04
Year 1921:..........................	266,938	1.72	458,628.20
Jan. 1-Dec. 18, 1922:...............	152,106	1.93	292,939.37
Total production:...............	5,344,489	$2.0439	$10,923,505.29

ALASKA UNITED (TOTAL BOTH MINES)

Total production:...............	7,825,997	$2.0496	$16,040,238.31

TOTAL - ALL DOUGLAS ISLAND COMPANIES

Total production:...............	28,777,266	$2.3464	$67,523,948.19

The dividend record of these companies is as remarkable as the other features of their operations. The figures for each company up to July 1, 1916, were summarized by the Consolidation Committee, consisting of H. C. Perkins, Hennen Jennings, and F. W. Bradley. Their grand summary for the group is reproduced below.

Tons (2,000 pounds) crushed.....	26,464,047.00
Yield..........................	$62,797,459.91
Yield per ton..................	$2.37
Operating profit...............	$25,038,597.07
Operating cost per ton..........	$1.42
Operating profit per ton........	$0.95
Dividends......................	$21,337,651.00
Dividends per ton...............	$0.85

To make any profit from such a low-grade ore would have been sufficiently remarkable in itself, but to be able to hand over to the shareholders one-third of the gross receipts was more remarkable still. This is all the more true when it is remembered that for much of the period of operations only stamp milling and amalgamation processes were available, though when cyanidation came in it was promptly applied to increase the recovery. Today nearly all marks of the Treadwell operations are gone, but the wealth they produced furnished capital that is usefully employed in many parts of the world. Now only a suburban community across the channel from Juneau marks the site.

The Alaska Juneau, the other great lode mine, is in the mountain back of the city, with access to the sea by adit and with a great mill and accessory works conspicuous on the mountainside directly south of Juneau. In many particulars it is a unique property. The ore consists of quartz stringers in greenstone, and the gold is found principally in the quartz or along the contact of the individual piece of quartz and the surrounding greenstone. In a minor degree it is associated, together with some silver, with finely divided iron and lead sulfides, and during recent years the major portion of the lead produced in Alaska has come from this mine. Despite the large scale of operations and the average low grade of the ore, it is still possible occasionally to see particles of free gold in the ore. In earlier years the mine was worked as an open pit in the summer season only, using Indian labor and water power, and by close hand-sorting a profit was made despite the small scale of operations. Later the mine was converted into an underground operation and a large mill built, which at first was operated at a loss. The plant was enlarged repeatedly, and larger and larger portions of the barren rock were sorted out until a profit began to appear on the books.

When the mine was closed down as a result of the economic dislocation incident to World War II, it was operating at the rate of 13,000 tons per day and was one of the world's outstanding low-cost producers as a result of applying mass production methods to gold mining.

The history of the property through its early years has been summarized by Clauson[5] as follows:

Early in 1897 the Alaska Juneau Gold Mining Co. was organized and on May 6, 1897, purchased 23 patented claims, which cover the greater part of the total apex of the lode now owned by the company. A 5-stamp mill had been crushing ore from these claims since 1893, and a 30-stamp mill was erected and began crushing in 1895. The ore treated in these mills was mined in open pits from areas showing the greatest number of quartz stringers. A large proportion of the slate and gabbro, which was broken with the quartz, was rejected before coarse crushing, the ratio of waste rejected to ore milled varying from 4:1 to 1:1. From 1893 to 1914, 472,783 tons of ore was mined in the open pits; from this amount 295,807 tons, yielding $2.26 per ton, was sorted and sent to the mill. For the years 1901 to 1912 inclusive of the above period from 1895 to 1914 of operations with the 30-stamp mill, milling and mining costs, together with the gold recovered, were as follows per ton mined and per ton milled.

Alaska Juneau 30-stamp mill

Year	Cost of milling per ton[1]		Cost of mining per ton[1]		Yield in gold per ton[1]	
	Mined, cents	Milled, cents	Mined, cents	Milled, cents	Mined, cents	Milled, cents
1901....	20.6	32.9	34.9	55.9	95.4	152.7
1902....	16.2	25.9	48.4	77.5	116.4	186.2
1903....	17.3	27.6	53.9	86.2	101.4	162.2
1904....	15.8	25.2	43.3	69.3	113.2	181.1
1905....	13.9	22.3	35.1	56.1	77.4	123.9
1906....	10.6	16.9	33.5	53.6	63.4	101.4
1907....	12.9	20.6	41.2	65.9	69.8	111.6
1908....	13.9	22.2	46.6	74.5	69.4	111.0
1909....	14.0	22.4	40.1	64.1	119.9	191.8
1910....	13.7	22.0	43.2	69.2	74.5	119.2
1911....	15.3	24.5	39.6	63.3	44.7	71.5
1912....	14.5	23.2	47.9	76.6	89.3	142.8

1/ Tons, 2,000 pounds.

As a result of these operations it was considered desirable by the company to tap the ore at a considerable depth below the surface and connect these deeper workings with the beach of Gastineau Channel. Although a number of tentative plans were considered, none took definite shape until 1910.

The new operations began with the driving of a long adit to undercut the old workings and by means of raises to connect through to the surface. A system of underground carving and of breaking the ground by giant blasts

5/ Clauson, V. C., The Alaska Juneau Mill: Min. and Sci. Press, San Francisco, May 7, 1921.

through powder drifts was developed, and the ore was carried out to the mill in train loads of 400 tons. At the head of the mill a picking belt was installed, and the coarse, dark country rock was rejected, the white quartz being sent forward to be milled. Through a term of years 39,482,014 tons of nearly barren rock was thus sent to waste dumps as against 44,428,244 tons crushed and milled. This system of rejecting so much of the rock mined and thus reducing the tonnage to be milled was an important factor in the ultimate success of the operation. Success, however, depended always on a narrow margin of profit, and constant vigilance was necessary. There were various ups and downs. Neighboring properties to the north and south were opened; but it was found that for various reasons they could not be operated profitably, and they were consolidated with the Alaska Juneau.

Details are given in the table below regarding the gold content of the ore and its recovery, the figures being taken from the report of the company for 1941.

Gold content of ore - 1893-1941, inclusive[1/]

Year	Tons of rock to mill from mine		Gold recovery per ton fine-milled		Gold losses per ton of tailings		Gold content of rock from mine to mill
	Tons of ore fine-milled	Tons of coarse tailings rejected	In bullion	In galena concentrates	Fine	Coarse	
1893-1913	330,278	176,976	0.1035	0.0097	0.0194	0.0073	0.0827
1914	60,026	2,410	.0445	.0087	.0131	.0077	.0639
1915	179,892	-	.0353	.0145	.0145	-	.0643
1916	180,113	-	.0227	.0068	.0145	-	.0454
1917	677,410	-	.0164	.0150	.0111	-	.0416
1918	574,285	17,933	.0281	.0082	.0092	.0073	.0445
1919	616,302	76,593	.0310	.0087	.0135	.0092	.0479
1920	637,321	305,549	.0440	.0121	.0164	.0106	.0522
1921	904,323	709,277	.0421	.0097	.0145	.0097	.0416
1922	1,108,559	1,201,991	.0440	.0116	.0145	.0097	.0392
1923	1,134,759	1,134,759	.0498	.0111	.0140	.0092	.0392
1924	1,367,528	1,700,662	.0532	.0140	.0145	.0097	.0421
1925	1,537,884	1,943,896	.0493	.0145	.0160	.0106	.0411
1926	1,649,678	2,180,022	.0440	.0126	.0145	.0097	.0362
1927	1,839,695	2,428,115	.0469	.0145	.0135	.0092	.0372
1928	1,795,191	1,922,949	.0648	.0198	.0155	.0101	.0537
1929	2,020,470	1,815,970	.0624	.0189	.0135	.0092	.0542
1930	2,066,239	1,858,221	.0581	.0203	.0135	.0092	.0532
1931	2,298,998	1,863,352	.0604	.0178	.0131	.0087	.0542
1932	2,414,469	1,587,161	.0493	.0135	.0116	.0082	.0484
1933	2,466,832	1,619,128	.0498	.0116	.0116	.0082	.0474
1934	2,387,138	1,915,462	.0503	.0034	.0116	.0082	.0402
1935	2,091,475	1,638,185	.0533	.0035	.0108	.0078	.0413
1936	2,462,046	1,904,754	.0544	.0061	.0089	.0069	.0422
1937	2,251,079	2,191,681	.0594	.0080	.0116	.0082	.0441
1938	2,478,928	2,184,952	.0515	.0081	.0090	.0071	.0398
1939	2,377,718	2,270,342	.0454	.0088	.0083	.0066	.0352
1940	2,308,397	2,431,393	.0442	.0089	.0081	.0065	.0331
1941	2,211,211	2,143,559	.0451	.0092	.0078	.0063	.0347
Totals and averages	44,428,244	39,432,014	.0507	.0114	.0119	.0084	.0432

1/ Gold in ounces. Tons, 2000 pounds.

A general summary of the economics of the operations from 1893 to 1944 is presented below, as given in the annual report for 1944.

Historical summary of operations, Alaska Juneau

Year	Tons Trammed	Gross values recovered	Operating general taxes and marketing costs	Gross operating profit
1893 to 1913, incl.	507,254	$ 707,730.15	$ 707,675.92	$ 54.23
1914	62,436	58,690.64	118,045.54	1/59,354.90
1915	179,892	214,877.52	303,765.97	1/88,888.45
1916	180,113	110,443.01	297,199.94	1/186,756.93
1917	677,410	459,359.56	660,370.91	201,011.35
1918	592,218	459,445.01	686,579.96	1/227,134.95
1919	692,895	542,713.99	703,226.60	1/160,512.61
1920	942,870	791,389.99	720,050.38	71,339.61
1921	1,613,600	1,035,250.65	1,004,644.87	30,605.78
1922	2,310,550	1,388,679.27	1,160,299.44	228,379.83
1923	2,476,240	1,514,774.14	1,344,713.67	170,060.47
1924	3,068,190	2,055,781.89	1,609,919.25	445,862.64
1925	3,481,780	2,184,384.08	1,826,903.46	357,480.62
1926	3,829,700	2,067,836.60	1,893,342.72	174,493.88
1927	4,267,810	2,463,262.38	2,206,850.23	256,412.15
1928	3,718,140	3,316,018.99	2,159,219.49	1,156,799.50
1929	3,836,440	3,627,247.31	2,233,071.71	1,394,175.60
1930	3,924,460	3,551,950.03	2,289,356.14	1,262,593.89
1931	4,162,350	3,879,839.30	2,394,948.19	1,484,891.11
1932	4,001,630	3,236,183.06	2,154,730.72	1,081,452.34
1933	4,085,960	3,960,165.46	2,179,547.34	1,780,618.12
1934	4,302,600	4,582,558.97	2,409,046.61	2,173,512.36
1935	3,729,660	4,281,110.26	2,443,544.42	1,837,565.84
1936	4,366,800	5,400,620.78	2,850,724.48	2,549,896.30
1937	4,442,760	5,516,414.20	3,156,305.97	2,360,108.23
1938	4,663,880	5,364,487.82	3,348,954.96	2,015,532.86
1939	4,648,060	4,695,537.40	3,404,112.32	1,291,425.08
1940	4,739,790	4,447,171.30	3,313,713.86	1,133,457.44
1941	4,354,770	4,370,920.49	3,209,509.95	1,161,410.54
1942	2,765,190	2,749,118.19	2,245,833.27	503,284.92
1943	1,461,830	1,455,860.76	1,536,822.27	1/80,961.51
1944	378,800	353,517.70	600,246.60	1/246,728.90
Totals	88,466,078	$80,843,340.90	$57,173,277.16	$23,670,063.74

1/ Deficits.

Tons, 2,000 pounds.

Historical summary of operations, Alaska, Juneau (cont'd)

Year	Nonoperating expense and revenue net	Depreciation and Federal taxes	Net (before depletion)	Dividends declared to date
1893 to 1913, incl.	$ 9,852.37	$ 6,495.93	$ 1/16,294.07	-
1914	31,410.75	11,619.85	1/102,385.50	-
1915	2/17,547.11	28,107.69	1/99,449.03	-
1916	2/37,659.25	75,108.52	1/224,206.20	-
1917	19,562.58	124,970.28	1/345,544.21	-
1918	98,364.86	143,256.94	1/468,756.75	-
1919	93,468.13	150,666.29	1/404,647.03	-
1920	138,790.68	158,797.09	1/226,248.16	-
1921	199,337.62	165,117.02	1/333,848.86	-
1922	206,238.40	167,252.65	1/145,111.22	-
1923	200,143.27	168,519.59	1/198,602.39	-
1924	186,368.81	172,968.91	1/86,524.92	-
1925	191,592.25	180,335.76	1/14,447.39	-
1926	208,648.20	186,750.13	1/220,904.45	-
1927	223,424.29	189,541.83	1/156,553.97	-
1928	176,700.29	198,970.58	781,128.63	-
1929	129,243.66	302,542.40	962,389.54	-
1930	170,860.61	293,280.18	798,453.10	$ 144,060.00
1931	37,678.91	325,950.14	1,121,262.06	620,890.90
1932	2/6,595.46	147,938.15	940,109.65	756,000.00
1933	2/686,625.13	323,459.21	2,143,784.04	1,333,260.00
1934	2/47,803.12	269,924.04	1,951,391.44	1,763,039.10
1935	2/11,072.65	284,840.58	1,563,797.91	1,800,000.00
1936	2/90,188.73	364,879.27	2,275,205.76	1,800,000.00
1937	2/55,010.46	329,825.40	2,085,293.29	2,015,250.00
1938	2/42,397.77	300,610.01	1,757,320.62	1,710,625.00
1939	2/38,330.98	213,243.42	1,116,512.64	1,041,250.00
1940	2/31,622.33	239,064.64	926,015.13	855,312.50
1941	2/41,553.92	285,037.55	917,926.91	371,874.75
1942	2/71,016.49	217,345.46	356,955.95	-
1943	2/79,164.65	109,464.99	1/111,261.85	-
1944	2/64,054.39	81,138.70	1/263,813.21	-
Totals	$1,001,043.24	$6,217,023.20	$16,451,997.30	$14,211,561.35

1/ Deficits.
2/ Net revenue.

It will be noted that there were no profits from the operation through a term of years while the mine was being built up and equipped or, again, after 1941, when war conditions affected operations adversely. It was not only that prices of supplies and labor rose in these later years; but, perhaps more importantly, shortage of manpower reduced output and increased unit costs. The management struggled to keep the operation going, but the decision of the War Labor Board decreeing an increase in wages with retroactive payment finally made it cheaper to pay shut-down expenses than to continue to operate at a deficit, and the directors reluctantly closed the property early in 1944. This closure of one of the principal industrial units in the Territory would have been a paralyzing blow to its economy had it occurred at any time other than when war demands called for every man and for most of the equipment available in the area. It is to be expected that the company, with its heavy investment and large remaining ore reserve, will make every effort to resume operations as soon as possible; but the whole wage pattern in Alaska has been so distorted by the war that resumption will be extremely difficult, and delay is to be expected. It is to be remembered that gold miners operate against a fixed price for their output and have no way to compensate for higher costs by increasing the sale price of their product. In 1932, for the first time in many years, the price of gold, in terms of United States dollars, was increased substantially, but it is considered that since then the cost of taxes, supplies, and labor have increased so much as to wipe out the margin of profit so created. For gold mining in general, the remedy is, as in other industries, to drop marginal ores and produce only high grade. This is impossible in the case of Alaska Juneau unless perhaps the management goes back to the five stamp mill and seasonal operations of 50 years ago. The record shows clearly that the mine can only be operated profitably by mass production methods and on a large scale. There is no way to run it as a small mine, and this fact also precludes resuming operation on a small scale and building up the tonnage gradually. It is for these reasons that a delay for an undetermined period is to be anticipated. Any consideration of possible increase in price of gold involves so many factors of national policy and of politics that the subject is hardly worth discussing. Meanwhile, one of the largest industrial units in the Territory, with abundant raw material and complete and proved equipment, remains idle.

As the production figures already quoted show, about two-thirds of the gold output of Alaska has come from placers rather than lode mines. This face has had great significance in the industrial history of the Territory because the impact on the economy of any area differs greatly in the case of the two forms of mining. Placer mining is an outdoor operation; lode mining is conducted underground. The former is to a very large extent seasonal, especially in a country having severe winters, as is true of most of Alaska. Lode mining continues the year around. One of the greatest handicaps that Alaska has had to face is that such a large portion of its industries is seasonal. In salmon canning, Alaska's largest industry, there are only 2 months annually of great activity and 4 months in all, including preparation and closing of the plants. Most of the year only a few watchmen are needed, and the larger part of the labor is brought in from outside for the season and returned to mainland when the canneries close. Outside, the men find work in other seasonal occupations or loaf through the winter.

Somewhat the same condition obtains in the gold placer industry, although the working season is longer and the movement of labor to and from the mines is almost entirely a matter of individual initiative. The companies now operating the larger placer operations have, by careful organization and many ingenious methods, done much to decrease the seasonal character of the work and to give full-time employment to as large a portion of the labor force as possible by bunching repair and renewal work in the winter months and by other methods. At best though there is some four months each year when the labor force is much reduced. The United States Smelting, Refining & Mining Co. was able to operate its dredges 265 days in 1939 in the Fairbanks district but only 163 days in the Nome district. Since many of the part-time workers go outside for the winter, a considerable part of their wages is not spent in the Territory, and at best the portion of the expense that wages constitute in so highly mechanized an industry as dredging is small in proportion to the output. In lode mining the cost of labor is still the largest item of expense. As one result of the seasonal character of Alaskan industry, it is true that, not counting cruise passengers, the annual inflow and outflow of passenger traffic on steamers to and from the Territory is not much less than the total permanent white population of the Territory. Alaska needs nonseasonal industries. Large lode-mining enterprises would supply this lack to some extent and in addition would furnish winter employment to hundreds of men who spread out as prospectors in the summer and so bring about additional development. It is a deliberate policy followed by most big mines around the world to foster this. In addition, the Treadwell companies long followed the policy of never refusing a job to any applicant who was able and willing to work. The management found it cheaper to let its reputation of always giving a job spread among western miners than to face the possible cost of recruitment and shipping in of labor. Companies and enterprises operated along such lines are needed in Alaska to balance the economy and to neutralize the handicap due to so much of the work being concentrated in the summer season.

Two other gold lode-mining districts than those cited have proved important, each yielding more than $20,000,000. Of these, the Chichagof6/ is in Alaska near Sitka, and while operations were on a much smaller scale than in the big mines near Juneau, the grade of ore was higher so that the profit was satisfactory. The second, the Premier mine in the Hyder district, is in the extreme southeast of Alaska, just across the line in Canada on the Portland Canal. Several good lode mines have been operated in this district, but the Premier is best-known and has been most profitable. Alone it has produced more than $20,000,000 worth of ore, mainly valuable for gold. Other minerals, notably lead, silver, and tungsten, are also mined in the Hyder district.7/ In the Willow Creek district in the railway belt lode mines have been operated for several years,8/ and in the Fairbanks district a number of small

6/ Reed, John C., and Coats, Robert R., Geology and Ore Deposits of the Chichagof District in Alaska: Geol. Survey Bull. 929, 1941, 148 pp.
7/ For general description, see Buddington, A. F., Geology of Hyder and Vicinity, with a Reconnaissance of the Chickamin River, Southeastern Alaska: Geol. Surv. Bull. 807, 1929, 124 pp.
8/ Capps, S. R., Willow Creek District: Geol. Surv. Bull. 607, 1915, 86 pp.

lode mines have been opened.9/ In the Prince William Sound area10/ the principal gold production has come form the Cliff mine near Valdez, which has been closed for some years but may be reopened. The country is rugged and difficult to get over so it has not yet been fully prospected. Both gold and copper have been mined in this area. In Southwestern Alaska gold has been mined in several localities. The Apollo mine on Unga Island was an important producer 40 years ago. The whole Aleutian Peninsula has been studied by the Geological Survey, and its geology has been described in various of its reports. In 1945 Unga and the adjacent Popof Island were examined by Burr S. Webber of the Bureau of Mines, but his report is not yet available. Despite its ready accessibility from the sea, Southwestern Alaska seems so far not to have received the attention from prospectors and miners that its probable importance warrants.

Other lode mines have been worked in various parts of Alaska but have not as yet proved large, and many of the operations have been short-lived. No important gold mining strike had been made in 10 years before World War II, which absorbed the attention of Alaskans and all but stopped gold mining. Considerable areas remain unexplored, and more have been inadequately explored, even for placer gold, which is the form most easily detected and which requires the least equipment and capital for either prospecting or operating. The outlook for lode mining is obscure, despite the fact that scouts have been maintained in the Territory for a number of years by several of the larger mining interests. Their failure so far to find, or to secure control of, desposits satisfactory to their principals does not necessarily prove the absence of good properties. For many excellent reasons the big mining houses cannot afford to take up small properties, and they rarely do so unless such properties show distinct promise of being capable of being developed into big ones. There is a gap between the prospector and his prospect on the one hand and the large mining interests which command the capital and have the staffs and experience to operate big mines on the other. That even very low grade ores can be worked at a profit if the ore bodies are sufficiently large for mass production methods has been proved in Alaska as elsewhere; but it requires time, patience, and money to open up enough ground to prove in each case that the ore body is of sufficient size and of high enough average grade to warrant the large investment necessary. Such enterprises are by no means always successful, and large sums have been lost even in Alaska in the attempt to convert prospects into mines. No entirely satisfactory type of organization has been developed to bridge this gap.

So far as Alaska gold mining is concerned, it is a further fact, probably of considerable significance, that so large a proportion of the output has been and continues to be from the placers. This, coupled with the

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9/ For a general account of the geology see: Prindle, L. M., Katz, F. J., and Smith, P. S., A Geological Reconnaissance of the Fairbanks Quadrangle: Geol. Surv. Bull. 525, 1913, 220 pp.; Mertie, J. B., Jr., The Yukon-Tanana Region: Geol. Surv. Bull. 872, 1932, 276 pp. The mines were more particularly described by Mertie in lode mining in the Fairbanks district: Geol. Survey Bull. 662, 1918, pp.403-424.

10/ See Grant, U. S., and Higgins, D. F., Reconnaissance of the Geology and Mineral Resources of Prince William Sound, Alaska: Geol. Surv. Bull. 443, 1910, 89 pp.

further fact deduced from the observation and experience of geologists in many lands, that big placers are seldom if ever derived from big lodes but rather come from the break-down of country rock cut by many little stringer lodes, is discouraging to the search for profitable lode mines. Even where big lode mines and rich placers occur in the same region, as in California, it is now considered that the relation is but coincidental. The placers of the Sacramento Valley were not derived from the Mother Lode but from numerous small quartz veins, none of which are conspicuous. In neither the Fairbanks nor the Nome districts, both deservedly famous for the extent and richness of the placer ground, have any large lode mines been developed despite active search and persistent effort, although it is true that in the Juneau belt, with its great lode mines, $2,500,000 was won from placers. It may well prove that in Alaska, as in California, any really important lode mines found in the future will have no significant relation to the placers. It may also prove that there are no big ones to be found.

Placer mining is ordinarily a simple operation, one well-adapted to the capabilities of single workers or small partnerships. With the proverbial pick, shovel, and pan or rocker, the prospector first finds the gold-bearing gravel and then washes out the gold. As operations are enlarged he constructs ditches and brings in water with which to operate sluices. If it is feasible to arrange so that the water will be under pressure when it reaches the diggings, he "pipes" it against the bank to break the latter down and then directs the stream so as to drive the gravel into the sluice. Finally the water can be made to stack the tailing by means of a hydraulic elevator, or to carry it away from the pit. In this way as few as two men, working together, can handle a considerable amount of ground each season and, if it is sufficiently rich, can make good clean-ups.

The gold, being heavier than rock, tends to settle to the bottom and so is most abundant on the bedrock or in the gravel just above. Most of the work of the miner goes into stripping off the waste rock or low-grade dirt above so as to be able to get at the richer portion which will pay for putting it through the sluices. This overburden may be anything from a few feet in thickness (which a man can handle with wheelbarrow and shovel) to great thicknesses that require much more elaborate equipment. On Cripple Creek, leading out from Ester Dome near Fairbanks, the United States Smelting, Refining, & Mining Co., hydraulics away 140 feet of frozen "muck" and then takes off by dragline scraper 60 feet of nonpaying gravel before getting down to a lower 60 feet rich enough to be dredged. Such an operation is beyond the capacity of any single operator or small partnership.

The ordinary miners of the north, however, accomplished notable feats in mining gold from gravels below the great areas of frozen muck and in permanently frozen ground. They did this by sinking small shafts to bedrock, thawing the pay streak by means of steam points driven into it, and hoisting out the dirt for sluicing. This is an expensive operation, and only the richest portion of the bottom gravel could be so worked. In the aggregate, nonetheless, several million dollars worth of gold was so won in the Fairbanks and other districts. To win the gold in the in-between portions-- the pillars, the fringes of the deposit, and the lower-grade gravel above the pay streak - requires application of highly mechanized mass production methods in placer mining just as in lode mining, where, as already stated, only the largest-scale operations have been made to pay.

Ordinary, shallow, small-scale placer mining in Alaska was all but stopped by World War II, since both the manpower and the simple tools used were needed for building air strips and other defense operations. The Army and its contractors absorbed both, and high wages were paid. It became both patriotic and profitable to desert the mines and go to work for Uncle Sam or his contractors. The defense works were built in record time; but, temporarily at least, Alaska's second-largest industry was wrecked, and wage standards were set up that cannot be maintained against the fixed price of gold in most of the mines operated before the war. On October 8, 1942, gold mining throughout the United States was declared nonessential. After that date mining could only be continued under special permits which were issued in limited number where only nonessential materials and overage workmen were required. In response to an appeal from Alaska, the Territorial Commissioner was authorized in April 1943 to issue permits for placer operations where not more than five men were required and where other limiting conditions could be met. In October of the same year this rule was liberalized to permit operations with seven men, and in February 1944, similar permits were authorized for lode mining. At the end of the year, December 31, 1944, the permits out and employees authorized were as below:

Gold-mining permits, Alaska1/

Permits issued	Number of operators	Employees authorized
Gold placers		
For crews of 5 men or more.....	44	669
For crews of less than 5 men...	42	102
Totals....................	86	771
Gold lodes		
For crews of 5 men or more.....	9	119
For crews of less than 5 men...	2	6
Totals....................	11	125
All gold mines............	97	896

1/ Stewart, B. D., Report, Commissioner of Mines, Territory of Alaska: Juneau, 1945.

In contrast, there had been, in 1941, 554 placer operations with 4,921 men employed and 126 lode mines employing 1798 men. More than half the lode miners were employed in the Alaska Juneau mine, which was later closed, but the effect of the restricting order was widespread and was felt throughout the Territory. Employment in placer mining dropped from 4,240 in 1940 to 1,658 in 1944 and in lode mining of all kinds from 1,974 to 489. The restrictions have now been removed, but operations cannot be resumed immediately. Not only were men drained away from the mines, but earth-moving equipment was largely taken over, except in the case of the highly specialized gold dredges, which could not be used in ordinary construction work. Supplies were also requisitioned in many cases, though again the dredging companies were able to keep those most essential, owing largely to their special character. It requires time to refit dredges for working, and they cannot be brought into operation until sometime later in this year. Those on Goodnews Bay are operated to recover the essential metals of the platinum group as well as gold and were not interfered with by the order.

The major effect of the war was the complete disruption of the wage schedule of the Territory. Wages have long been higher there than for similar work in the States, the usual differential being about $1 a day. This reflected the higher cost of living, the shorter working season, and the necessity for attracting men to the Territory, such as is usual in pioneering communities. In wartime, however, basic rates were raised to as much as $1.36 per hour. Added to this was the cost of shortened hours, with increased pay for overtime and for night shifts. The most significant change was the upgrading of labor, which took place as contractors came to bid against each other for the limited manpower available. This went far beyond legitimate recognition of special skills, and frequently the classification of the individual workman bore no relation whatever to the actual work he was performing. As a result, it has been said, with more than a grain of truth in the saying, that there no longer is any common labor in the Territory. Most of the operations in placer mining are those ordinarily performed by common labor. One inevitable result of all this will be a shrinkage in the number of operating placer mines and away from marginal ground. In time, probably, the opportunity for independent work and the speculative hope of making at least a small fortune by a lucky strike of rich ground will attract men back. Equipment has now been released, "surplus property" is for sale locally, and manpower is already becoming available. Gold mining is an old industry, and from the days of Jason has attracted the hardy and adventurous. Creeks remain to be explored, and it may safely be predicted that within a few years placering, the simplest form of gold mining, will come back to its prewar position in the economic structure of Alaskan industry.

Not all the effects of the war were bad for Alaska. Wartime wages spread a lot of money over the Territory. Alaska was advertised widely, and the Nation became Alaska-conscious as never before. Many were brought into the Territory as soldiers, sailors, or workmen to whom it was new, and many of them have come to feel the undoubted lure of the Far North. One element in all this, which may eventually prove of considerable significance, was the moving in of large contracting firms having courage, capital, and unrivaled experience in moving dirt. The methods of doing this work have been all but revolutionized in recent years, and the big construction companies that were attracted to Alaska to build roads, air bases, and other military structures brought in staffs and equipment such as had not been locally available. Their main business is essentially the same as all mining, that is, the moving of dirt, and while in mines dirt is moved under very special conditions, the methods in one field can largely be adapted to the other. The heads of the construction firms are men of bold spirit, and it argues well for the future of the Territory that several have been attracted to mining and are already looking for properties on which to apply their skill and energy. Doubtless they will learn as well as teach, but the significant matter is that a new and potentially powerful force has been brought into local mining. It will probably be first and most effectively applied to placer mining, to which some of the construction equipment is especially well adapted.

In addition to small-scale placer mining so far discussed, dredging must be taken into account. In 1941, according to B. D. Stewart, commissioner of mines,[11] there were 50 dredges in operation; in 1942, 32; and in 1943 and 1944, only 10. In 1944 five dredges were operated on the Seward Peninsula, three in the Yukon Basin, and two in the lower Kuskokwim Region. In 1945 the dredges at Fairbanks and Nome were all down but were being put into condition for an early start in 1946. Dredging represents the highest form of mass production and mechanization in placer mining, although in early days before hydraulicking was stopped in central California, equal or greater amounts of gravel were mined with even simpler equipment and at lower cost.

The largest fleet of gold dredges in Alaska, and one of the largest in the world, is that of the United States Smelting, Refining & Mining Co. in the Fairbanks district. The same company operates a smaller but still powerful fleet at Nome. The salient points of the Fairbanks fleet are given in the table below.[12]

11/ Report, Juneau, 1945.
12/ Taken from a general description of the technical operations of the company in Mining World, January, August, December, 1942.

Dredge	Location	Make	Started work	Hull Dimensions, ft.	Power load hp.	Bucket size, cu.ft.	Digs below water, ft.	Stacker length, ft.	Stacks above water ft.
2.....	Goldstream	Bethlehelm	1928	128x60x12	509	10	48	120	44
3.....	Chatanika	do.	1928	148x60x12	507	10	73	190	76
4.....	Pedro	Yuba	1938	85x44x6	177	3	20	80	27
5.....	Cleary	Bethlehelm	1929	108x60x9	354	6	38	105	35
6.....	Ester	do.	1929	108x60x9	354	6	38	105	35
7.....	Fish Creek	Yuba	1940	110x44	205	5	40	100	32
8.....	Fox	Bethlehelm	1928	99x50x10-1/2	284	6	28	95	27
10.....	Cripple	Yuba	1940	167-1/2x74-1/4x12	1612	10	66	110	27

Dredge	Location	Make	Started work	Table area, sq.ft.	Pump capacity g.p.m.	Screen size, ft.	Average daily yardage	Bucket drive, hp.	No. of Buckets
2.....	Goldstream	Bethlehelm	1928	4,535	6,000	8x44	10,000	250	88
3.....	Chatanika	do.	1928	4,535	6,000	8x44	10,000	250	112
4.....	Pedro	Yuba	1938	1,260	2,000	5x30-1/2	2,800	75	65
5.....	Cleary	Bethlehelm	1929	2,125	4,000	6x43	6,000	150	75
6.....	Ester	do.	1929	2,125	4,000	6x43	6,000	150	75
7.....	Fish Creek	Yuba	1940	1,085	2,000	6x36	3,500	100	84
8.....	Fox	Bethlehelm	1928	1,460	3,000	6x36	6,000	150	66
10.....	Cripple	Yuba	1940	4,800	6,000	9x59	8,000	300	106

In addition to the above dredges, the company has, at one of its operations, a 10-W Bucyrus-Monighan dragline machine to take off top gravel after the muck has been removed by hydraulicking. The dragline uses 8- to 12-cubic yard scraper buckets and operates in this instance to a depth of 60 feet. Its task is to remove some 15,000,000 cubic yards of gravel preparatory to dredging. It delivers to a mobile conveyor system of belts which carries away and spreads the waste gravel. Here, and in general, before any gravel digging can be done the overlying muck must be thawed and washed away. This is done by exposing the cut face to the summer sun and daily washing away the thawed muck by playing hydraulic giants against the face to expose fresh material. After the muck is gone the gravel underneath must, in turn, be thawed. This is done by using cold water introduced through points driven into the ground as the thawing takes place. The actual temperature of the ground may be but little below 32° F., but a large amount of water is none the less needed, owing to the latent heat necessary to change ice into water. These various operations in total call for a very large amount of water. The Davidson ditch in the Fairbanks district is 90 miles long and delivers 125 cubic feet per second. It is supplemented by several shorter and less elaborate water systems. The Chena water supply is obtained by pumping from the river. There are five pumping units each delivering 6,000 to 7,000 gallons per minute, against a 400-foot head. Each unit requires a 400-hp. motor operating at 2,300 volts.

The whole sequence of operations, starting from the frozen muck-covered ground and running through to the final clean-up, requires careful planning and best of coordination. There was a waiting period of 4 years at the beginning, and in regular operation stripping may be started 3 to 6 years ahead of dredging. It must be clear that such operations require much capital, and that they succeed in producing a profit under so many adverse conditions is a great tribute to both the engineers and managers when it is remembered that the gravel mined only contains approximately 25 cents per cubic yard. Recovery of this evidently involves much work for a small unit profit.

Other dredging operations in the Territory are on a smaller scale and must be restricted to working on the richer portions only of the placers. Many of them also recover tin, some the platinum metals, and others still other byproducts, and it is probable that the full possibilities of such byproduct recovery are still far from completely explored. Whether opportunity exists for further consolidation of interests and reworking ground on a large scale, as at Fairbanks and Nome, is not certain, but careful search for such opportunity may well result in rich reward now or later. There are some indications that point to a favorable conclusion. The United States Smelting, Refining & Mining Co. has been prospecting for several years on Hog River, a tributary of the Koyukuk, and has recently announced that large-scale dredging operations are to be begun in 1947. A group headed by Norman Stines has been consolidating a group of claims on the Koyukuk itself and while still drilling has begun to move in heavy equipment. These operations and the activities in the asbestos district later to be described are of considerable significance as marking the movement of serious mining operations into previously little explored regions, to the north of established districts.

Copper

The history of copper mining in Alaska (and unfortunately the matter is at present significant mainly as history) has been briefly summarized by Dr. Philip S. Smith[13] so well that one cannot do better than quote it entirely. In reading Dr. Smith's summary it is well to remember that, while it was not published until 1941, it covers developments up to and including 1939 and that the essential facts have been widely known since that date.

> For many years the copper production of Alaska has been second in value only to the gold production of the Territory and during the past span of years has accounted for more than $227,000,000 of the mineral wealth that has come from Alaska. Obviously all mineral deposits have a limited extent; and as their mining is continued there necessarily comes a time when they become depleted and finally exhausted. The great copper mines of the Territory reached that state in 1938 and late in that year were definitely closed down by their managements. This of course does not mean that no other copper ores are known to occur in Alaska or that subsequently new deposits may not be discovered and developed. It simply means the closing of the great epoch of copper mining that began with the opening of the unique and phenomenally rich deposits near Kennecott in 1911 and ended with their final cessation in 1938. Henceforth, for at least some years, the only copper that is likely to come from the mines of the Territory is that recovered as an accessory or byproduct from ores that are valuable mainly for their content of some other metal. This was the source of the small amount of copper credited to 1939.

The following table shows the amount and value of the copper produced in Alaska since the earliest recorded mining of that metal:

13/ Smith, Philip S. Mineral Industry of Alaska in 1939: Geol. Survey Bull. 926-A, 1941, pp. 78-81.

thus balancing the silica present in other ores. In this way the copper, gold, and silver are all saved, and while the iron is not recovered it serves a useful purpose. The ore so far marketed from this district has been so treated, at first in a small local smelter at Hadley, which has long since been abandoned, but later in smaller amounts at British Columbia plants and the Tacoma smelter of the American Smelting & Refining Co. As a copper-gold ore it is not of high value, but it is useful whenever the smelter has to contend with large volumes of siliceous ore. In the district itself the latter has not so far been found in large quantity though it has been shipped from the Mount Andrew and Mamie mines, and when the Hadley smelter was in operation enough was evidently found to make an acceptable smelting mixture.

These deposits have been extensively studied by the Federal Geological Survey, the Federal Bureau of Mines, the Territorial Department of Mines, and various mining groups, but as yet no satisfactory basis has been found for any large development. Similar ore bodies occur elsewhere in Southeastern Alaska and British Columbia, and as various new deposits are opened in the region it may well happen that these ores may again come into demand in non-ferrous smelting, the copper serving as a collector of gold and silver and the iron going into the slag. Meanwhile, shipments may be made of small lots of which the gold and silver content is itself high enough to make such movement profitable. It does not now seem probable that, as an independent source of copper, the deposits will attain much importance. Their possible value as a source of iron ore will be later discussed.

What has just been said regarding the Prince of Wales Island ores applies more or less exactly to various small deposits at other points in Alaska where low content or small size militate against development on the scale that would be necessary to warrant providing transportation and other facilities necessary to bring the ore to the market. The one striking exception among the copper-mining districts of Alaska was the Kennecott mine, where the extraordinary richness of the ore made it profitable not only to mine under more than ordinary difficulties but to build and operate a costly railway some 200 miles long and to provide steamship service to Tacoma where a smelter was largely built up on the basis of this ore supply. Cargo shipments were made from Kennecott containing more than 70 percent of copper, and much ore went forward which contained as much of the metal as is ordinarily concentrated into matte in the course of smelting. It was this phenomenal richness of the ore that made the enterprise a success and enabled the owning corporation to amortize the heavy cost of the facilities provided. The company was also fortunate in that much of its tonnage went to market in a period of relatively high prices for copper. Nonetheless it is worth remembering that, despite the application of the best in technology and the development of ammonia leaching to supplement shipment of smelting ore, the cut-off point in mining, generally about 3½ percent, was above that of many important copper mines in various parts of the world. That proves, as nothing else would so clearly, the great difficulties that had to be overcome.

The ore bodies at Kennecott occur in a favorable bed in the Chitistone limestone not far above the Nicolai greenstone and where vertical or nearly vertical fissures have allowed metal-bearing solutions rising from or through the greenstone to reach and to spread out in the limestone. In pattern the result was a series of flat-lying tabular ore shoots following the stratification down the dip. These ore bodies were of variable thickness and extent but were closely related to particular horizons and to fissures. The ore faded out marginally, and there came a time and place where mining was no longer profitable. Despite, too, persistent search and expenditure of much time and money, no similar deposits were found by the company elsewhere that were workable, although the contact between limestone and greenstone has been traced and mapped many miles, and showings of copper are widespread. Several known prospects may warrant development, but their owners have not been able to interest capital on terms considered mutually satisfactory.

It is not impossible that other deposits may still be present in the region and that, by reason of the incidental presence of nickel or other accessory metals, they may be of sufficient value to make a mine. Persistent search for such possible ore bodies is still going on. It is well to remember, however, that the organization which had the longest and most intimate experience with the ore bodies of the region and which had the most to gain by continuing operations with facilities already provided, reluctantly abandoned the search.

The ore bodies at Kennecott were supplemented to a considerable degree by those worked on Prince William Sound, which in time came into possession of the same company. The principal mines then were the Beatsons Bonanza on Latouche Island and the Ellamar. Although a number of other prospects in the vicinity attracted attention, only the two mentioned were ever developed into mines of size. The region is one of graywackes and slates cut by greenstones which are probably metagabbros and to which it has been considered that the copper was genetically related. The ores were found in breccias in shear zones and in replacements along contacts. They were markedly irregular in shape, and mining was only continued to a few hundred feet in depth. They were made up of pyrite, chalcopyrite, and pyrrhotite, with various secondary copper minerals in minor amount. Flotation concentration was applied to them and the product shipped to the Tacoma smelter. The mines have been inactive for some years and are considered to have been worked out.

There are a number of copper deposits in the Ilimna Lake district. At least two well-financed companies plan to start exploration as soon as the reservation which now blankets the region is lifted. The Geological Survey has described the area in Bulletins 485 and 862. J. C. Roehm, mining engineer for the Territorial Department of Mines, examined several of the properties in 1941. Several engineers working for private companies have also made examinations. Exploration was active there about 40 years ago. The Kasna claims are about 2 miles above Kontrashibuna Lake on Kasna Creek. The lake itself is east of Lake Oark and northeast of Ilimna Lake, a few miles northeast of Ilimna village and airfield. The Dutton prospect is about 6 miles south-southwest of Ilimna Village. There are also the Copper King, Durand, Duryea, and other claims. The McNeil prospect is west of Kamishak Bay and southwest of Ilimna Lake.

Lead and Zinc

Both metals have many uses in industry, and each has held a high position, following copper, in the nonferrous metal production of the United States. World War II made heavy drafts on the reserves of both. This was especially true of zinc. As to it in particular, it seems certain that domestic output cannot be kept up to prewar standards even without allowance for growth in demand as industry expands. The great Tri-State zinc district of Missouri, Oklahoma, and Kansas, which has long been the ultimate reservoir of ore and so a regulator of price, has undoubtedly been seriously depleted. Mining geologists especially familiar with the district estimate that probably not more than one-third of the wartime mines can continue to run without subsidy in some form. However accurate or inaccurate this estimate may in the long runprove to be, there can be no doubt that, unless wholly new domestic sources are found or marginal production is subsidized, it will, in future, be necessary to continue to import ore and concentrates heavily, as has been done during the war period. To a much smaller degree, the same situation obtains as regards lead, although almost to the end the domestic mines, supplemented mainly by imports from other American countries, were able to keep up with demand. Here again, however, new sources are seriously needed. Since the two metals occur most commonly in the same ores, they will be discussed here together.

The general situation in Alaska has been well-summarized by Robert S. Sanford[14], district engineer of the Federal Bureau of Mines, as follows:

> The production of lead for the period 1880 to 1943, inclusive, was 24,756 tons. For the past several years most of the Alaska yield has come from lead concentrates produced by flotation at the mill of the Alaska Juneau Gold Mining Co., where about 900 tons was the normal annual output. In 1943 the production from this plant dropped to 200 tons, and practically no Alaskan lead has been marketed since the closing of the plant in April 1944.
>
> Only in recent years has any serious consideration been directed to the possibility of mining lead and zinc in Alaska, as excessive freight costs, high wages, and low base-metal prices had previously discouraged the industry. The increase of prices which followed the outbreak of the war, and the accompanying premiums (for new production) offered by Metals Reserve, have aroused some interest in dormant prospects. A few moderately low grade zinc deposits are known to exist in the Territory, but as none have been exploited, Alaska has remained a nonzinc producer.

14/ Sanford, Robert S., The War's Impact on the Mining Industry of Alaska: Juneau, Alaska, Jan. 6, 1945 (unpublished manuscript).

Zinc has attracted attention in three regions: (1) The Mount McKinley district of Central Alaska; (2) Southeastern Alaska; and (3) certain islands of Southwestern Alaska. To the knowledge on all three, the Geological Survey has made important contributions, and in the first-named in particular surveys and studies been made with specific attention to zinc ores. In the second area the work of the Survey has been supplemented by drilling, trenching, and underground work of the Federal Bureau of Mines. In it, as in the southwest, exploration by private or company engineers has yielded many of the data now available bearing on the economic phases of possible production. In the Southwestern district the Territorial Department of mines has reported a specimen of high-grade blende from Unalaska, and probably important deposits on nearby Sedanka Island have been reported both by the Survey and private engineers. A project for systematic exploration of this region by the Bureau of Mines was cut off by the end of the war.

In the Mount McKinley region zinc and lead are known to occur on the West Fork of Chulitna River, in the Kantishna district, on the flanks of Mount Eielson. So far as present knowledge goes, the last is the most promising district. It has been studied by Dr. John C. Reed as part of a comprehensive investigation of the railroad belt by the Geological Survey in cooperation with the Alaska Railroad under a special appropriation by the Congress. Dr. Reed has summarized the situation as below:15/

> The Mount Eielson district lies in south central Alaska, on the north side of the Alaskan Range, about 30 miles east of Mt. McKinley. The most widely distributed rocks of the district include a thick series of thin-bedded limestone, calcareous shale, and graywacke of Paleozoic, probably Devonian, age. The sediments are cut by a mass of granodiorite which forms most of Mt. Eielson and which was intruded probably in late Mesozoic time. The intrusive has sent a multitude of dikes and sills into the associated sediments.
>
> Material given off by the granodiorite permeated the enclosing sediments and selectively replaced them with minerals of the epidote group and to a somewhat lesser extent with sphalerite, galena, chalcopyrite, and pyrite.**** A normal fault of large displacement abruptly terminates the granitic area on the south.
>
> An ore-bearing zone can be definitely traced for about 4 miles along the north side of the granodiorite mass. Its width on the surface is not uniform, but its thickness is about 2,000 feet. Sphalerite is the most abundant sulphide and several times as abundant as galena. Chalcopyrite is present in minor quantities. The small amount of silver in the ore appears to be irregularly distributed.

15/ Reed, John C., The Mount Eielson District, Alaska: Geol. Survey Bull. 849-D, 1933, pp. 231-287.

Systematic sampling and estimation of ore reserves were not attempted in this district, since so little had been done in the way of development. Individual exposures which were chip-sampled are reported to have shown contents of 3.99 percent Zn, 3.56 percent Pb, 0.90 ounce Ag; 16.28 percent Zn, 10.45 percent Pb, 6.00 ounce Ag; 7 percent Zn, 2.5 percent Pb, 0.6 ounce Ag; 12.28 percent Zn, 6.66 percent Pb, 1.30 ounce Ag; 13.12 percent Zn, 4.78 percent Pb, 0.6 ounce Ag; 10.82 percent Zn, 8.89 percent Pb, 3.80 ounces Ag, 0.01 ounce Au (composite sample); 2.31 percent Zn, 0.3 ounce Ag; 20.16 percent Zn, 4.22 percent Pb, 15.3 ounces Ag. The gold and copper present were found to be small and irregular. Dr. Reed considered it safe to estimate an average content of 10 percent combined sulfides in the numerous ore bodies of workable size. From such an ore concentrates of standard character should easily be made by fine grinding and differential flotation, but difficulties have, in fact, arisen.

The Bureau of Mines sent Neal Muir to sample the deposits and he formed an unfavorable impression of their value. This was confirmed by a reexamination by Bruce Thomas, whose report is in preparation. A composite of Muir's samples was sent to the laboratory of the Bureau at Rolla, Mo. for study. The analysis of this composite showed 4.22 percent Pb, 5.64 percent Zn, 0.36 percent Cu. Grinding to 150- to 200-mesh freed 95 percent of the valuable minerals, but some of the galena and sphalerite was intimately locked with gangue even after finer grinding. Numerous flotation tests of this material have given unsatisfactory results, the ore failing to respond to the usual treatment for lead-zinc ore. The sphalerite in the sample was easily floated but did not respond to the depressants used in common practice. The lead concentrate contained 43.7 percent Pb, 21.6 percent Zn, and 2.8 percent Cu and represented 44.4 percent of the lead present. The zinc concentrate contained 42 percent Zn, 2.3 percent Pb, and 0.2 percent Cu, representing a recovery of 24.1 percent of the zinc. The samples were from surface trenching, and fresher material would probably yield better results. Indeed slightly better recoveries have already been realized, but the results are unexpectedly discouraging so far.

The major difficulty, however, in the way of development is the cost of transport to any available market. A truck haul of 70 miles followed by 348 miles of railway haulage to the ocean at Seward, and ocean haulage from there to the States, is necessary. At present the rates quoted are prohibitive, and no ore has been shipped. It is the general experience, however, that wherever considerable tonnage is available, freight rates fall. The wartime development of truck haulage for ores indicates that a 70-mile haul of a concentrate is not likely permanently to prove a serious stumbling block, and indeed antimony concentrates have been already shipped from this region. The railway rates now are admittedly high, but this is due to standards established a few years ago following a Senatorial investigation designed to assure that the railroad should at least meet its operating charges. They have more than done so, and a comfortable surplus has been built up which it is planned to spend on rehabilitation of the road and purchase of new equipment as soon as feasible. A general reduction in all rates may then be expected since the Congress has regarded the railroad as a Government utility needed by the Territory and a necessity to national defense and has not expected it to contribute to amortization of capital. Still further reductions will become feasible when highway construction makes it possible for the railroad to abandon its southern division (which is exceedingly expensive both to operate and to maintain) and take full advantage of the new cut-off to Prince William Sound.

A more serious difficulty than that of transportation charges is the absence of any zinc smelter on the Pacific coast. As this is equally a handicap to development in the remaining districts to be discussed, it will be taken up here. The nonferrous smelters on the Pacific coast were built primarily to recover gold and silver from ores not amenable to amalgamation, cyanidation, and other processes within the capacity of individual mining companies. The gold and silver in such ores are most commonly associated with lead or copper, either of which serves admirably as a collector of the precious metals in normal smelting processes, so it came about naturally that the Selby works near San Francisco became a lead smelter and the Tacoma plant specialized in copper smelting. Zinc ores do not so commonly carry important amounts of gold or silver, although in mixed ores there is some tendency for silver, especially, to follow the zinc. Zinc smelting is a different process and requires different plant from that used in lead or copper smelting, and in the latter the presence of zinc in the ore is not only a nuisance but a source of loss. As a result, western smelters long failed to pay for any zinc in the ores but instead penalized it when buying. Under these conditions, there was no market for zinc ore; and where zinc was present in lead or copper ores it was, if possible, wasted into the tailing. In the Coeur d'Alene district, for many years only lead and silver were recovered, and the streak of zinc blende from the concentrating tables was run down the creek. It is not surprising that no effort was made then to find zinc ores in the west or to open zinc mines. While blende and other zinc minerals were known to be present at many points they were neglected.

As the mines got deeper and deeper and as the levels were driven out into marginal zones more and more zinc came in. Eventually it became necessary to do something about it. At Butte it was found that in certain parts of the district zinc rather than copper formed the main content of the ore. The Butte & Superior Co. applied to such ores the newly developed flotation process and found it profitable even though the concentrates had to be shipped the long distance to the Kansas-Missouri zinc smelters, where they competed with the high-grade Joplin ores. The Anaconda Co., having already a copper refinery at Great Falls and the Montana Power Co. a surplus of electric current, undertook instead to treat its ores by roasting and electrolytic refining. Under the stimulus of wartime demand and prices during World War I, the company succeeded in this project and in postwar years was able to establish itself in the zinc business. The Bunker Hill & Sullivan Co., which has been experimenting with electrolytic refining of lead and was considering this as an alternative to building a lead smelter, turned to zinc refining and, by a process somewhat different from that perfected by Anaconda, produced a 99.99 zinc which was of so much higher grade than previously marketed that it found special uses and sold at a premium price. Joining the Hecla

Co., an electrolytic zinc plant was built and put into operation, which has proved to be a highly profitable operation. Later the Anaconda modified its process so as also to produce high-grade as well as ordinary metal.

High-grade zinc was produced in America for many years by the New Jersey Zinc Co. by pyrometallurgy, from extremely pure ores from its own mines. In World War I this grade of metal was in special demand in England, where it was used in making cartridge brass. The largest use for zinc however is in galvanizing steel sheets and wire; for this purpose a metal containing a minor amount of lead, such as is ordinarily produced, is necessary. Indeed, when the Ekabastus smelter was put in operation in Siberia about 1915, it was necessary to mix lead into the zinc metal produced to market the output.

Ordinarily zinc is reduced by the so-called Belgian retort process, in which the roasted ore is placed, with suitable reducing material, in a horizontal retort and heated exteriorly until the zinc is driven off as a gas which is cooled down to the liquid form at the front of each retort in a suitable condenser projecting out of the furnace into the cooler air. This is the standard process used around the world, and most zinc is recovered in such furnaces. As the amount of zinc in western ores increased and had to be handled in some manner, this process was applied. The American Smelting & Refining Co. in the early years of this century operated such a plant at Pueblo, Colo. and so got into the zinc business. Later the Pueblo plant was dismantled and a larger one built at Amarillo, Tex., to take advantage of the low-cost natural gas for exterior heating of the retorts. The movement of coal-fired zinc smelters into the gas belt of Kansas and Oklahoma had already begun, and an increasing flow of zinc concentrates from the Western States came to them, despite the long railway haul and correspondingly high freight rate.

Meanwhile the Consolidated Smelting & Refining Co. had bought the Sullivan mine to secure an adequate supply of iron for fluxing its lead ores. At almost the same time, the process of differential flotation came into operation, and somewhat to the surprise of the management and the fortunate stockholders it became apparent that the Sullivan would not only supply iron for slag making but was one of the great lead-zinc mines of the world. So the company was forced into the zinc business, and ultimately the Trail plant became one of the world's largest and the producer of a wide variety of metals as well. To handle the zinc the company metallurgists followed the earlier practice of running it into the slag in the course of the lead recovery. The slag was then treated as a zinc ore, and the zinc was fumed off in special furnaces, recovered as an oxide, and reduced to metal by usual processes.

Substantially all the zinc produced from western ores by these various methods found its markets in the Eastern States. No important uses for it were developed in the West, in galvanizing, brassmaking, pigment manufacture, or die casting, so that only those ores could be mined that could stand the accumulation of freight and transfer charges that this movement involved. It was a heavy handicap to be met by western ores and would be still heavier as regards ores from Alaska. In addition, too, there is not even yet any comprehensive system of zinc-ore buying in the West, or any considerable local market. The producer of zinc ore has to find his own market at a considerable distance and ordinarily must wait for his returns. In contrast, in the Tri-State district buyers make the round of the mill bins each week and bid on the concentrate where it lies. Settlements are made weekly, the banks keeping open Saturday night so that checks may be cashed, supply bills met, and labor paid. This is an old local custom, and Saturday night at Joplin has long been the big night of the week. While conditions have changed somewhat it is evident that it has been much easier to develop a small zinc mine in the middle west than beyond the Rockies or in Alaska. The western miners have had one advantage. Their ores usually contained small amounts of gold and silver and often some copper, most of which could be recovered separately while the concentrate was being produced and the remainder passed into the retort residue which can be sold to lead or copper smelters; or, at the electrolytic refineries, the slimes could be precipitated out and sold. Nonetheless the difficulties faced in the West by miners of zinc ore have been so great that even now there is no measure of the zinc resources of the region. Probably a local market would stimulate a considerable production both in the Western States and in Alaska, but one cannot be positive as to that in advance. It is a matter of belief, not of knowledge.

One factor pointing toward a more favorable situation for zinc smelting is the change the war has brought about in the steel industry. The increased production of sheets and wire that will be necessary to market the larger local steel output should lead to more galvanizing and so afford a market for ordinary slab zinc of Prime Western grades. Local manufacture of metal products, to be foreseen as the new steel seeks a market, should make it possible to establish Pacific coast plants for brass and alloy making, in which cheap electric current is important. All of these industries have their peculiarities, and special technical knowledge and skilled workmen are necessary, perhaps the least in galvanizing. However, some copper manufacturing is already done on the Pacific coast; fortunately, all of the possible fields mentioned are such that they can be entered on a small scale with moderate investment and can be enlarged as markets are found. To bring about any of this change will, however, require building a local zinc-smelting works to afford a local market for ores and local supply of metal. The chances for success would seem to warrant a careful study, looking forward to the building of a small, low-cost works that will permit entry into the business and enlargement as it grows.

For reasons just suggested, it would seem that, despite the presence of relatively cheap electric current and the general scarcity and more than average cost of coal, the possibility of a successful retort plant should be considered first. From the point of view of low capital cost and initial investment, such a plant offers exceptional advantages, because a plant consisting of as little as one block of retorts can be built and operated though ordinarily it is not as economical as a larger, more expensive plant. It is, however, easily expanded by building additional blocks. Whether such a plant would be more profitable if built on Puget Sound, where coal is available, or in California, where natural gas may be had, could only be determined by a close study of conditions and costs, including that of the major source of the ore. Whether, too, the roast gases should be used to produce byproduct sulfuric acid would probably be determined by local market conditions, despite the fact that from each ton of 60-percent zinc concentrates a ton of ordinary sulfuric acid is obtainable.

In the use of the slab zinc, the galvanizing industry will probably prove to be the largest consumer on the Pacific coast, as elsewhere. This business is usually, though not necessarily, conducted as a mere department of a steel plant, and the steel companies could probably be relied upon to develop it. Brass making is usually independent, though now a large portion of the business is done by subsidiaries of the big copper companies. Independent manufacture is still possible, especially by the maker of specialties. The easiest and least costly entrance is through brass casting. To roll or extrude brass and other alloys is more complicated and requires higher skill and heavier investment. Even here, however, the field is not closed, since it has been found that steel works can roll copper sheets, as has been done at Wheeling, W. Va., during the war. Surprisingly low costs were obtained. Already copper nails have been made at a California steel plant, operating on toll for one of the copper companies. Presumably brass nails and various other particular products could similarly be produced on toll, pending the time when business had grown to where it really warranted building a complete copper and brass works. In contemplating such a program, it should not be overlooked that in brass and copper industries, as well as in steel, scrap metal plays an important role.

In Southeastern Alaska a little lead ore has been mined and zinc minerals are known to be present; but in the main exploration so far has been directed to finding gold and silver, with lead, antimony, scheelite, copper, and nickel strictly subordinate in quantity. The region is a rugged one, much cut up by short rivers and channels of the sea. Much of the land is in the form of islands. Considered in most general terms, the area is occupied by a belt of sedimentary rocks, now widely metamorphosed into greenstones and related rocks, intruded by the Coast Range granodiorites to the east, and by gabbros and other basic rocks farther west. The juxtaposition of the intrusive rocks and the sedimentary and metamorphic rock in places has been favorable to ore genesis, and mineralization is widespread. To a certain extent, it is observable that the effect of the dioritic intrusions has been to produce gold-silver lodes, with lead, zinc, antimony, and scheelite accessory in a few lodes, while the basic intrusions have favored the formation of copper-iron ores with lower percentages of gold and silver and in places with nickel and members of the platinum group of metals present in minute amounts.

Several subordinate districts are commonly recognized, the Juneau gold belt, the Sitka district, the Wrangell district, the Ketchikan district, and the Hyder district, the latter at the extreme southern end. Lead has been obtained as a byproduct from the mines of the Juneau gold belt and from the Hyder district. Lead and zinc ores are present in the Wrangell and Ketchikan district, as well as in the Hyder, but await development. One of the facts now more generally appreciated, as a result of much flying over the ground, is that ore deposits are probably to be found on the crest as well as the flanks of the Coast Range. The immense difficulty of prospecting the rugged, forest-covered area, with its heavy rainfall, has heretofore prevented prospecting more than a short distance from the shore line. This may prove deeply significant in the future.

The region and most of the subdistricts have been studied by the Federal Geological Survey,[16] and some half dozen properties have been drilled or otherwise prospected by the engineers of the Bureau of Mines while various of the larger mining corporations have scouted the region. The results of the examinations by the Bureau of Mines are summarized by Robert S. Sanford,[17] district engineer, as below:

> A preliminary examination of the Ground Hog Basin property 13 miles east of Wrangell, Alaska, was made by the Bureau. The property was estimated to have a reserve 124,000 tons of material containing 8 percent zinc, 2 percent lead, and 2 ounces of silver a ton. A typical sample was submitted to the Rolla laboratory to determine the amenability of the ore to concentration and the grade of concentrate recoverable. The sample contained pyrrhotite, sphalerite, marmatite, galena, and chalcopyrite in a silicate gangue. The sulfides were so intimately locked that grinding to minus 200-mesh did not give complete liberation. The best result obtained was 74.2 percent recovery of the lead in a concentrate containing 50.10 percent lead and 10.98 percent zinc, and 70.9 percent of the zinc was recovered in a concentrate which contained 36.11 percent zinc and 7.17 percent lead. The poor recovery and low-grade concentrates as well as a high grinding cost would discourage exploitation of the deposit at this time.
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> A deposit at Tracy Arm was examined by the Bureau of Mines and estimated to contain 7,000 tons of indicated ore and 140,000 tons of inferred ore with a grade of 4.1 percent zinc, 1.5 percent copper, 0.01 ounce a ton gold and 1.00 ounce a ton silver. The

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16/ A partial list of the eariler and more general reports follows.
Wright, F. E., and C. W., The Ketchikan and Wrangell Mining Districts, Alaska: Geol. Survey Bull. 347, 1908, pp. 171-172.
Buddington, A. F., Mineral Deposits of the Wrangell District: Geol. Survey Bu..l 739, 1923, pp. 64-65.
Smith, P. S., Lode Mining in the Ketchikan Region: Geol. Survey Bull. 592, 1914, pp. 90-91.
Stewart, B. D., Report, Commissioner of Mines, Biennium Ended March 31, 1931.
Robinson, G. D., The Zinc-Copper Deposits near Moth Bay, Revillagigedo Island, Southeastern Alaska: Geol. Survey mim. rept.
Twenhofel, W. S., The Zinc Deposits of the Lucky Boy Claims, Dora Lake, Prince of Wales Island, Southeastern Alaska: Geol. Survey mim. rept.

17/ Sanford, Robert S., The War's Impact on the Mining Industry of Alaska: Juneau, Alaska, Jan. 6, 1945.

metallic sulfides are pyrite, pyrrhotite, marcasite, sphalerite, chalcopyrite, and galena. The property, consisting of 17 claims, is owned by Harry Townsend of Seattle, Wash.

Small lead-zinc deposits have been examined by the Bureau of Mines at Dora Bay on Prince of Wales Island and at Moth Bay in the Ketchikan area. Other small deposits occur along the northwest shore of Thorne Arm and at Dolomi on the east side of Prince of Wales Island. The Fish Creek property, Hyder Lead group, and Greenpoint claims in the Salmon River district north of Hyder were examined by the Bureau of Mines in September 1944. Moderate percentages of lead are contained in these deposits as well as in the Gray Copper vein at the Mountain View mine where a Bureau of Mines project was conducted during the past summer for the exploration of tungsten.

The Federal Geological Survey has also studied the Ground Hog deposit and released a mimeographed report by H. R. Gault giving many details. It has also issued a press release giving details, including reserve estimates of the Tracy Arm deposits and reports on Dora Bay and other districts.

It will be noted that, in the ore of the Ground Hog Basin properties, the zinc occurs at least in part as marmatite and so is iron bearing. This materially reduces the value of any zinc concentrates made from this ore. In retort smelting the iron corrodes the retorts and shortens their life. In electrolytic reduction it also complicates the process aside from operating to reduce the grade of the concentrate. The Federal Geological Survey reports this condition general in Southeastern Alaska. One favorable factor in the district is the multitude of water channels which cut it up and so make assemblage of even small lots of ore easy and cheap and delivery of ores from the district to any outside market feasible at relatively low price. Another factor is the large amount of water power that can be easily and cheaply developed in most parts of the region.

A project that warrants careful study and perhaps favorable action is to build somewhere in the region a sampling and ore buying plant such as was formerly common in Colorado and other western states.

Southwestern Alaska, despite its easy accessibility by sea, is one of the least-explored parts of the Territory. A few lode mines have been worked there in the past, but none are now operating. In each instance gold alone was sought and scant attention paid to other minerals, including, as elsewhere, lead and zinc. Yet there are deposits on Sendaka Island, Unga Island, and possibly on Unalaska which show distinct promise. The situation is so favorable from the point of view of ocean transportation, though not it must be admitted in other particulars, that it deserves attention. The Geological

Survey[18] has explored the region and collected much of the data necessary. B. S. Webber of the Federal Bureau of Mines made a preliminary study and a project for an extensive exploration was in the program for 1945 which was cut off by the end of the war. From a preliminary study by the Federal Geological Survey and more detailed observations by private engineers, it is believed that on Sedanka Island in particular there is a zinc-lead-copper ore body, perhaps of real importance. Sanford, in the summary already quoted says:

> A deposit which is one of the largest known zinc-lead occurrences in Alaska is on Sedanka Island, one of the Aleutian group. The mineralized area is 25 miles from Dutch Harbor and near Biorka Harbor, which is readily accessible to shipping vessels serving the Aleutian Islands*******. Sphalerite and minor amounts of galena, chalcopyrite, gold, and silver have been reported.

In 1945 Webber trenched this deposit and cut 29 samples. Of these, 19 averaged 9.16 percent Zn, 0.55 percent Cu, 0.25 percent Pb, nil Cd, 0.04 oz. Au, and 1.4 oz. Ag. The width of the bed sampled was 5 to 15 feet, and the sampling covered 120 feet along the lode. Additional study is considered desirable.

Other deposits of possible value are known and a wide variety of minerals have been collected from the region. It is entirely possible that the first big zinc-lead mine in Alaska will be developed in this district.

Iron Ores

In any consideration of the degree of industrialization of a country, the possibility of local manufacture of iron and steel or, alternatively, of furnishing one or more of the raw materials for such manufacture, must be taken into account. The three essential materials are iron ore, coking coal, and limestone. Equally essential is it that these materials occur in juxtaposition or in such geographic position as to permit their easy assemblage at a common point. There are few things more useless than an iron-ore deposit in an isolated district from which ore cannot be economically transported to any suitable assembly point. For example, there are, on the northwest coast of Australia, large deposits of hematite of excellent grade, but the cost of taking the ore to the steelmaking districts in southeastern

18/ Dall, W. H., Coal and Lignite in Alaska: Geol. Survey 17th Ann. Rept., pt. I, 1896, pp. 763-908.
Becker, G. F., Reconnaissance of the Gold Fields of Southern Alaska: Geol. Survey 18th Ann. Rept., pt. III, 1898, pp. 83-85.
Spurr, J. E., Reconnaissance in Southwestern Alaska in 1898: Geol. Survey 20th Ann. Rept., pt. VII, 1899, pp. 31-238.
Martin, G. C., Gold Deposits of the Shumagin Island: Geol. Survey Bull. 259, 1905, 196 pp.
Collier, A. J., Auriferous Quartz Veins on Unalaska Island: Geol. Survey Bull. 259, 1905, pp. 102-103.
Atwood, W. W., Geology and Mineral Resources of Parts of the Alaska Peninsula: Geol. Survey Bull. 467, 1911, 137 pp.

Australia is so great that serious consideration is now being given to using instead the lower-grade lateritic ores from New Caledonia. Under special circumstances iron ores are transported long distances, the movement of Tofo ore from southern Chile to Baltimore being a case in point, as is also the occasional shipment of iron ore from Sweden to the United States or the movement of ore from Newfoundland to Europe. In all these cases, and in others that might be cited, special circumstances make the shipments possible. In general, iron ores are so heavy and so bulky that steel makers prefer to use even slightly inferior grades of ore that may be obtained in nearby districts rather than undertake long-distance shipment.

It is also a general rule, based on much experience and with many sound reasons to support it, that iron ore moves toward coal rather than the reverse and into districts where, by reason of the presence of fuel, power, scrap iron, or steel, manufacturing has already been established or local conditions favor it. Alaska does not afford these conditions nor does it now seem probable that they will obtain them in any near future.

Although the coal is abundant and even coking and other high grades are present, the larger part is not of such quality as to be valuable for blast-furnace use. Such coking coal as has been found is "patchily" distributed and difficult and expensive to mine. As stated elsewhere, the early hopes of mining large quantities of coking, or at least of low-volatile coal, in Alaska have now faded; and, on the basis of present knowledge, it is considered improbable that any such industry will develop.

The third material ordinarily required in making pig iron is limestone, of which one-third to one-half ton is ordinarily needed in producing 1 ton of pig iron. Alaska is fortunate in possessing large quantities of this material, well-situated for mining and near the sea. It has already become an article of commerce in Southeastern Alaska, though not used as a flux in iron manufacture. The quality of the material makes it suitable for such use, but for other reasons it does not now seem likely that it will find such a market.

Iron ore is present on Prince of Wales and other accessible islands in Southeastern Alaska, and hopes have been held that it would find a market on the Pacific coast. The ores occur in lenses in metamorphic rocks, very probably marking the former presence of limestone bands in the sediments that have now become greenstones, and they consist of magnetite and hematite with minor amounts of pyrite and chalcopyrite. They have been described in connection with the discussion of copper and have been to some extent mined and shipped as copper ores. Just at present they are in little demand, since the amounts of copper, gold, and silver in them are too small to pay for shipment and the iron is only valuable to the copper smelters when they have to treat an excess of siliceous ores. Judged strictly as iron ores, these deposits are at a disadvantage, because they require preliminary treatment to fit them for blast-furnace use. The copper and the sulfur present are detrimentral in iron making and must be removed. A technology for doing so has been developed, and the Bureau of Mines has tested the ores from the Poorman and Mount Andrew mines and found it to be applicable. Such methods are in actual commercial use in eastern Pennsylvania, where the ore from the Cornwall mine is crushed, concentrated, and sintered profitably by the Bethlehem Steel Corp. the copper concentrate going to one of the smelters in New Jersey and the iron sinter to the blast furnaces at Bethlehem. Unfortunately there are no blast furnaces nearby the Alaskan deposits; and, while ocean transportation can be provided, the distance to the only iron blast furnace on the Pacific coast, the Fontana in southern California, is considerable. The ocean trip, too, would need to be supplemented by rail haulage from San Pedro to Fontana since for strategic reasons the Fontana furnace was built inland and not on the coast. While the grade of the ore that could be produced by proper treatment at the Prince of Wales Island mines would make it desirable for mixing in, the cost per unit of iron would undoubtedly be higher than for ores much nearer the furnace.

Alternative plans that have been discussed propose shipment of the concentrate or sinter to some point on Puget Sound or the Columbia River and its use in a plant erected there. Usually it is proposed to make the steel from the ore by use of electricity. The difficulties in the road of any such development are:

(a) There is now no plant in existence to buy the ore nor is there an unsupplied market for steel that would warrant building one. Indeed, the existing steel plants in the Western States face the necessity of making a vigorous sales campaign if they are to market enough steel to keep them all working at an economic rate.[19] This is certainly no time to launch into building more pig-iron plants in the west.

(b) The technology of making steel direct from ore is one that is as yet in the development stage, although it has been demonstrated as sound in principle and possibly of economic applicability under special circumstances. Even, however, with low-cost power it has so far only been possible to apply it in small works favored by particular conditions. It is not believed that such works can compete with large plants following standard practice in production of the grades of steel that are demanded in quantity. It has already been stated that on or tributary to the Pacific coast there are now in being works with ample capacity to supply existing markets.

There is, then, no present market on the Pacific coast for these iron ores, nor does one seem probable in any near future. The question naturally arises as the feasibility of erecting a plant especially to utilize the ore. So far as a standard blast furnace is concerned the known ore reserves are too small to amortize such a plant. That would, under modern conditions, require 10,000,000 to 20,000,000 tons, preferably the latter, of suitable ore.

Following careful study of the deposits on Prince of Wales Island and elsewhere by the Federal Geological Survey, the Federal Bureau of Mines undertook to examine the more promising ones by trenching, diamond drilling,

19/ See Bain, H. Foster, A Pattern for Western Steel: Bureau of Mines Inf. Circ. 7315, 1945, 35 pp.

sampling, and estimating and followed this by ore-dressing studies at Rolla, Mo. The results at the two largest were as below:

Poorman mine: Estimated reserve, including measured, indicated, and inferred ore, 1,394,000 tons. Analysis: Fe, 52.4 percent; Cu, 0.25 percent; S, 3.72 percent; phos., 0.03 percent.

Mt. Andrew mine: Estimated reserve as above, 2,009,000 tons. Analysis: Fe, 44 percent; Cu 0.35 percent.

In neither mine was the reserve sufficient to support an independent operation, nor would the two together do so. It follows that, for iron ore, the deposits only have value to the extent that the output can find a market supplementing other supplies. Entirely aside from the detrimental presence of copper also, neither ore as mined is sufficiently high in iron to constitute a premium ore. By selective mining a smaller amount of ore of higher iron content could probably be mined, but this would increase cost and diminish the reserve. It is possible, as already stated, to treat this ore so as to produce, as a byproduct, a copper concentrate containing such gold and silver as is present, and, with this removed, to sinter the iron ore into a presumably useful furnace product. At Rolla such a sinter was produced from the Mount Andrew ore, with the following analysis: Fe, 59 percent; SiO_2, 9.2 percent; phos., 0.02 percent; S, 0.06 percent. This is a desirable product, but its delivered cost at the blast furnace is open to question, as is also the matter of whether the copper concentrate would contain enough copper, gold, and silver to pay for the cost of fine-crushing the ore, floating it out, and magnetically concentrating the remaining iron. Calculations are necessarily based on numerous assumptions not all of which could be expected to be realized in practice; and, in view of the marketing difficulties already mentioned, it can hardly be doubted that reopening and equipping these mines would be highly venturesome.

One possibility that has been suggested remains to be discussed, namely, a small local works depending on hydroelectric power and the use of charcoal for reduction material and making special alloy steels. Such an enterprise would closely follow lines of development well worked out and proved in Sweden. Sufficient ore for such a plant is present and various alloy minerals are to be found elsewhere in Alaska and British Columbia. The forests of southeastern Alaska afford plenty of wood for making charcoal, indeed a supply for a charcoal blast furnace could doubtless be had in case that be preferred to an electric furnace. Hydroelectric power can be easily developed with fair economy at numerous points in southeastern Alaska[20] and a suitable assembly and shipping point could readily be found. The difficulties to be overcome are more commercial than technical. The process that would necessarily be followed would call for experienced direction and highly skilled workers, and such enterprises do not usually flourish in isolated localities. The products made would be sold in an intensely competitive

20/ See Dort, Joseph Cummings (hydroelectrical engineer, U. S. Forest Service), Report to the Federal Power Commission, on the Water Powers of Southeastern Alaska: 1924.

market where brand name and reputation have high value but are slowly built up. Because of the high unit value of the steels, transportation cost to market is not especially important, but marketing costs are. Alloy steels are generally made near centers of manufacture and by companies that are in position to merge their distribution and selling costs with those of a large volume of other business. Just how successful a new concern would be against such competition is doubtful. Actually few such enterprises are now in business under similar conditions; and it should be remembered that a slight advantage, even if realized, in manufacturing costs would be easily lost in the cost of sales. Such as it is, though, this seems to be the only present opportunity for steel making in Alaska. It has recently been announced that a Canadian company has purchased the old smelter at Anyox, B. C., with a view to entering this field.

Coal

General

Coal beds are present in many parts of the Territory, although coal mines, other than strictly local operations, are to be found in only two districts, the Matanuska and the Healy River. Both of these are connected by spur lines to the Alaska Railroad, which fact emphasizes the rule that it is only where transportation facilities are available that coal mining developes. Coal is a low specific gravity mineral and so makes bulky freight. A gold placer miner can carry his poke of gold dust to market but a coal miner must have railroad, boat, or at least truck transportation available if he is to survive.

As early as 1902 Alfred Brooks presented a map of the coal fields of Alaska[21] showing their wide distribution and general extent. Both before and after the appearance of this summary, the bulletins and other reports of the Geological Survey have contained many details as to the various fields. After the organization of the Bureau of Mines the latter took an active part in the testing and exploitation of Alaska coals, the inspection of the mines, and the effort to promote development of the fields, and as the Territorial Department of Mines developed it in turn took over much of this work. The publications of all three of these agencies furnish important data regarding nearly every known coal field.

The coal beds occur in rocks of various ages, including the Permian, the Cretaceous, and the Tertiary, especially the Miocene of this last. While coal of all grades from lignite to anthracite is present, the largest portion is of subbituminous grade, and the major developments have been in the Tertiary formations. Expectation of being able to develop important tonnages of smokeless and coking grades have been disappointed, and the coal now being mined is only of steaming grade, ranging on an air-dry basis from 8,000 to 10,000 B.t.u. This coal is satisfactory when used in plants adapted to it, as at Fairbanks and Anchorage; but, as is true elsewhere, such coal is now meeting

21/ Brooks, A. H., The Coal Resources of Alaska: Geol. Survey 22d Ann. Rept., pt. III, 1901, pp. 515-571.

stiff competition from petroleum. Even in Juneau, the capital of the Territory, it is cheaper to use petroleum than Alaska coal. One of the changes in the local coal business in recent years has been that local production has almost altogether supplanted the former imports of coal from Washington and British Columbia; but it is still true that, by reason of shipping conditions, it is cheaper to import coal at many Alaskan ports than to use Alaskan coal. Adequate facilities have not been provided for shipping to other Alaskan ports even the Matanuska coal, which is mined in the field nearest the coast; even if docks and colliers were provided, the shipments would probably be unprofitable, because at most Alaskan ports only less than cargo lots are needed, and such freight is better handled as a part of general freight movement to and from such ports than in specialized boats and barges. At one time a heavy export trade was anticipated, based on the assumed high quality of the coal. Experience in mining has shown that high-quality coal is rare in the Alaskan fields, and mining conditions are far from good. Not only the physical conditions as to roof, foot, faults, and dip are unfavorable to mining, but the beds thicken and thin most irregularly as a result both of original differences in conditions of deposition but also because of deformation of the formation. This, in turn, has resulted in variation in the degree of metamorphism of the coal itself and hence in its rank. Even to produce good steam coal it is necessary in the Matanuska field to wash it to reduce the ash.

When the Alaska coal fields first attracted public attention some 40 years ago, a violent controversy arose as to the conditions under which they were to be opened and operated. The then existing law under which coal lands were taken up was far from perfect and had led to much abuse, although it had permitted extensive development and rapid industrialization throughout the Western States. There was considerable public opinion which demanded that future development be on some different basis. In response to this, the Congress established a leasing system for Alaska coal fields.[22] It provided for 10-acre permits under a simple form of application to meet local village demands and, after settingaside national reserves in the then known coal fields, for leasing the remainder in units of 40 acres or multiples thereof on a royalty basis, coupled with annual acreage rentals. The charges were moderate enough, but there was written into the law a very stiff antimonopoly clause limiting ownership direct or indirect by any individual or corporation to 2,560 acres. This provision made itimpossible to develop the fields on the old basis under which a single corporation, or the same financial interest operating through two or more corporations could own both the mines and the transportation lines. It undoubtedly checked development though that was a blessing in disguise to those who were then planning to invest large sums in coal lands and railways, since the coal proved to be less minable and of lower grade than was anticipated at the time. Had, for example, a railway been built by private capital into the Bering River coal fields, a project of the time, the money would have been lost. In actual experience, railway lines to the two fields that have been developed have been provided at the expense of the taxpayers. Even so the number of mines opened has been small, and the struggle has been to find enough market to keep them alive rather than to provide a large output. It was only in the recent wartime emergency that coal

22/ Public 216, 63d Cong., H. R. 14,233.

supply ran short and that it became necessary to open new pits and resume imports. The leasing system, as applied to Alaska, makes very little difference in actual practice, and looking backward one is sometimes inclined to wonder what all the rowwas about. At present, in view of the very limited market, the antimonopoly clause seems objectless, since even with it in force it is easy to produce more coal than is normally needed. What the long-time effect may prove to be remains to be seen. That, however, is but a part of the general problem of monopolies or attempted monopolies in American business. It is not clear that conditions in Alaska are sufficiently different to justify a separate policy, although an argument for it might be built up on the unusual difficulties that must be faced in Alaska by anyone wishing to develop any industry.

Development of coal mining in Alaska has been slow not only because of the character of the coal, the inherent difficulties in mining, the thin and limited market, and the competition of petroleum but also by reason of the fact that, in many localitites, water power is available under favorable conditions. All through Southeastern Alaska and only to a slighter degree along the south coast, the abundant rainfall, the presence of lakes and natural reservoirs, and the high slopes of the short rivers make for easy and cheap hydroelectric development. In certain localitites power can be had so cheaply that development of electrochemical industries may be anticipated. The region is not one, however, in which any single large system can be expected to be profitable owing to the technical difficulties and cost of transmission of current across ocean channels cut deep into the mainland and between the numerous islands.

Matanuska Coal Fields

The principal coal-mining operations in Alaska now center in the Matanuska Valley at Eska and Jonesville, neighboring mines about 60 miles east of Anchorage with which they are connected by a branch of the Alaska Railroad. The Glenn Highway, a year-round gravel road, extends past them to connect with the Richardson Highway to the interior. The Chickaloon field, in which for a time the Navy undertook exploration, and Anthracite Hill, which has attracted considerable attention but which is as yet of unproved value, lies a short distance to the east. The region has been much studied by Government and Territorial geologists and engineers, and convenient summary may be found in a report[23] issued by the Geological Survey and covering the district of known present importance. The coal field is about 7 miles long and $1\frac{1}{2}$ miles wide, with a northeasterly trend, and lies parallel to and south of the Talkeetna Mountains. The coal measures lie in a structural trough, with Cretaceous and older rocks on both sides. The coal measures are of Tertiary age and are somewhat concealed by glacial and other Quaternary deposits. They consist mainly of silts and sandstones, with subordinate beds of coal and clay, and are of nonmarine origin. The Chickaloon formation,

23/ Barnes, F. F., and Byers, F. F., Jr., Geology and Coal Resources of the Eastern Part of the Lower Matanuska Valley Coal Field, Alaska: Geol. Survey Mim. Rept. 113,198, 1935.

5,000 feet thick, includes the coal beds and is covered by the massive Eska conglomerate 11,200 feet thick. The Chickaloon lies on an unnamed thin bed of Tertiary sediments, below which is the Cretaceous. The strata have been folded and faulted, and the coal beds are found on both flanks and around the nose of a westward-sloping syncline. Ordinarily they dip 30° to 40° but in places as low as 12° and in others as high as 55°. The syncline has been cut by a number of transverse faults which divide the coal beds into a series of blocks along the strike and complicate the problems and increase the expense of mining. The individual beds thicken and thin along strike and dip, but the general sequence is fairly constant and good markers are present. The faults form zones, in one place as much as 1,000 feet wide, of disturbed strata, and the frequent small displacements further complicate the problem of mining.

Coal is mined from nearly a dozen beds, and while the horizons are persistent, workable thicknesses are found in different beds in different parts of the area. Most of the coal mined is in 4- to 5-foot beds; but some comes from 8-foot to 9-foot beds, and some are even thicker. The coal contains numerous partings and can rarely be mined clean, so both Jonesville and Eska mines require washeries to prepare marketable products. The difficulties in mining such beds may be readily inferred from the following description of the Shaw or No. 10 bed, quoted from the report by Barnes and Byers:

> The Shaw bed in the Eska mine consists of two benches of coal, separated by 1½ to 4 feet of coaly claystone and bone, that are known locally as upper and lower Shaw. The upper Shaw ranges from 2½ to 4 feet in thickness and commonly includes one to three hard claystone markers an inch or less in thickness. This coal has been mined on both limbs of the syncline as well as in the old east-side workings. The lower Shaw coal has an over-all thickness ranging from 3 to nearly 5 feet but includes as many as 5 claystone partings 1 to 2 inches thick. The coal has been systematically mined only on the north limb for a short distance on each side of Eska Creek. To the west on the south limb it has not been mined, largely because it is too close to the upper Shaw bed to be mined separately and because the amount of rock in the lower Shaw partings and in the thick parting between the two benches make the mining of both benches together undesirable. West of the present Eska workings the main parting may be thin enough and the lower bench clean enough to encourage mining of the entire bed, particularly now that a washer has been installed at Eska.
>
> Bed 10, the equivalent of the Shaw bed in the Evan Jones cross-cut tunnel, consists of two benches, each about 2½ feet thick, separated by about 1 foot of coaly claystone. The upper bench is clean coal with a single siliceous claystone parting about 1 inch thick. The lower bench includes only 1 foot of clean coal, the upper and lower opened only by a short gangway in the Evan Jones Mine, but the two benches may eventually be mined as a single bed.

At locality U, the Shaw bed includes two benches of clean coal 14 to 15 inches thick separated by more than 2 feet of coaly claystone. A similar section is exposed at locality T, but further west both benches gradually thin and the number and thickness of claystone partings increase.

The various other beds, Martin, Eska, Emery, David, Maitland, Chapin, and others, show somewhat similar though not identical conditions, but in each mining is along horizons rather than beds, and careful work is necessary to mine the coal. Coal dust is present, and explosions have occurred. The method of mining called for by the positions of the beds, namely crosscuts from the surface, long drifts along the strike, and high raises to the surface, makes it difficult to maintain good ventilation at all times and further increases the cost. This, with the high wage scale obtaining throughout Alaska and the difficulty that would be involved in conducting large-scale operations even if market conditions were favorable, makes it impossible to look forward to cheap coal from this field, although a very useful output at moderate price has been produced in the past and may be expected in the future. The Navy explorations at Chickaloon indicated that, to produce any considerable amount of naval-grade coal, even after a washery had been built, would involve large investment and would be at high cost. According to Barnes and Byers, the estimated probable reserve in the eastern or known part of the Matanuska coal field is of the order of 70,000,000 tons.

In three of the mines in the western part of the field, as described by Payne and Hopkins, a reserve of 9,000,000 tons was estimated.24/

Analyses of Matanuska coal

Bed	Location	Moisture	Vol. comb.	Fixed C.	Ash	Sulphur	B.T.U.
4....	South limb, Evan Jones mine	4.39	38.40	40.72	16.09	0.27	11,298
3....	do.	3.50	37.30	40.20	19.00	.30	10,990
2....	North limb, Evan Jones mine	3.50	36.80	38.40	21.30	.20	10,450
2....	North limb	3.80	37.90	43.30	15.00	.30	11,540
8....	North limb, Evan Jones mine	4.90	36.10	45.90	13.10	.30	11,830
Upper Shaw	South limb, Eska mine	3.70	41.00	44.40	10.90	.50	12,410

24/ Payne, Thomas G., and Hopkins, David M., Geology and Coal Resources of the Western Part of Lower Matanuska Coal Field, Alaska: Geol. Survey Mim. Rept. 105, 117, 1944.

The coal in the western part of the Matanuska field is substantially the same in quality. Payne and Hopkins quote the following figures of B.t.u. values for coal as received:

Premier mine	11,765
Baxter & Bedell	11,020
New Black Diamond	11,940
Wishbone Hill mine	11,505

The quality of the coal mined at Eska and Jonesville is perhaps sufficiently illustrated by the analyses quoted above from the records of the Geological Survey and the Bureau of Mines, the figures being for coal "as received."

At present there are three operating mines in the district, the Eska and Jonesville in the eastern part and one, the Buffalo, in the western portion. Near the last was the Premier or Moose Creek, which operated for some years but was lost when the creek broke in as a result of too close pillar robbing. Other smaller mines have been operated at various times but are now closed. The Eska mine was opened to supply coal for the railroad but has not been operated continuously. For some years it remained idle, and coal was bought on bid from other lessees to give them a backlog of orders and to assist them in building up a domestic market. At the same time, the mine served a useful purpose to the railroad since, by being available for reopening at any time, it fixed a ceiling on bid prices. The Evan Jones mine has always been privately owned and has grown from small beginnings to its present important position. The Buffalo mine is new and was developed with the aid of the Army to help meet the demand for coal during the war. Up to now it has proved to be a high-cost mine, and its immediate future is somewhat in doubt. Its outlet is by truck service, since the narrow-gage railroad that formerly ran up Moose Creek to serve the Premier was washed out in 1942 and has not been rebuilt.

Nenana Coal Fields

The second-largest coal production in Alaska comes from the Healy River fields well up toward the interior. Healy Creek is a tributary of the Nenana River, which flows into the main stream 112 miles south of Fairbanks. Along Healy Creek, Lignite Creek, and other streams are numerous outcrops of coal, but mining is now only active along Healy Creek, the Suntrana being the principal mine. The region is part of the plateau country north and east of Mount McKinley. It is largely covered by a thick bed of gravels known as the Nenana formation. At various points the streams have cut through this into or through the coal-bearing formation, which consists of loosely consolidated sand stones, sands, clays, and coal beds. Below this formation lies the Birch Creek schist, a series of metamorphic rocks of supposed pre-Cambrian age. Before the Nenana gravels were laid down, the country was subjected to long and continuous erosion, and apparently only patches of the coal formation in basins and hollows of the old surface of the pre-Cambrian have survived. These patches extend over a considerable area, but so far extensive mining has been confined to the lower part of the Healy Creek, since there alone is transportation available. In 1943 coal was mined by stripping 4 miles west of Healy Station, but the operation has ceased. The Suntrana mine is connected by means of a 4-mile spur track with the Alaska Railroad at Healy station. From this mine a motor road extends a few miles farther up the creek to coal claims that were worked on behalf of the Army through the recent emergency.

The Healy Creek field has been described in various reports of the Geological Survey.[25] The Bureau of Mines began drilling there in 1943 in cooperation with the Army Procurement Division. In 1944 the region was restudied for the Survey by Clyde Wahrhaftig and Jacob Freidman, and a brief summary prepared (mimeographed release, 112,613) from which most of the following description has been taken.

In 1920 the Healy River Coal Corp. began mining on the west side of the Nenana but transferred its operations to Suntrana on the east side when the bridge and connecting railway were completed to the larger outcrops at that point. This has been the only continuous operation in the field. The Roth lease higher up the river lapsed for failure to perform, although a small amount of coal was mined recently by open-cut on Army account. The Sanford-Usibelli mine between the two was also a temporary open strip operation on account of the Army. According to the Survey, to the end of 1944 the coal produced has totaled 1,775,750 tons.

The coal measures are considered to be part of a fault block tilted to the north. More specifically, they form a syncline closed at the East and opening out trough fashion to the West. There are numerous individual beds ranging in thickness from 1 foot to 55. Prindle reported a total thickness of 230 feet of coal in 23 beds, of which 7 aggregated 174 feet. Wahrhaftig and Freidman state that the coal-bearing sediments range from 185 feet in thickness at French Gulch to 375 feet at the east end of the area. The number of coal beds ranges from 30 to 32. Individual beds range from 7 feet in thickness to 40 feet of workable coal; with limited areas in which the coal is 50 feet thick or more. The lowest beds are thickest but also most irregular, as is common where coal beds have been formed overlying an unconformity. In Missouri, for example, small patches of coal as much as 90 feet thick have been found under similar conditions, but none made long-lived mines. The areas of thick coal are much less limited along Healy Creek, and the total quantity of workable coal in the field is really large. The Survey estimates that the reserve runs to 850,000,000 tons, plus 215,000,000 tons "inferred" reserve. About 460,000 tons is believed to be minable by open-pit methods. As mining has only been conducted along Healy Creek, there is not much doubt that additional large amounts of coal may be expected to be mined along lignite and other creeks in the region.

In structure, reserve tonnage, age, and character of the coal, the Healy Creek field resembles in many ways the great Fushun field east of Mukden, Manchuria. The coal in Alaska is of slightly lower grade and the beds are not so thick, but in the end it is possible that the Alaska field may prove equally valuable.

25/ Collier, A. J., The Coal Resources of the Yukon, Alaska: Geol. Survey, Bull. 218, 1903, p. 46.
Brooks, A. H., and Prindle, L. M., The Mt. McKinley region, Alaska: Geol. Survey, Prof. Paper 70, 1911, pp. 188-192.
Capps, S. R., The Bonnifield Region, Alaska: Geol. Survey, Bull. 501, 1912, 64 pp.

The coal is subbituminous B and C in quality. Most of it has an ash content of less than 10 percent, and considerable contains only 4 to 8 percent. The quality varies considerably from bed to bed but does not show systematic variation along the strike. In general, the coal at the base of the formation is higher in heating value than that nearer the top. Although the ash content is not high, the moisture in the coal is. The air-dry loss ranges from 7.4 to 8.5 percent, in general, while a number of the beds contain 15 to 19 percent of hygrocopic moisture. On an air-dry basis the principal beds run from 9,250 to 10,400 B.t.u. The coal is not adapted to locomotive use, as it makes too many sparks, but when burned on chain-grate stokers in a central power station, such as that of the Fairbanks plant of the United States Smelting, Refining & Mining Co., very good efficiency is obtained. Despite the necessary charge for shipping the coal over 100 miles from mine to power plant, it has proved practicable to generate power at a very favorable rate, lower in fact than that obtaining in many cities in the States. Using such coal advantageously is largely a matter of correct design of plant and of good operating.

Although some of the Healy Creek coal is gaseous enough to require care in mining and underground fires have at times interfered with operations, it is entirely possible to mine safely, and this has been accomplished with rare exceptions. Some of the beds, too, are subject to spontaneous combustion and require special care in stock-piling. This is true of only part of the coal; and, in fact, coal has been stored as much as 7 years without even getting on fire, probably because it was frozen. In the recent emergency such stored coal was fed into the furnaces at Fairbanks without showing material deterioration in quality.

The lignite and subbituminous-coal fields along the coast and inland rivers could probably be burned with approximately the same relative efficiency if the volume of business permitted operations on a similar scale as at Fairbanks. It is such matters as scale of operation, design of plant, and skill of operation rather than quality of coal that determines cost. This is illustrated by the fact that the same coal that permits a low kilowatt cost at the power plant at Fairbanks is expensive and inefficient when bought in retail lots and burned in house-heating stoves and furnaces.

Future Markets

At present coal production in Alaska is about 350,000 tons per year; during the war the demands of the defense plants constituted an important proportion.

The mines now open can yield enough coal to meet expected demands, and no good purpose would be served by opening more at this time. This does not apply to small mines in isolated localities such as Point Barrow, where the Bureau of Mines opened a pit to supply coal for the school, hospital, and other institutions and for household heating. At that point the native population has increased greatly in recent years as the people have moved in from the surrounding country. The driftwood, which for many years contributed heavily to the fuel supply, has now been largely exhausted, as has also the oil-rich sand mined at an oil seepage near by. The new coal mine is worked under a cover of frozen ground, and while up to now the local price of fuel has remained high, largely because of the cost of sled haulage, this may be improved. With a small amount of temporary technical supervision it is probable that similar useful mines can be opened at other points in the Territory. Any large increase in coal mining, however, will necessarily wait for increased industrialization. With the world moving rapidly toward using petroleum as fuel and with other deposits situated nearer ports where steamship traffic centers, the outlook for any export trade in coal from Alaska is far from bright. The problem of coal mining there is less one of production than of markets.

If one looks to the long-time future, attention may properly be directed toward the possibility of marketing the output in some different form than raw coal. Consideration may also be given to burning it by other methods than those now in use. Mechanical stokers of various types are available, and one type is in successful use at Fairbanks, as already indicated, while another is used on the locomotives of the Alaska Railroad. Powdered coal, largely used in the United States, may find a field in Alaska. Both methods have, however, as yet found a place only in central power plants and on locomotives. They are not available for small plants or for household heating. For the latter, some form of briquets may be visualized, but their production is tied in with the making of coke, char, or some other high-carbon byproduct of high- or low-temperature distillation. For Alaska the latter route seems likely to be found preferable, as it permits production at the same time of synthetic petroleum and oil products. This whole field is now under serious investigation by the Federal Bureau of Mines under a special appropriation; and while, as applied to Alaska, economic conditions at present point rather to continued attempts to develop petroleum fields locally or to continued importations of oil from California, there are possibilities of using Alaskan coals at some time in the future.

The more favorable opportunity seems to be in low-temperature carbonization of the coal with petroleum products as the main product and briquets of char to be used as domestic fuel as a byproduct. The principal coals produced in Alaska have been tested and have been found to be adapted to such treatment.26/

The results of the test were summarized as below:

The low-temperature carbonization products of the bituminous coals from the Matanuska field were (a) a coke weighing about 70 percent of the orginal coal, (b) 29 to 41 gallons of tar and light oil per ton of coal, (c) about 10 percent of water, and (d) 840 to 970 B.t.u. in gas per pound of coal. The sub-bituminous coals tested from the Broad Pass, Forty Miles and Nenana districts yielded (a) a char weighing about one-half as much as the original

26/ Selvig, W. A., Ode, W. H., and Davis, Joseph D., Low-Temperature Carbonization of Alaskan Coals: Bureau of Mines Tech. Paper 668, 1944, 16 pp.

coal, (b) 9.7 to 37.3 gallons of tar and light oil per ton of coal, (c) 23.4 to 36.4 percent of water, and (d) 510 to 650 B.t.u. in gas per pound of coal. The coal from the Eska Mine gave the most tar and light oil of any of the coals tested; it also yielded the highest B.t.u. in gas per pound of coal. The second most important coal as a potential source of fuel oil is coal from the No. 6 bed in the old Suntrana Mine. It yielded nearly as much tar and light oil as the Eska coal but considerably less carbonized residue and lower B.t.u. in gas per pound of coal. The Jonesville coal from the Matanuska field gives the highest yield of carbonized residue.

Coal from the No. 4 bed at the Suntrana mine was also tested and found, as was expected on account of its rank and character, to give a low yield of carbonization products.

The moisture plus distillation liquor at 500° C. amounted to 32.7 percent of the coal changed and the carbon dioxide amounted to 33.0 percent of the gas by volume or 6.6 percent by weight of the coal charged; that is almost 40 percent of the coal yields products of no value.

It is evident that the individual coal beds differ greatly in characteristics and in probable yield, although the latter may to some extent be controlled by selecting the process to be used. That the coals are as a whole amenable to treatment argues well for the long-time protection of industry in the future, though it must be conceded that, at present, and for an undetermined number of years in the future, it will not be economically feasible to process Alaskan coals. In reading this summary, it should be kept in mind that the coke and char referred to as one of the products produced is not metallurgical coke but is instead a light, friable product which is valuable only for nonmetallurgical uses. Under suitable conditions it can be burned for heating or steam making or preferably may be briquetted with a binder derived from the distillation products, in which form it is a superior fuel for household heating. This whole matter is one for future rather than present consideration.

Petroleum

As noted in the discussion of coal mining, the fuel market in Alaska is now largely dominated by petroleum. In 1940 imports of petroleum were as below:

	Gallons
Heavy oils, including crude, gas, oil, etc.	52,026,828
Gasoline, including lighter products of distillation	12,246,906
Illuminating oil	627,396
Lubricating oil	777,126

The large and rapidly developed oil fields in California have poured into the market such qualities of oil that at times long-time contracts were made for fuel oil at as little as 20 cents per barrel. This was an extremely low price. In contrast it may be mentioned that the Buffalo mine on Moose Creek in Alaska was opened with an Army contract for 40,000 tons of coal at $10 per ton. In each case emergency conditions obtained. Actually most of the petroleum heretofore sold in Alaska was marketed at a considerably higher price, and most of the coal sold brought much less than that mentioned. The figures do, however, illustrate the wide range in competition that has obtained. In passing, it may be noted that wood, which once was substantially the only fuel used in Alaska, has now dropped back to its normal position as domestic fuel for house heating. Even the river steamers of the interior are now fired with oil.

The many advantages of petroleum as a fuel, including those that derive from its use in direct power generation in Diesel and gasoline engines, are well-known. They are inherent in its higher heating value and its properties as a liquid which permit cheaper transportation and handling per heat unit. For isolated power units oil in barrels has many advantages over coal in bulk or in sacks, and where larger amounts are needed tankers and bulk storage afford all but ideal means of distribution. Several California companies have put in excellent distributing systems with bulk storage at principal consuming centers and thus offer local coal fields competition which it is hard for them to meet. The natural reaction to all this is an intensification of the search for petroleum fields in Alaska.

Indications of the presence of petroleum have been found both along the southern coast from Icy Bay on the east nearly to the end of the Alaska Peninsula on the west and in northern Alaska, and there are Triassic oil shales in Central Alaska. At Katalla a small production was maintained for a number of years, and a small refinery topped oil for local use along the coast.[27] This plant burned in 1933, and there is now no oil production in the Territory.

Oil seeps and gas leaks have been known at a number of points, and periodically there has been an oil boom, with an epidemic of staking of claims for oil leases. Little has come of this, since those who staked the claims had neither the capital nor the experience for developing them and when drilling was attempted it was, with a few exceptions, not based upon accurate local surveys nor was it always adequately supervised.

The formation that has been the source of the seeps and other evidences of the presence of oil on the Alaska Peninsula is now known to be the Jurassic, which incidentally is one of the chief sources of oil in the Near East and is known to be oil-bearing in Manchuria. The potentialities of many Jurassic formations as a source of oil have not attracted much attention elsewhere and, until recently, it was not much studied from this point of view in Alaska. At Katalla, where the oil was found in Tertiary rocks, much of the drilling was rather blind, the oil being found in cracked and crushed portions of a thick shale formation of which the structure remained to be

27/ Smith, P. S., Mineral Industry of Alaska in 1940: Geol. Survey Bull. 933-A, 1942, p. 85.

worked out. This has since been done by the Geological Survey,[28] and a map is now available upon which systematic search for oil might well be undertaken. At Yakataga, where some drilling has been done in the Tertiary, general conditions were very adverse. No real harbor existed, and access was difficult, whereas there is now a good landing field and the place is easily reached by regular airlines. One of the Yakataga structures is a long, narrow anticline with faulting to be contended with, and most careful geological work will be necessary to spot holes successfully. Here again the Geological Survey can now supply helpful guidance. The failure of holes drilled some years ago to discover commercial oil should not be taken as conclusive.

Farther southwest, drilling for oil has been undertaken in two districts. The place where most of the work has been done was at Cold Bay,[29] where in 1923 both the Associated and the Standard of California sent in rigs and drilled to depths of about 4,000 feet without finding commercial pools. The Geological Survey has now made a modern map of the Wide Bay field; and it seems probable that, taking advantage of it and supplementing the geological with geophysical surveys, a more favorable result could be obtained.

Between Katalla and the Kanatak district the principal attempt that has been made to find petroleum was at Inisken Bay on the west side of Cook Inlet. Here a well was completed shortly before World War II by experienced and careful oil operators, using the best modern methods and under close control. The well was carried down into the Jurassic, and the showing was sufficiently satisfactory to the operators so that they were prepared to go ahead at their own expense with the further drilling necessary to open a field. Their application, however, for the usual preference lease met with so much opposition and delay in the Land Office that nothing further has been done.[30] Meantime, as a war precaution, a reservation was put down over much of the Alaska Peninsula; and further search for oil by private initiative was interdicted, although Public Land Order 82 was subject to existing rights. What the condition will be when the war is officially ended cannot now be foreseen, but this stoppage of search for oil in the region where it was most needed and could be most useful was decidedly unfortunate. Probably no one thing would do more to solve the economic problems of Alaska than would the discovery and exploitation of oil fields, especially along the southern coast not far from steamer lanes and in a region where year-round operations are feasible.

28/ Miller, Dow J., Rossman, Darwin L., and Hickcox, Charles A., Preliminary Report on Petroleum Possibilities in the Katalla Area, Alaska, accompanied by Geologic and Topographic Map and Sections of the Katalla Area, Alaska: Geol. Survey Mim. Rept., 1945.

29/ See Kellum, L. B., Daviess, S. N., and Swinney, C. M., Geology and Oil Possibilities of the Southwestern Part of the Wide Anticline, Alaska, accompanied by Map and Sections: Geol. Survey Mim. Rept., 1945.

30/ Since this report was written, the application has been granted (1946).

The other area in which there are prospects of finding oil is the Arctic plains. Oil seeps at Point Simpson 60 miles from Point Barrow have long been known, and oil-soaked earth from the region has been used as fuel by the Eskimos for years. The Geological Survey reported the probability that oil might be found under the plain or along the front of the mountains to the south. In 1923 a large portion of this plain was set aside by Presidential proclamation as a naval petroleum reserve, and the Navy supplied funds for a reconnaissance by the Survey. Results were not considered sufficiently encouraging to warrant active attempts at development, all the more since the difficulties and expense of access measured against the cost of bringing in oil by tanker from California were considered excessive.[31]

With the advent of World War II the situation changed. The expected invasion of Alaska, and the actual invasion when it did take place, led to local demand for oil and oil products for defense purposes far beyond anything previously anticipated. At the same time enough tankers were not to be had, and petroleum even began to run short in the fields in the States. Large sums were hurriedly spent on the Canal project to develop a field in northern Canada to supply the need. A refinery was built at Whitehorse and connected by pipe lines, both with the oil field and with Skagway on the coast. Lines both for crude oil and for products were laid from this refinery to Fairbanks, and pending local production oil from California was delivered by tankers traversing the relatively safe inland passage to Skagway and from there through the pipe lines mentioned. Before the project was completed the Japanese had diverted our attention from the Nome-Fairbanks air route to the Aleutian Islands, in which they gained a foothold for a time. The alarm had, however, emphasized the importance of finding, if possible, a local source of petroleum in central or northern Alaska. The motive for such search was strengthened by the new interest in international air transit by northern routes.

Rumors of more seeps in northern Alaska had persisted, and 1943 the Bureau of Mines sent in a party to make an aerial reconnaissance to determine the truth or falsity of these rumors. The party included Norman Ebbley of the Bureau of Mines, Dr. Henry R. Joesting of the Territorial Department of Mines, and Capt. Henry Thomas of the U. S. Army Engineer Corps. The plane was flown by Sigmund Wien, an experienced Alaskan pilot familiar with the region and widely acquainted with the Eskimos. With their help especially, a number of additional oil seepages were located, and the presence of wide areas worthy of prospecting was demonstrated. Encouraged by this finding, the Navy in 1944 sent a company of Seabees and a large amount of drilling equipment and supplies to Point Barrow and prepared to explore the field and survey a route for a pipe line to Fairbanks. Part of the drilling equipment was hauled south to the big bend of the Coleville River, where a favorable structure had been found and drilling began in 1945. Meanwhile in Public Land Order of January 22, 1943, a temporary reservation had been made covering much of northern Alaska and Arctic Plain not in the original reserve.

31/ Smith, Philip S., and Mertie, J. B., Jr., Geology and Mineral Resources of Northwestern Alaska: Geol. Survey Bull. 815, 1930, 351 pp.

In 1945 the Navy drilled to a depth of 1,900 feet and found several oil sands, though the oil had been largely drained from them. Contracts have now been let to an engineering firm to continue the exploration.

The results of this exploration are likely to be highly significant for Alaska; but whether or not oil will be found on the Coleville River, it is clear that, in view of the numerous indications of oil in Alaska and the favorable geographic situation, the potential fields have received far too little attention. A first step should be extension of the detailed geological maps and studies of the Federal Geological Survey. Modern oil finding calls for application of a complex and highly developed technology, which, in turn, requires ascertainment of a multitude of facts as to local sequence and structure of the rocks. In the absence of such accurately obtained and carefully digested data, oil may remain undiscovered despite the putting down of several drill holes in a structure. Drilling, it is true, is the final answer, since it is necessary not only to find but to produce the oil, but modern wells drilled to such depth as is likely to be necessary in Alaska are expensive. It is only when the maximum of favorable conditions have been provided that operators are justified in drilling such wildcat wells.

It is a serious question whether the present laws and regulations applicable to Alaska are sufficiently favorable to promote development. They are based on a system of free staking for permits, with drilling followed by the granting of leases for limited areas. These features are deeply ingrained in the land policies of the United States, although it may be fairly pointed out that the big development of the West took place before the concept of strictly limited areas was applied. This feature has come in as a part of the antimonopoly policy of the country; but it is a question whether, control of monopolies being a general policy applicable to all American business, the general laws and methods applied to other industries should not be sufficient to accomplish the desired results as regards the petroleum industry. Certainly the limited amount of land that can be owned or controlled is a serious determining factor when any experienced company considers the risk and probable rewards of the heavy investment called for. Much better opportunities remain to be exploited elsewhere, a fact that has undoubtedly influenced the attitude of companies that would otherwise have been expected to undertake Alaskan development.

Assuming, too, actual discovery of oil there remains the necessity for providing pipe lines, refineries, and other facilities. These call for additional and fairly heavy investment which cannot be supported and amortised on the basis of small acreage unless exceptionally large wells happen to be found. The law permits a limited amount of combination of individual producers to supply these facilities in common, but it is far from certain that these permissive provisions will prove adequate. It is therefore possible that, even if oil fields are found in the Territory, it will become merely a source of crude oil to be refined elsewhere or that producers will be forced to use small, wasteful plants.

Another question that may be raised concerns the real value of the permit system administered as it is. It is notorious that permits are taken out by people who have neither the capital or experience to develop them, that the provisions of the permits are very commonly disregarded, and that the net result is to encumber the land with claims, often conflicting and even superimposed, that must be bought out before any real development can be undertaken. This is a heritage of a long-established belief in the public land States that local residents are justly entitled to some tribute from outsiders coming in to develop the natural resources. The situation in Alaska is not singular, and it probably cannot be remedied standing alone, although a special reason for doing so would seem to lie in the large sum that must be risked to drill an oil well under Alaskan conditions. The only economic benefit contributed by the permittee is that of a promoter who sees an opportunity and brings it to the attention of someone able to do something with it. This benefit, in practice, has proved to be small, and the permit holder has proved more of a nuisance than a help. Probably the best that can be expected would be to provide the local Land Office with the facilities and the backing necessary to insist on strict compliance, in fact, with the terms and purposes of the permits granted.

The possibilities of producing synthetic petroleum products in Alaska have been mentioned in connection with the discussion of the coal fields.

Minor and Strategic Metals

A considerable number of metals are known to be present in Alaska that have not, up to now, been brought into production or have been produced only sporadically and in small quantities. As several have high strategic value search for workable deposits was pursued actively during the war by various Government agencies. It seems probable that out of their effort will eventuate a few additional mining industries in the Territory that can survive against peacetime competition. Others are doubtful, and in still others the additional data acquired but serve to confirm prewar doubts. A permanent mercury-mining industry seems fairly certain. Lode tin mining has been shown to be possible. Antimony and tungsten production seems certain to increase. Mining the platinum group of metals was already established but may well grow in importance. The future for nickel mining and for chrome mining in the Territory is far from bright, despite the presence of interesting prospects. There is no encouragement for expectation of finding manganese or bauxite deposits of commercial value or indeed any of the group of ores of which commercial deposits commonly reflect a period of long-continued surface leaching. Arsenic production is a possibility if demand should greatly exceed present sources of supply; but cadmium, bismuth, and the ferro-alloy minerals, such as molybdenite, cobalt, vanadium, etc., production is wholly problematical at present. Silver output will depend on the future of gold mining. The presence of uranium is known in at least one locality; but adequate search for it has just begun, and as yet there is no evidence of any such occurrence as in Canada nearby. Conditions as regards copper, lead, and zinc have already been discussed.

Mercury

Mercury, or quicksilver, is one of our most essential minerals, although the total tonnage mined is not large. Its peculiar properties adapt it to many uses, and were large quantities available still other fields would become exploitable. It is sold in iron flasks with a normal content of 76 pounds. The New York price has ranged from $103.94 per flask in 1939 to $196.35 in 1942. Mercury was bought by Metals Reserve during the war at as much as $200 per flask. It is, therefore, a high-value metal, and its "normal" price is something above $1 per pound. Unfortunately the price is subject to wide variation, so much so that one experienced American producer has held that a quicksilver property to be of value as a steady producer must be prepared to withstand periods in which only $60 per flask can be counted upon. World prices have been determined by an Italian-Spanish corporation which owns mines yielding much richer ore than any mined in America. The sales policy of this company is erratic, so that, despite a tariff of $19 per flask, American producers have frequently been hard put to survive. In January 1944 the producers estimated that at a price of $80 per flask very few could continue in operation for more than a brief period.

Despite the handicap of very low grade ore and the high wages that characterize American industry, our producers have managed to bring out a surprising amount of metal. The principal production has long come from California, with smaller amounts from Oregon, Idaho, Nevada, and Arizona. In more recent years Texas and Arkansas have contributed materially. Mexico has long shipped in mercury, and during the war British Columbia became an important producer.

In prewar years California mines kept going on ore containing 15 pounds or less of mercury per ton of rock, and total United States production was of the order of 20,000 tons per year. The essential statistics in recent years are quoted below from the Bureau of Mines Minerals Yearbook:

Year	Production, flasks	Imports	Exports	Apparent consumption, flasks
1939...	18,633	3,499	1,208	20,000
1940...	37,777	171	9,617	26,800
1941...	44,921	7,740	2,500	44,800
1942...	50,846	38,941	345	49,700
1943...	51,929	47,805	384	54,500
1944...	37,688	19,553	747	42,900

As has been mentioned, the uses of mercury are many. It was only through rigid conservation measures and active substitution that war demands were met. The largest use was in pharmaceuticals, and here there could be but little restriction. Use of fulminate of mercury in detonators was, however, nearly entirely replaced by lead azide, and use of the oxide in antifouling paints for ship bottoms was greatly decreased. Use in amalgamating in gold production has been decreasing for years, as cyanidation and other modern recovery methods have come to be adopted. Very recently, however, a new use has been developed that has such potentialities that the whole consumption pattern may be changed. This is the mercury dry-cell battery, which has many advantages and is expected to be widely adopted. For various reasons implicit in the circumstances related above the future for mercury producers is considered to be bright, despite the big potential European output which hangs over the market. In wartime the domestic industry has surprised everyone in the way production has responded to price stimulus and in the large and rapid increase in output that proved possible.

Recognizing the necessity for a marked increase in output, the Federal and State agencies took early steps to find additional deposits and bring them into production. The Geological Survey pushed its examination of regions in which mercury was known to occur and it was followed by the Bureau of Mines which trenched and sampled the outcrops, following this, where it seemed desirable, with drilling for depth, examination of underground workings, and studies of ore dressing. In Alaska particles of cinnabar had frequently been found in the sluices at placer mines, and occasionally small amounts had been collected and retorted in crude stills to supply quicksilver for amalgamating the gold. Such occurrences were particularly common in the Kuskokwim Valley and the mountain country around the headwaters of that stream. For 300 miles from Ophir in the north to Aleknagik in the south, and in a belt as much as 80 miles wide, mercury was known to be present. The first substantial effort to produce the metal was by E. W. Parks, a trader near Sleitmut on the Kuskokwin. In 1906 he staked the Alice and Bessie group of claims and thereafter retorted mercury from time to time, with a total output of 120 flasks in the 17 years succeeding. Operations ceased in 1923, and the properties remained idle until the needs of World War II attracted attention to them and to others in the valley. The Geological Survey and the Territorial Commissioner of Mines kept note of the presence of mercury in the region, and in 1942 the Bureau of Mines undertook field examinations in the Sleitmut area where, within about 10 square miles, were found the Red Devil, Alice and Bessie, Barometer, Fairview, and Willis prospects. Surface prospecting having shown the presence of both marginal and commercial deposits, underground operations were undertaken on the Red Devil prospect. By March 1943 it was estimated that seven leases had 11,360 tons of ore containing 45.3 pounds of mercury per ton plus 15,900 tons containing 36.7 pounds. The ore contained antimony in almost equal amount and a small percentage of arsenic. Surface exploration at four other deposits in the area indicated 42,500 tons containing 11.66 pounds, with cut-off point taken at 4 pounds. There was an additional 105,000 tons of inferred ore containing 9.68 pounds per ton.

With these encouraging showings, the H. W. Gould Co. of San Francisco, widely experienced in mercury production, was encouraged to join in the enterprise, and the New Idria-Alaska Quicksilver Mining Co. was formed to operate the property. A production plant was moved up from California, and satisfactory production was initiated. In the first season it produced 1,100 flasks of mercury and in 1945, 960. The property is now leased to the Kuskokwin Mining Co.

The second locality from which mercury has been shipped in quantity during the war years is on Decoursey Mountain in the Iditarod district. Here, as at Sleitmut, the country rock consists of sandstone, shale, and graywacke.

The ore is found in joints, fault zones, and breccias associated with altered andesite and more basic rocks, probably of Tertiary age. Examination by the Bureau of Mines showed five zones of mineralization over 1,800 feet in length and 385 in width. In 1943 the reserve was estimated at 6,970 tons containing 32.3 pounds to the ton, with an additional inferred tonnage of 7,600 tons containing 31.4 pounds. Hand-sorted ore, treated in a small furnace, ran 30 percent mercury. The operations were financed by a loan from the Reconstruction Finance Corporation, and 700 flasks have been produced.

The Bureau made preliminary examinations of several other deposits in the region, but much remains to be done before exploration is completed. Enough has been accomplished, however, to show that mercury is to be found over a wide area and that some, at least, of the properties yield ore high in grade as compared with that worked in California and elsewhere at a profit. Not enough work has been done as yet to prove the deposits at depth, but reserves have been found sufficient to justify equipment, which fortunately is not costly per ton of capacity and can be adapted to relativly small scale operations. Access to any part of the area is easy by airplane, and in peacetimes heavy machinery can be brought up the river by steamer. Mercury is high enough in value to stand air freight charges, so it can be flown out promptly and reduce interest charges on working capital. At usual prewar prices of $100 or more per flask, it seems reasonably certain that operations may be conducted at a profit, and this should lead to wider development and an increasing output.

Tin

Among the metals found in Alaska and for which there is large demand in the United States is tin. This country is the world's largest consumer of tin and has substantially no tin ore within its borders. The situation is reflected in the figures below, being for the year 1939, which has been taken as representative of prewar years. In 1940 the country began to stock up, and imports were far more than normal. This continued true through 1941, but by 1942 the Japanese were in possession of Malaya and Netherlands East Indies, the world's chief sources of supply, and thereafter only Bolivia and the Belgian Congo, among important sources, were open to us. For comparison, the figures for 1944 are also given in the table below, although to some extent they are merely estimates. The statistics are those used in Minerals Yearbook, 1944, and the figures are in long tons.

Tin statistics

	1939	1944
Production		
Domestic mines	34	5
Domestic smelters		30,884
Secondary sources	26,000	20,100
Imports for consumption		
Metal	70,102	13,338
Ore (tin content)	500	36,504
Exports (domestic and foreign)	2,105	843
World production	177,500	100,000

Tin is one of the metals most essential to our economy, and cutting off our normal source of supply was a heavy blow. It was only by most comprehensive conservation measures and through the development of the Bolivian and Belgian sources that it was possible to keep our war production up to demand. Active search was made, substantially regardless of cost, for domestic ores but without much hope or results. Possible sources in the various States had been well combed over during World War I, and the renewed search added nothing of importance to our knowledge.

The search was extended to Alaska, from which a small supply of tin ore had come from year to year since 1900, when it was discovered there. The total recorded production, according to Robert S. Sanford, district engineer of the Bureau of Mines, has amounted to 1,450 tons.

The Geological Survey had long been active in searching for tin in the Territory, so that favorable localities were already known. Both placer and lode tin had been found. In the Yukon-Tanana region cassiterite, the oxide of tin, had been recovered in small amounts from gold placers near Hot Springs, and at several other localities and a few tons per year had been saved and shipped. On Seward Peninsula tin was also found in the gold placers of several localities, and in addition lode tin had been discovered though attempts to produce it had not been successful. Both the placer and lode deposits were investigated by the Bureau with the advice and assistance, as usual, of the Geological Survey and of the Territorial Department of Mines.

In Central Alaska three placer deposits were tested by careful drilling in 1942 and 1943 but found to be too lean in tin to warrant working for it alone. Other deposits were studied in less detail, and the conclusion was reached that, while the possibilities of discovering tin in this region have not been exhausted and in only a few instances have the bedrock sources been located, tin production is possibly only as an adjunct to gold mining. For the time being the latter industry was dead, a war casualty as already related, so further tin production from this region must wait. It is one of the anomalous results of the war that, despite the need and the activity in search for tin, the war activities actually stopped the small prewar production that had become established in Alaska.

On Seward Peninsula drilling several of the most promising placers led to the same conclusion - that while tin was present it was in such small amounts per cubic yard that it could only be expected to be produced as a byproduct of gold placer mining. It may be mentioned in passing that, as is usual elsewhere, tungsten as well as tin is found in the black sands of the gold placers. Other heavy minerals are present but have not heretofore been saved. The Geological Survey has now opened a well-equipped laboratory at Fairbanks for examining such sands, and while it is established primarily for helping the petroleum surveys, it is possible that byproduct recoveries from gold placering may be materially increased as a result of its work.

The Seward Peninsula placer-tin deposit contains only about $0.05 per cubic yard in gold. In this case the gold would be a byproduct of the tin mined.

In the Potato Mountain, Buck Creek area, Bureau of Mines exploration in 1943 indicated the existence of approximately 1,148,900 cubic yards of gravel, averaging less than 0.33 pound of tin a cubic yard or containing approximately 375,800 pounds of tin. These tin-bearing gravels are covered with approximately 705,300 cubic yards of overburden. Eight selected deposits covered with approximately 252,500 cubic yards of overburden aggregate 227,500 cubic yards of gravel averaging 1.115 pounds of tin a cubic yard or contain 253,700 pounds of tin. Production costs for mining the selected deposits were estimated at $1.00 to $1.50 per cubic yard of gravel and $0.90 to $1.40 a pound of tin recovered. In the Cape Mountain area, Bureau of Mines exploration the same year indicated the existence of approximately 690,400 cubic yards of gravel, averaging 1.00 pound of tin a cubic yard and containing a total of 692,800 pounds of tin. These tin-bearing gravels are covered by approximately 168,000 cubic yards of overburden. This reserve includes four selected deposits covered by approximately 152,700 cubic yards of overburden and contains 585,700 cubic yards of gravel averaging 1.15 pounds of tin a cubic yard or a total of 674,800 pounds of tin. Production costs for mining the selected deposits are estimated at $1.00 to $1.50 a cubic yard of gravel and $1.10 to $1.70 a pound of tin recovered.

The lode prospects on Seward Peninsula were likewise studied by the Bureau engineers. Such underground workings as existed were sampled, the outcrops were trenched, and 22 diamond-drill holes were put down in the Lost River area. The subarctic conditions imposed many difficulties, but these could be overcome in case of year-round underground mining.

The region is one where a tin-bearing intrusive granite underlies, at shallow depths, a series of limestones and slates and breaks through to the surface. Tin has been found both at the contact and in the adjacent sediments, and in the course of the exploration was found in the granite itself. Initial drilling was on rhyolite dikes, which previous exploration has indicated were the principal tin lodes. Later two holes drilled away from the contact intersected a granite intrusive which apexes about 200 feet below the surface and contains more tin than the average. In one of these drill holes 13 feet of granite averaged 2.91 percent tin. Four later drill holes cut this same lode at 150 to 180 feet. This indicates an excellent prospect of finding workable ore, and it is believed that it will be found within easy mining depth. In addition, it is estimated that at Lost River approximately 4,000,000 tons of low-grade lode tin ore is available, averaging 0.336 percent of tin plus 0.061 of tungsten calculated as WO_3. Although this is not rich ore when account is taken of the isolation of the district and the many difficulties of mining in the Arctic, the combination of high- and low-grade ore would seem distinctly to warrant an attempt at commercial production in the district.

Antimony

Another of the war-stimulated minerals was antimony, which has many uses, such as in flameproofing cloth, in making batteries, and in bearing metals, type metal, and other useful alloys and chemicals. From a tonnage point of view, the business is small, but production in the United States grew from

3,174 short tons in 1939 to 16,785 in 1943. Most of this increase came from the Yellow Pine mine in Idaho, but there were several smaller producers, including two in Alaska. Domestic production is ordinarily supplemented by imports from China. These being cut off by the enemy, ore was brought in in quantity from Mexico and Bolivia. With a sale price ranging from 12.36 cents per pound in 1939 to 15.92 in 1943 (after which demand fell off), antimony metal or ores can stand a considerable transportation cost to reach the market. Alaska mines are therefore not as severely handicapped as in the case of lower-priced metals, such as lead and zinc.

In Alaska antimony has been found in workable quantities in three districts and is probably present in several others. In the Hyder district in southeastern Alaska it is present, though not yet worked. In the Sleitmut district in the Kuskokwim Valley antimony occurs with the mercury in approximately equal amounts. In treating the ores it is not saved, and indeed is a nuisance rather than the reverse. This, however, may be regarded as temporary. The technical methods and means of separating and recovering the antimony are known and in use elsewhere. If and when mercury production becomes important in this area, an output of antimony may also be anticipated. For the small-scale operation of the present, it is not economical to make the additional investment in plant.

Actual production of antimony in Alaska has come almost entirely from north of Mount McKinley in the region already discussed as a potential lead-zinc field. Two mines, the Stampede and the Slate Creek, in this area have made antimony shipments. The mines are about 110 to 120 miles southwest of Fairbanks and deliver to the Alaska Railroad by truck through the Park. In earlier years the Stampede had been credited with a total of 2,400 tons of ore, containing 1,300 tons of metallic antimony, but had been closed for some years when war demand attracted attention to it. A geological examination was made followed by Bureau of Mines explorations. This was conducted underground since the formation appeared unfavorable for diamond drilling. It developed 5,000 tons of measured and 2,600 tons of indicated ore, averaging 10.5 percent antimony, and this led to reopening of the mine.

The Slate Creek property is in the same region but about 8 miles beyond the end of the highway. It had a recorded production of 125 tons. By means of surface trenching and churn drilling a reserve was established of 10,000 tons of 9.4 percent antimony, plus 6,700 tons of partly developed ore assaying 10 percent. This mine also was brought into production. In addition to the shipping ore, considerable quantities of milling grade are available, and a basis for larger production seems to be present.

The Geological Survey has examined other potential deposits, including one on Caamano Point, Cleveland Peninsula, and others on Wood River and Tok River. Antimony is found in connection with the gold mined near Fairbanks, and small deliveries have been made from there. It is found at a number of points in Southeastern Alaska but has attracted little attention. Although there is now no evidence pointing toward the finding of any large deposits capable of being worked for antimony alone, there is reason to expect that in the further development of Alaska's mineral resources the metal will make worthwhile contributions to the annual output.

Tungsten

Tungsten production is another high-value, small-tonnage industry. In general terms, United States production is now of the order of 10,000 tons annually of concentrate, of which the value per ton is $1,500 or more. Tungsten concentrate is usually quoted in price per unit, meaning 1 percent each in a ton of 2,000 pounds, or 20 pounds of contained WO_3 per ton. The quoted price ranged from $17.11 per unit in 1939 to $23.36 in 1944 or from $1.08 to $1.47 per pound. At these prices, very lean ores may be worked profitably, and concentrate can be gathered in small lots from long distances. Tungsten mining therefore fits well into Alaskan conditions. The metal contributes extraordinary properties to steel alloys, enabling them to retain their properties at high temperatures, so that tungsten steel is the preferred material for making high-speed cutting tools. Although molybdenum has been substituted in increasing amounts, tungsten is still in high demand and seems likely to remain so. As is true of antimony, China is the world's chief producer, but during the war American production increased surprisingly. The Yellow Pine mine in Idaho is a leading producer.

Tungsten is easily overlooked but may be recognized by its high specific gravity. Ferberite, wolframite, and hubnerite, the iron-manganese compounds, may easily be mistaken for cassiterite, the tin oxide, or even for magnetite. Scheelite, the calcium tungstate and now our chief source of domestic supply, looks not unlike quartz, and since it is commonly found as small veins and veinlets in limestone is easily overlooked. It is probable that careful examination of the heavy minerals found in the sluices at placer-gold mines will show it to be present at many points where it has not been recognized.

In Alaska production has come principally from the Fairbanks and the Hyder districts, although the mineral is known to be present at Wasilla and elsewhere. At Fairbanks production began in 1915 but lapsed after the end of World War I, when a period of low prices ensued. The principal mining was on and around Gilmore Dome and along Cleary Creek, the Stepovich property being best-known. In 1943 the Bureau of Mines examined it and estimated the indicated ore reserve to be 8,900 tons containing 3.60 percent WO_3 plus 12,600 tons of similar ore inferred. Henry Joesting of the Territorial Department of Mines cooperated in this examination by making a geophysical survey of the dome and of a larger region around. His studies brought out a number of helpful hints as to the presence or absence of important amounts of black sands in the placers and the even of distribution of frozen and unfrozen ground. The Bureau of Mines also examined and estimated the ore in the Gilbert scheelite zone and in the Yellow Pup and other properties in the vicinity. Production was established, but the difficulties imposed by distance and wartime operation, and perhaps also those involved in practicing a technic of treatment new to gold miners, militated against large financial success. In 1944 the Stepovich shipped 17 tons of 64.27 percent concentrates and 12 tons of secondary averaging 15.56.

In Southeastern Alaska the Geological Survey had called attention to the presence of scheelite in the Riverside, Mountain View, and Monarch properties as early as 1924. At the Riverside mine production began in 1940 and has been pushed vigorously. In 1944 the mine shipped 46 tons of 21.23 percent concentrate plus secondaries treated at Salt Lake City. At the Mountain View mine a mile and a half away the Bureau of Mines estimated reserves of 8,000 tons of 0.40 percent WO_3 ore, and it is believed that still other claims in the district will prove valuable for tungsten as a byproduct if not as the principal mineral. The total recorded production of Alaska in 1943was 627 units of WO_3, and in 1944, 1,111 units contained in 19 tons of concentrate. The output was sold to Metals Reserve Company. Some secondary concentrate was also re-treated at Salt Lake City.

Molybdenum

Among the more important ferro-alloy metals is molybdenum, which comes now mainly from the Climax Mine in Colorado. Molybdenite, the mineral from which the metal is derived, has been found at several points in Alaska, but as yet there has been no production. The Geological Survey has reported it in the Virginia Lake district and on the Ohong River 30 miles east of Aniak. It has also been found on St. Lawrence, Baker, and the Koscieskö Islands in Southeastern Alaska. On Kosciesko near Shakan, one ore shoot estimated to contain 10,000 to 20,000 tons of ore containing $1\frac{1}{2}$ percent MoS_2 was observed, and smaller amounts have been found elsewhere. Systematic sampling, where it has been done, has not as yet shown workable deposits to be present, but in view of the general character of the geology in several parts of the Territory, molybdenum production must be kept in mind as a distinct future possibility.

Chromite

The use of chrome and its compounds in metallurgical and chemical industries is now so important and the United States is so dependent on imports that as part of the war effort an active and widespread search was made for chrome ores. In Alaska the major development undertaken was at the lower end of the Kenai Peninsula about 10 miles from Seldovia. Here the presence of chromite was well-known, and the Geological Survey made maps and field studies. These were followed by explorations conducted by the Bureau of Mines, including the usual trenching, sampling, and estimating of reserves and checking by diamond drilling. In this instance it was necessary also to build a road from the head of Jakolof Bay to one of the mines. This was begun by one of the companies concerned but completed by the Alaska Road Commission. Work was done in two separate areas. About 2,000 tons of metallurgical ore had been shipped from Claim Point during World War I, so exploration was begun there. The work showed the presence of an estimated 263,000 tons of 17.8-percent Cr_2O_3 ore, and arrangements were made to treat it in one section of the Alaska Juneau mill, but before this project could be carried through pressure for chrome ore relaxed and the operation was given up.

Chromite had also been found in the course of the earlier work in a dunite intrusive at Red Mountain, 17 miles away. The exploration here, begun by the Bureau of Mines, was completed by the Chrome Queen Mining Co., and 5,000 tons of 42 percent plus ore was mined and delivered to the local deposit of Metals Reserve Company in 1942-43, with 1,650 tons of 40 percent ore in 1944. The operations of Red Mountain Chromite, Inc., did not reach the stage of shipment ore. The reserve estimates here were 30,400 tons of 44-percent ore if mined alone or 47,130 tons of 41.74-percent ore won by sorting plus 44,044 tons of 19.14-percent ore for milling.

The results of this exploration on Kenai Peninsula were similar to those elsewhere in the United States in that they failed to show the presence of any notable amounts of metallurgical-grade crude ore. Any large production would require milling of lower-grade ore. At present that is not considered necessary. Ore of refractory grade is to be had, and by utilizing the olivine in various ways, if they prove feasible, and industry could seemingly be built up; but in view of the abundance of crude ore of satisfactory grade in various parts of the world, this does not seem probable in any near future.

Nickel

Nickel, the most versatile and widely used of the ferro-alloy metals, has long been known to be present in Alaska, although there has been no commercial production. The search for additional sources of supply, provoked by the war demand for the metal, led to thorough restudy and reassessment of the deposits. In the area between Juneau and Sitka nickel was found some years ago on a number of the different islands including Admiralty, Yakobi, Chichagof, and Baranof. Nickel also was known to be present in the Copper River Valley on Spirit Mountain and perhaps at other localities. While the Geological Survey had studied all these occurrences and various attempts had been made to mine at some of them, there was much doubt as to whether any deposits of commercial importance were really present. They were, accordingly, reexamined by the Geological Survey, Bureau of Mines, and the Territorial Department of Mines, and the results are now available.

The geology in the various areas concerned between Juneau and Sitka is similar and in general resembles that of the Sudbury district in Canada. The region is one of meta-sediments, including graywackes, slates, phyllites, and altered limestones, all intruded by ultrabasic sills and dikes of gabbro to norite type. This complex has, in turn, been cut by more acid intrusives, offshoots from the Coast Range granite mass. In these rocks, and more particularly in the basic igneous intrusives, are found the ore minerals magnetite, pyrrhotite, chalcopyrite, and pentlandite, usually disseminated but in a few places segregated in blebs and small masses. Unfortunately there has not been found so far the large veins and replacements that have proved so valuable at Sudbury.

The Admirality deposits have been described by John C. Reed[32] with references to earlier work. At Funter Bay, where there is a gabbro sill known as the Mertie lode, 100 to 128 feet thick running through the greenstone. The rock is rich in olivine and contains disseminated through it the usual ore minerals magnetite, pyrrhotite, chalcopyrite, and pentlandite. It has been partly explored by tunneling and by drilling, and various samplings are of record. The Bureau of Mines in 1942 cut a large sample for metallurgical test,

32/ Reed, John C., Nickel-Copper Deposit at Funter Bay, Admiralty Island, Alaska: Geol. Survey, Bull. 936-O, 1942, pp. 349-361.

and a year later took 14 channel-cut samples over a 90-foot section in the Mertie adit. These average 0.46 percent nickel and 0.41 percent copper. There was also a small amount of gold and silver ($0.40 per ton) and a little cobalt. The ratio of nickel to cobalt ranged from 3.1 up to 6.1. The large sample taken was subjected to beneficiation tests and a concentrate made which in character and grade was comparable to the ore smelted at Sudbury. The situation is favorable for mining, and there is little doubt that large bodies of the material are available. It remains a question whether such low-grade ore can be worked at any profit.

Another of the deposits that has attracted much attention is in the Bohemian Basin on Yakobi Island. It also has been described by Reed, in this instance associated with J. van N. Dorr, 2d.33/ The rocks here are thought to be of Upper Triassic or Lower Cretaceous age and consist of volcanic and sedimentary beds, now metamorphosed to schist. They were invaded, probably in Cretaceous time, by acid intrusives, now gneisses, related to the Coast Range and later by basic intrusives. On Yakobi Island and the west coast of Chichagof Island still younger intrusives are present. The usual sulfides are present in small amounts and are believed to represent magmatic concentrations. According to Bureau of Mines engineers, 12 ore bodies have been identified, but only those in Bohemia Basin have been prospected. Here the Bureau drilled, and four drill holes indicated ore to the amount of 4,681,000 tons containing 0.342 percent nickel and 0.219 percent copper. By selective mining it is estimated that the grade could be raised to 0.410 percent nickel and 0.263 percent copper, the tonnage being cut to 3,904,000. In addition, four ore bodies examined show the presence of 5,660,000 tons of inferred ore so that a total tonnage of 10,000,000 is believed to be present. The ore can be concentrated by fine grinding and flotation. Here, as on Admiralty Island, the question is whether or not all this can be done within a cost that will permit a profit.

Similar deposits are known on Chichagof and Baranof Islands, although the known or probable tonnage is not so great and mining conditions are not so favorable. On the other hand, there has been some tendency to segregate the sulfides at certain localities, which opens the possibility of finding at least limited quantities of higher-grade ore with which to sweeten the output.

At the Spirit Mountain prospect on Canyon Creek, lower Copper River district, much richer ores are known to be present; but the region is one to which access is most difficult and expensive, and the size of the ore bodies is wholly unknown. Termination of the war and consequent dropping of the search for strategic minerals interfered with a project for examining this locality by the Bureau of Mines in 1945 just as it was getting underway. The general situation as regards further search for ores in this region has already been discussed.

33/ Reed, J. C., and Dorr, J. van N., 2d, Nickel Deposits of Bohemian Basin and Vicinity, Yakobi Island, Alaska: Geol. Survey Bull. 931-F, 1942, pp. 105-138.

In general, the prospect for mining nickel in Alaska can hardly be judged to be good, although it cannot be entirely dismissed. The ore so far demonstrated to be present in quantity is extremely low in grade, much below that which is rejected at Sudbury. On the other hand, by grinding and suitable flotation a concentrate of grade equal to that of good Sudbury ore can be made. This has been demonstrated not only by Bureau of Mines tests on Alaska ores but by its studies of Bunkerville and other Nevada ores of little better grades. The Canadian Department of Mines has also been successful in floating similar ores, but again these were of somewhat higher grade. They were from a British Columbia deposit, and serious consideration has been given to operating the property. A concentrate having a combined nickel-copper content of 10 percent has been made in pilot plants and is a valuable ore. The Alaska and British Columbia ores are similar, and both are sulfide ores. This latter is at once an advantage and a disadvantage, in that the ores can be treated by well-known processes but must be reduced by smelting as they are not amenable to any leaching process as yet known. The latter method of treatment is now applicable to oxidized nickel ores much lower in nickel content than any handled by the smelters, but smelting alone must be relied upon to treat the Alaskan ores. Unfortunately no smelter nearer than eastern Canada is prepared to treat such ores, and they have in the territory tributary to them much richer deposits already available. Before the war consideration was given to shipping concentrate from British Columbia to Japan, and under the peculiar conditions of Japanese shipping and smelting the project appeared feasible. It is doubtful whether Japanese industry will so recover that such an ore movement can be contemplated in any forseeable future, and it is hardly worth while to consider the building of a West coast nickel smelter. Even most optimistic estimates of the probable ore reserves do not indicate a sufficient supply base, and the amount of capital necessary would be large since any nickel-treatment plant requires a heavy investment per ton of annual output.

Platinum Metals

Platinum is a white, heavy metal more valuable than gold, which has important chemical and metallurgical uses as well as in jewelry. It is but one of a group of related metals usually found together and including palladium, iridium, osmium, ruthenium, and rhodium, as well as the better-known metal which gives name to the group. Alaska is the principal source of domestic supply, although the Sudbury nickel district in Canada leads the world in production, followed by Russia and Colombia. Alaskan production became important in 1938 and has continued since at about the same rate, 27,000 ounces more or less per year. It comes mostly from Good News Bay on the west coast below the mouth of the Yukon River where it is produced from placers with an incidental and minor yield of gold. A modern dredge and a drag line scraper are employed in the operations. The properties have been described by J. B. Mertie of the Geological Survey.[34] Fortunately the ground in this field does not require to be thawed.

[34] Mertie, J. B., Jr., Platinum Deposits of the Goodnews Bay District, Alaska: Geol. Survey Bull. 910,B, 1939, pp. 115-145; The Goodnews Platinum Deposits, Alaska: Geol. Survey Bull. 918, 1940, 97 pp.

Metals of this group, especially palladium, have also been recovered from the ores on the Kasaan Peninsula of Prince of Wales Island in Southeastern Alaska by the Alaska Gold Metals Co., which from 1937 on mined a gold-silver-copper ore containing a significant amount of palladium. On the Seward Peninsula, Koyuk River, Quartz Creek, and in the Fairhaven district small amounts of the platinum metals have been recovered as a byproduct in gold placer mining. The presence of the metal has been detected in numerous other districts, and from some of them occasional lots have been sold. It seems probable that a continued moderate production may be anticipated.

Miscellaneous Metals

Many minerals, not discussed herein, are found which contain metals of value but are not now mined, in Alaska. It is doubtful whether many of them will ever be important locally, but as to some of them it may be well to keep a look-out. The Territorial Department of Mines maintains a very helpful service for examining specimens and making assays for prospectors, with offices at Ketchikan, College, Anchorage, and Nome, and has published useful booklets on Prospecting in Alaska and Industrial Minerals as a Field for Prospecting in Alaska, including a Glossary of Elements and Minerals. The University of Alaska not only maintains a school of mines but provides short winter courses at various points. Through these agencies the men who have previously prospected for gold only or mainly are now becoming acquainted with other minerals of possible value, and a distinct broadening of the basis of mining in the Territory is to be hoped for.

Certain minerals are not likely to be found in quantity for good geological reasons. Bauxite may be mentioned as one and manganese ore, less certainly, as another. Cadmium, if present, is likely to occur principally with zinc ores. Bismuth similarly is likely to be a minor constituent of lead ores. Cobalt and nickel go together and have already been discussed. Titanium, no doubt, is present in some of the magnetite ores but is of doubtful value in this region. Vanadium and molybdenite would be valuable if found. Arsenic is to be looked for if sulfide ores come to be worked in quantity. It is doubtful whether all the platinum-group metals present in the gold placers are saved, and uranium has so far been reported from but one locality. It is easily overlooked. All these are as yet mere possibilities but deserve mention as such.

Nonmetallic Minerals

The total value of the mineral output of the United States is now about 8 billion dollars per year. Of this the fuels supply 57 percent, the metals 31 percent, and the miscellaneous nonmetallics 12 percent, or slightly less than 1 billion dollars. The importance of the nonmetallics to our industrial economy is easily overlooked, since the output is made up of a very large number of individual items no one of which contributes a really large amount. Writing in 1933, Oliver Bowles noted that 80 percent of the total was produced by four classes of materials - clays, cement, stone, and sand and gravel. He called these the "100-million-dollar materials", referring to the value of their annual output. The second, which he called the "10- to 50-million-dollar group" and which was responsible for 13 percent of the total, included sulfur and pyrite, lime, gypsum, salt, and phosphate rock. The remaining 7 percent of the annual output came from minerals then yielding less than 10 million dollars per year. In this group the important members were abrasives, asbestos, barite, diatomite and tripoli, feldspar, fluorspar, fullers earth, graphite, magnesite, mica, potash, talc, and soapstone. These are all bulky and usually low-value products. Their bulk restricts their shipment, and this and the fact that most of them are fairly widely distributed has led to the development of local rather than centralized industries. In Alaska they have been generally overlooked or neglected. Only one of the whole classification of nonmetallic minerals has as yet produced as much as $1,000,000 output per year; that is sand and gravel, which came into large use for roads and defense projects in war years, but production has now dropped back to less than half that amount. Nonmetallic mineral production is seldom dramatic, and there is not often the opportunity to get rich quickly which has lured so many into gold mining. The nometallics do, however, include many materials even more essential to industry than gold, and fortunately they frequently offer the opportunity for building up sound local industries of small to moderate size. In evaluating the industrial opportunities of any region they should not be overlooked.

Asbestos

This term is applied to a group of related minerals that have the common property of crystallization in long, slender forms of such small diameter and flexibility as to constitute mineral fibers. Like plant fibers and, as has recently become appreciated, glass fibers, these can be woven into cloth or twisted together in masses or felts, in which form they are used for packing and insulation. Unlike the common vegetable fibers, the material is fireproof and hence can be used where it must withstand high heat which would weaken or disintegrate ordinary fibers. The peculiar properties of asbestos have been known since early times, and more than one ancient priest or magician owed his reputation as a miracle worker to possession of a piece of asbestos cloth which would not burn but instead was purified by fire. The fact that the long acicular crystals of chrysotile and certain related minerals can be split parallel to the axial cleavage repeatedly until only fine, silky fibers remain has made possible their use as a textile material. Fibers long enough to be so woven, however, constitute but a small portion of the material found in a mine, and while spinning fiber brings a high price ($500 per ton and up) other uses take more stock and in the aggregate bring in more money. Fibers too short for weaving can be matted or felted together, and in that form the material is adapted to many uses such as steam packing, insulation, and brakeshoe lining. The growth of the automobile industry gave great impetus to production of asbestos. Still shorter fibers are available for a wider variety of uses either alone or in combination with other minerals. Mixed with 85 percent magnesia, a popular insulating material results. With 20 percent asbestos and 80 percent cement it is possible to manufacture pipe having peculiar properties which fit it for many uses. Shingles and other structural shapes are made with 85 percent cement and only 15 percent asbestos which are fire resistant and are increasingly popular. Thirty years ago only the spinning fiber, 3/4 inch or longer, was in demand, and purchasers were required to take with each ton of this a proportionate amount of the lower-grade material. In an effort to find markets for this the manufacturers built up such a demand that the spinning fiber is now the incidental rather than the main product. Length of fiber is no longer the sole test of value. Indeed, in one mine in Vermont an extra-long fiber is cut into shorter lengths before being spun.

A half dozen or more minerals are marketed as asbestos; but broadly speaking they fall into two classifications, chrysotile and amphibole. The first is a fibrous serpentine of the composition $H_4Mg_3O_9$. It is characterized by the fineness of the fibers, silkiness, and high tensile strength. The amphibole asbestos is usually too harsh for spinning but is more resistant to heat and to acids. In this class is tremolite asbestos $CaMg_3(SiO_3)$. This variety also has good resistance to electric currents and is used for insulation against electricity as well as heat. As a heat insulator, asbestos serves not because of any special properties as a nonconductor but because of its form and the distribution of air space among the fibers. The heat waves are broken up and reflected back, as in other forms of porous insulators. It is the minute division that is important.

The United States is the world's largest consumer of asbestos but an insignificant producer. Approximately 75 percent of our supply is imported from Canada and 20 percent from Africa; the remainder is derived from domestic and other sources. Under these conditions there is an excellent opportunity to develope any deposits found in the States or Alaska. It is not to be forgotten, however, that asbestos is an industrial mineral and is therefore marketed mainly in the industrialized part of the country, namely, the Eastern States and New England. The Canadian deposits, which are in southern Quebec, have a natural and large advantage in shipping into this area, as well as an established position in the trade.

Asbestos was known in Alaska in pre-historic times and has been found in excavations on ancient village sites between Shungnak and Kiana on the Kobuk River, the same area within which it is now beginning to be mined. Its presence on Dahl Creek was noted as early as 1910 but as the fiber was then judged unsuitable for spinning no further attention was paid to it until 1931 when Irving Reed of the Territorial Department of Mines visited the region. He sent to the Bureau of Mines at Washington samples of chrysotile asbestos of high quality. Later, as part of the search for the strategic minerals, both Territorial and Federal engineers and geologists[35] examined the area in 1943 and 1944, and the work of the Bureau of Mines was continued into 1945.

35/ Anderson, Eskil, Asbestos and Jade Occurrences in the Kobuk River Region, Alaska: Territory of Alaska, Department of Mines Pamphlet 3, Juneau, 1945.
Coats, Robert R., Asbestos Deposits of the Dahl Creek Area: Geol. Survey mim. rept.
Heide, Harold E., Dahl Creek Asbestos Deposits, Kobuk River Region, Alaska: Bureau of Mines mim. rept. 7299, 1944.

The Kobuk River asbestos district is about 300 miles northeast of Nome or 150 miles east of Kotzebue on Norton Sound. It is easily accessible by plane or by river boat from Kotzebue. The deposits are found in a range of mountains paralleling the river and some 10 to 20 miles north of it. These are known as the Cosmos Hills at the east and Jade Hills at the west. The district is about 45 miles long from east to west and extends from the Kogoluktuk River to Jade Creek. The Cosmos Hills rise to about 2,000 feet, but the Jade Hills are higher. The range is cut by a number of southward-flowing streams - Kogoluktuk River, Dahl Creek, Wesley Creek, Camp Creek, Cosmos Creek, and Shungnak River - flowing across or out of the Cosmos Hills and Ambler River, Redstone River and Jade Creek cut through Jade Hills. The mountain mass consists of ancient sediments, graywackes, and limestone, now represented mainly by schist. These rocks were intruded by an ultrabasic rock, presumably a peridotite but now a mass of serpentine. In the Cosmos Hills the serpentine seems to be a sill resting on the metamorphic rocks. In this serpentine, both chrysotile and tremolite asbestos has been found in the form of veinlets of cross fiber and as slip fiber along planes of movement. The surface is much covered by talus, and only small patches have been uncovered, but float asbestos is widespread. Jade is also found, in one place as a veinlet in asbestos but mainly in the form of large boulders of float. The presence of chrysotile of good quality was recognized as a result of the work of Michael Garland, who prospected the region in 1932-33, and about 10 years later James S. Robins of the Arctic Circle Exploration Co. entered the region and began staking claims. In the fall of 1944 shipments began to be made and the company has continued active exploration, especially on Dahl Creek. The chrysotile found on this creek includes slip fiber of unusual quality and length, but up to now the quantity produced has been small. The tremolite fiber has, contrary to general experience, been found to be of more immediate value, its high resistance to acid fitting it for use in acid filters. This market was formerly largely supplied from Italy, but the latter country being cut off by war, the Alaska material has found ready acceptance. So insistent was the demand that shipments were made by airplane in the winter of 1944-45.

Following the geological explorations, the Bureau of Mines trenched and sampled a number of the outcrops with good results, but the end of the war stopped the exploration before it was completed. At the moment it can only be reported that asbestos of commercial value has been found at a number of localities over a belt 45 miles long in a readily accessible region and that there are many excellent reasons for believing that continued exploration will result in finding ore bodies of considerable size and workable grade. The importance to the national as well as Territorial economy of their development cannot be doubted.

Barite

The sulfate of barium is a heavy mineral that is white when fine ground and finds many uses. Formerly it was looked on as primarily an adulterant, but it has come to be recognized as having properties that endow it with value in its own right. It has long been used as a filler in paints, paper, rubber, linoleum, and other commodities; but now, particularly when made into lithopone, is recognized as a valuable white pigment. Lithopone consists of 70 percent barium sulfate, 26-28 percent zinc sulfide, and 1 to 3 percent zinc oxide. Until very recently the larger part of the barite mined found its way to the market through lithopone. A newer use which has grown rapidly and seems capable of still larger growth is as a weighting material for the muds used in drilling oil wells by the rotary method. This is a true tonnage market and has created a large demand for the material. In 1944, of the crude production (amounting to 515,136 tons) 277,792 was used for this purpose. The second largest use was in lithopone, amounting to 134,597 tons, while the chemical trades took 100,921. Glassmaking, paint filler, and rubber filler absorbed most of the remainder. Barite sells at $8.50 to $12.50 per ton at the mine, depending on locality and purity. It comes mainly from Missouri, Arkansas, and the Southeastern States, but there are two producers each in Nevada and California.

The presence of barite in Alaska has been known for some years, and in 1914 E. F. Burchard[36] described a deposit, estimated to contain 50,000 tons of 90-percent barite, above tide level on one of the Castle Islands in Southeastern Alaska. It seems probable that search would reveal other deposits in the region, and if so they would be favorably situated for water transportation to California, where there is a rapidly growing market.

Clay

Clays of various types and character are present in Alaska in both the Coal Measures and the Quaternary deposits but have not come into use. Clays suitable for making common building brick are present in the Matanuska and Healy River fields, where abundant coal is available, and it is believed that there is opportunity for a brickyard at Anchorage and possibly for another on Healy River to supply Fairbanks. Both cities are growing out of the log-cabin and frame-house period of building and are affording a steadily increasing market for some more durable type of building material. At present the only alternative to wood is concrete, although plaster board of various types is being more and more widely used. Concrete absorbs local sand, gravel, or broken rock, but both cement and reinforcing bars must be brought in. Local conditions do not favor manufacture of either of these materials or are they likely to do so for many years. On the other hand, it would be possible, at Anchorage at least, to build brick houses out of local material, and Southeastern Alaska affords unlimited quantities of limestone from which to make lime for mortar. This is the historic path that the building trades have followed, not only in the United States but generally, and over much of the world a brickyard was about the first local industry developed after the grist mill. Fortunately, brickyards suitable for local manufacture do not require much capital or call for much high-grade technical skill. Brick, being a heavy product handled in small units, is not ordinarily shipped far unless it is of some special quality, such as firebrick. Brickmaking is an industry especially adapted to being built up in small units with limited absorption of capital, and for making ordinary grades of building brick a wide tolerance is permissible in the choice of clay and of fuel. Brick is, nonetheless, an excellent building material, being fireproof and permitting

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36/ Burchard, E. F., A Barite Deposit near Wrangell: Geol. Survey Bull. 592, 1914, pp. 109-117.

a great variety of architectural expression. Both small and large buildings are made of brick, and wide latitude as to design is permissible. In time, if one may judge by events elsewhere, the industry may be built up into the manufacture of better grades and higher-priced goods, but the immediate need and present opportunity is for a brickyard to make ordinary but good building brick.

Fluorspar

Calcium fluoride is used in both metallurgical and chemical industries. Between 5 and 6 pounds is usually consumed as a flux in making each ton of steel, and it is also essential in the reduction of alumina to aluminum. Hydrofluoric acid has many essential uses in chemical manufacture. The material has been in keen demand during the war, and the prices of metallurgical fluorspar rose to as much as $33 per ton. Ordinarily the price is much below this, and in the postwar period a severe shrinkage in market demand is to be expected.

Fluorite is a conspicuous mineral, usually brilliantly colored. Blue, green, lavender, and yellow are common colors. It occurs ordinarily in limestone and is commonly associated with lead and zinc. It crystallizes as a cube and is easily recognized. It has been found in a number of places in Alaska but, as yet, not in quantity. In view of the remoteness of the country from the principal centers of consumption and the presence of producing centers much nearer the market, development of fluorspar in Alaska is very doubtful. The possibility however of its production as a byproduct should be kept in mind.

Garnet

Many minerals are used as abrasives, from the old-fashioned whetstones and millstones to novaculite and emery. Artificial abrasives now control a good deal of the market, but natural material is still sold in amounts up to $6,000,000 per year. Among those in demand, which are known in Alaska, are the garnets. The total United States production in this classification has ranged between 4,056 tons valued at $278,534 in 1939 and 5,935 tons valued at $429,120 in 1943. A material selling for $70 per ton will stand considerable in the way of production and marketing cost.

Garnet is a name applied to a group of minerals of metamorphic origin and found usually in gneisses, schists, and metamorphic stones. Commonly they are distributed through their matrix like plums in a pudding and must be broken free and separated from the remaining rock. To a subordinate extent garnets are to be found in stream gravels and placer beds and may sometimes be recovered as a byproduct of gold mining. Near Wrangell there is a well-known deposit not now in production, and it cannot be doubted that others would reward search.

Gypsum

This, the hydrous sulfate of lime, occurs in beds and occasionally in small veins as well as in gypsiferous clays. It is an important building material, being used either as plastic in built-in construction or as wall-board or in other prefabricated forms. It is also used as a constituent of fertilizer and has numerous minor chemical and industrial uses, among which may be mentioned papermaking and cement manufacture, where it operates as a retarder to keep the cement from setting until it can be worked. It is a low-value product in the crude state, priced in 1941 at $1.42 per short ton at the quarry. By boiling off the combined water, which may be done in open kettles, it is converted into plaster and as such has a value of about $5 per ton. While gypsum is relatively abundant, it is irregularly distributed and for particular uses, such as cementmaking, is sometimes shipped long distances. Far Eastern cement manufacturers draw their supply from eastern Canada and the United States, and since the amount used per ton of cement is small the cost of transportation is easily absorbed. It is generally accepted that the use of gypsum and gypsum products will increase steadily with further industrialization and rebuilding, though in certain areas the industry is periodically overbuilt and the business is highly competitive. A good deposit favorably situated for mining and transportation has nonetheless a considerable potential value. Gypsum has been found at a number of localities in Alaska, and commercial developments are a possibility of the future.

Limestone and Marble

Building stone of any variety has been little quarried and used in Alaska, as is usual under pioneer conditions, especially where wood is widely available. The early Russian forts and trading posts were built of logs and the American gold miners who followed stuck to log houses until sawed timber became available. For some time now concrete has been almost exclusively used for permanent structures, the brick and mortar stage which characterized so much American development having been bypassed. It has already been suggested that even so there is now some field for brick in particular localities and if brick is used mortar, and hence lime, will be needed. For structures of the monumental type stone will doubtless be preferred as elsewhere. The pillars of the Territorial building at Juneau are cut from Alaska marble; and this material is regularly quarried and shipped in Southeastern Alaska. Minor amounts of granite, which is abundant, have also been quarried and sold for grave markers and monuments, but as yet the building-stone industry in Alaska is small and undeveloped. The occurrence of good stone suitably situated for quarrying near the shore and available for water transportation in Southeastern Alaska would favor a much larger development; but in the United States other building materials are generally preferred, and at best only a slow and probably deferred development of any building-stone industry in Alaska may be safely anticipated.

This, however, does not apply to limestone, since the latter has important uses aside from that as a building stone and brings considerably higher prices in some of their uses. It is used in considerable amounts in the agricultural, chemical, and metallurgical industries, in the latter both as a flux and, in the form of dolomite, as a refractory. It happens that in Alaska excellent lime both of the cacitic and dolomitic varieties can readily be made from abundant materials. The Paleozoic formations there, as commonly elsewhere in the United States, are characterized by widespread occurrence of both limestone and dolomite. This holds especially in Southeastern Alaska, where there is a limestone bed of great purity in the Silurian series which is present at a number of good quarry sites. Limestone is already being shipped from this region to Puget Sound by the Superior Portland Cement Co., and both the Vermont Marble Co. and the Alaska Marble Co. have shipped to Pacific Coast States and elsewhere and the Aluminum Co. of America has recently begun preparations for shipping from Edna Bay on Kosciesko Island. The geology of the region and the occurrence of the marble and limestone have been described and discussed by various members of the Geological Survey, including especially F. E. and C. W. Wright37/ and E. F. Burchard,38/ and the whole area was restudied and sampled by one of the engineers of the Territorial Department of Mines in the summer of 1945. As his report is now being prepared and will doubtless shortly appear, no attempt will be made to repeat or even summarize what is already in print. It will serve present purposes sufficiently to point out that high-grade material is present in abundance and in situations favorable to operating and shipping by water and to call attention to certain economic conditions obtaining in the region.

Chief among the latter is the fact that the Pacific Coast States are but meagerly supplied with limestone deposits of good quality. At present California industries depend in part on rail shipments from Nevada and, where considerable amounts of limestone are needed, as at portland cement plants, there has been an all too frequent failure of individual quarries and necessity for opening new ones. The rock used at the large Permanente plant was long undeveloped because of the presence of excessive silica in the form of chert. It was only brought into use as a war measure, with expectation of applying ore-dressing methods to beneficiate the limestone. Fortunately the large demand for high-silica cement makes this no longer necessary. For other uses, such as sugar refining, where very pure limestone is needed, the Alaska rock should be particularly fitted. For papermaking and for chemical industries in general, where quality must be taken into account, the delivered price of lime over the country as a whole has in recent years run from $7 to $8.65 per ton, and for special uses or in special situations considerably higher prices have been paid. When these prices, even though they are for delivered rock, are compared with the value of lode-gold ores widely worked,

37/ Wright, F. E., and C. W., Economic Developments in Southeastern Alaska: Geol. Survey Bull. 259, 1905, p. 68; The Ketchikan and Wrangell Mining Districts: Geol. Survey Bull. 347, 1908, pp. 191-198. Wright, C. W., Nonmetallic Deposits of Southeastern Alaska: Geol. Survey Bull. 284, 1906, pp. 55-57; Nonmetalliferous Mineral Resources of Southeastern Alaska: Geol. Survey Bull. 314, 1907, pp. 73-77; The Building Stones and Materials of Southeastern Alaska: Geol. Survey Bull. 345, 1908, pp. 116-122.

38/ Burchard, E. F., Marble Resources of the Ketchikan and Wrangell Districts: Geol. Survey Bull. 542, 1913, pp. 52-77; Marble Resources of the Juneau, Skagway, and Sitka Districts: Geol. Survey Bull. 592, 1914, pp. 95-107.

it seems obvious that opportunities lie fallow in this field. So far as known, there is not a single limekiln in the whole of Alaska, and yet in 1944 the average price of quick lime and hydrated lime produced in the United States was $7.52 per ton. The total output was 6,473,563 tons. Forty States contributed to the total. It would seem that, in view of the wide variety of uses of lime, the average price, and the abundance and excellence of the rock in Alaska, a beginning, at least, of production would be possible.

Sand and Gravel

These materials are widespread in Alaska, as elsewhere. Along the beaches and streams and in the glacial deposits they occur plentifully, though not always sufficiently assorted to be useful. The recent period of road building and military construction showed that materials that can be cheaply won and easily prepared for use are abundant. The old tailing piles from placer mines and the dredge tailing of modern workings afford a large supply of easily available rock for aggregate requiring only sizing and washing. Except for such material, the airfields and network of roads recently built would have been all but impossible. Much remains to be built, especially road extensions. As, too, the Territory passes over from the pioneer period calling for cheap temporary buildings into the industrialized stage where permanent structures are economical, the lowly sand and gravel will come more and more into use as concrete aggregate. It is of interest to note that in many situations in the United States such materials, when near towns, can be mined, prepared, and sold at a price per cubic yard far higher than that yielded by any but the richest gold placer ground.

Jade

A considerable number of mineral species are sold as jade, although only two, jadeite and nephrite, are properly so-called. The first is a variety of pyroxene, essentially a metasilicate of sodium and aluminum. Nephrite is a variety of amphibole, a metasilicate of iron, calcium, and magnesium. The minerals are found in the areas underlain by ultrabasic rocks and, being characterized by great toughness, persist through the processes of serpentization and weathering of these rocks. Jade is now found in Alaska and in Burma, in the form of boulders, in the soft clay which is the final product of decomposition. Jade has been highly esteemed in the Orient for centuries. It was also valued by prehistoric peoples in both North and South America and in New Zealand. In recent years its beauty, hardness, and durability have come to be appreciated in the United States, and there have been considerable imports of cut pieces, especially from China, where carving jade is an art practiced as a household industry even in the far interior.

In the United States a minor jade industry has been growing up in Wyoming, where the mineral is found as boulders and pebbles on hill slopes near Lander. Boulders weighing as much as 8,000 pounds have been found, and in 1943 local sales totaled $15,000. Better specimens, translucent and green, have been sold for as much as $5 per pound, according to S. H. Ball's report in the Minerals Yearbook.

Jade, to use the commercial name, occurs in a variety of colors, though the apple green is the one most highly esteemed in the United States and southern China. In northern China and frequently elsewhere the so called shui jade, white to brown, is preferred. In New Zealand and Mexico the local product is dark green and is highly esteemed. It is a matter of taste, and styles change so that marketing jade is highly speculative business. Mining and cutting are also speculative, since the quality and color are rarely uniform, even throughout a single boulder, and the real value is only determined when the material is cut. Much has little or no value. A new industry has recently grown up in supplying uncut jade and other stones to amateur lapidaries. According to Ball, Wyoming nephrite sells in this trade at $3 per pound.

Jade, in the form of nephrite, is found on Jade Mountain in the Kobuk River asbestos field and may well become an important byproduct of mining there. It is possible that a native jade-cutting industry may be built up to supplement or supplant the ivory carving of the Eskimos and help support them. The material occurs as usual in the form of surface boulders.39/ It has been found in the gravels of various creeks flowing into the Kobuk as far east as Dahl Creek and is now being collected by the Arctic Circle Exploration Co. in connection with the mining of asbestos. The importance of the deposits is yet to be fully determined, and this can only be accomplished slowly, as it is so largely a matter of building up a demand in a field where style is important. Since there are other areas in which the parent rock outcrops in Alaska, jade may also be found in them.

Sulfur

The sulfur deposits of Alaska are of the volcanic type. They are relatively small and have not been mined, though an attempt to do so was made on Akun Island in 1919-20. The Geological Survey estimated the reserves there to be 18,000 to 24,000 tons. A deposit at Makuskin Volcano has been reported to indicate 100,000 tons. Sulfur is also known near Stepovak Bay, but the quantity has not been estimated. Probably other deposits are present at various points along the Alaska Peninsula, which extends 1,000 miles to the southwest. Owing to the abundance and low cost of sulfur mined from salt domes in Texas and Louisiana, it would be difficult for Alaska deposits to compete successfully in the world's markets. It is only in a few countries and to a limited extent that solfataric sulfur is now produced, so that the prospect for a sulfur industry in Alaska is not now bright. There are, however, considerable amounts of sulfur that may come into production at some time in the future as a byproduct from treating sulfide ores of various metals.

CONCLUSIONS AND SUGGESTIONS

From what has already been said, it is clear that in Alaska are considerable reserves of mineral resources of varied character, sufficient to form the basis for much more general industrialization than has yet taken place. It is also extremely probable that future discovery will add even more to the reserves. Without disparaging the possibility of developing other resources, it

39/ Anderson, Eskil, Asbestos and Jade Occurrences in the Kobuk River Region, Alaska: Territory of Alaska, Department of Mines Pamphlet 3, Juneau, 1945.

may properly be pointed out again that it is to mining that the Territory must look primarily for breaking the deadlock that now all but paralyzes growth of industry and increase in population. Despite the limitations imposed by the climate, Alaska must get away from the present dependence on seasonal industries which in turn leads more to enrichment of the national than the local economy. Although large lode mines are to be expected and sought for in the interior and along the coast and large pulp mills should be brought into being, a balanced economy demands that the base be broadened by attention to small industries as well. Alaskans have reveled overlong in a bonanza atmosphere. Nome, Fairbanks, and Kennecott have led the citizens to think in terms of large and rich deposits and to be dissatisfied with smaller ones, but a number of small mines will spread labor and industry even better and in the aggregate should furnish adequate returns, both financial and social. Along with Treadwells and Alaska Juneaus there should be developed more mercury and antimony mines. Tungsten is present, and a marketable deposit of this metal may be as profitable as a gold mine though smaller. The openings for a limekiln or two and for a brickyard or so have already been suggested. While waiting for the large wood-pulp mill in southeastern Alaska to be opened, why not make furniture for the local market? That requires simple tools, only small capital, and good design; coupled with merchandizing methods adapted to the local situation. Surely the fountain of American ingenuity and initative has not perished in the assumed cold of the Far North. A new generation has come of age in Alaska, men and women born there, who expect to make it their home and a home for their children. These should take the lead in developing local industries, however small, so long as they are soundly based, and would do well to devote less time and energy trying to sell prospects to outsiders and turn to developing smaller projects that can be handled by local capital. This change in the mental attitude of Alaskans has already begun, and it is one of the most hopeful signs to be observed in the local situation.

There is now an Alaska Development Board supported out of Territorial funds and composed of men who really know the local resources and capabilities of their people. It has already made some excellent suggestions and deserves encouragement and support. Large scope remains for private initiative, and the areas of unreserved land are enormous. Very likely there are too many reservations and they do extend over too much area, and undoubtedly the procedure for obtaining title to land is often discouragingly complicated. It is unfortunate if the law or its interpretation sometimes makes it impossible for experienced and capable companies to undertake development there when they are willing to do so, and some revision of the law and regulations seems called for. On the Arctic slope the difficulties to be overcome in petroleum development have been so great that private concerns have not been willing to venture capital for development, and it has been necessary for the Navy to take the lead. It is pleasant to note the announcement of that organization that use of private experience and initiative is contemplated in further development.

There has been widespread criticism in Alaska of the activities and restrictions of the Federal Government, but in appraising this criticism it is necessary to take account of what the Government gives as well as what it takes. It has not been feasible to compile a complete list of taxes and expenditures, but it is notable that Territorial citizens go substantially untaxed and yet enjoy most of the benefits that accrue to citizens in the States, such as courts, roads, and schools, as well as others not elsewhere provided by the Federal Government, including railroad and telegraph service. The old picture of Alaskans living in isolated log cabins out on the creeks and making a bare living while hoping to strike it rich with pick, pan, and shovel is no longer representative. The majority of the inhabitants live in comfortable cities and towns, which usually have all the conveniences and amenities of much larger places in the States. To a considerable extent this has been made possible because of appropriations made from the Federal Treasury.

Alaska produces more than it consumes and continually makes large contributions to the national economy. This is shown by the approximate trade balance shown below, although figures are not available to include the invisible items. The figures are from the Statistical Abstract for the United States and give the 5-year average for 1935-39.

Merchandise imports for consumption in Alaska	
From U. S. A.	$40,173,708
From elsewhere	213,751
Total	40,387,459

Merchandise exports from Alaska	
To U. S. A.	$51,662,623
To other countries	451,360
Total	52,113,983

Shipments of gold to U. S. A., $18,351,674

This indicates an average merchandise credit for Alaska of $11,726,524, to which may be added gold shipments of $18,351,674 or an average contribution to the mainland wealth of over $30,000,000 in prewar years.

Further light on the contributions made by Alaska to the national economy is shed by the figures below, these being, again, averages for 1935-39 and being taken from the same source.

Mineral sales	$24,762,985
Government fur sales	1,136,096
Fish sales	43,280,675
Sales from national forests	49,339
Sales from fruits and vegetables, 1939 only	27,542
	$79,256,637

All of these figures, except that for mineral sales, increased in wartime. Mining, as already related, was greatly restricted by the war.

It is not possible to make a complete statement of taxes collected or of Federal funds expended in Alaska because much of the money spent by the various services is derived from general funds. It would require a minute study, for example, to determine just how much the Coast Guard spends in the Territory, though it is known to be large, possibly $2,000,000 or more a year. This is, nevertheless, a small sum when considered in relation to the extent of the coast line and the wide variety of services the Coast Guard performs. Probably the Office of Indian Affairs spends as much on schools, hospitals, and other services to native peoples. The Geological Survey has had an annual appropriation of about $100,000 for some years. The Bureau of Mines, General Land Office, Fish and Wildlife Service, National Park Service, Forest Service, and several others are also spending considerable sums in Alaska. The aggregate amount is undoubtedly small in proportion to area, though high in relation to population, but it is certainly much less than the Federal Government collects in taxes levied on Alaskans and Alaskan products.

It has been interesting to observe that not all discussion in Alaska of Federal activities is adverse. A large amount of commendation also is offered. It seems to be generally accepted that salmon fishing, the largest industry, was saved and built up by the investigations and regulations of the Bureau of Fisheries, after the fishing grounds were nearly exhausted by the drive for fish during World War I, and that only this Federal control prevented later depletion by the activities of foreign fishing companies or by overfishing during the World War II. Each year there are protests over the length of the season allowed in particular areas, but the industry as a whole and the people of the Territory seem generally to recognize the necessity for and beneficent effects of informed regulation in this field. Other Federal bureaus are also generally commended. The Geological Survey has always been liked and is only criticised for not doing more. Other bureaus could be mentioned, but it is sufficient for present purposes to indicate that Alaskan opinion by no means demands the moving out of all Federal bureaus, bag and baggage. It does demand clearer understanding of the needs of the Territory and better correlation of the activities of the various bureaus with these needs.

Any attempt to put to use the mineral resources of a region must begin with determining what they are and where they are. This has been the field of the Federal Geological Survey from the first. Its work in the Territory has already been reviewed. It remains here but to emphasize its importance and to call attention to one phase of the situation that should be remedied if possible. It has been noted that nearly all of the areas in which ore deposits are known or suspected to be present have received attention from the Survey and that a large number of valuable maps and reports have been issued. Many of these are now out of print and are not available to an intending prospector. The Territorial Department of Mines has done something to bring together all existing data by district and subject, but its facilities for reproducing maps are inadequate to assume the job. Today it is necessary to go to Juneau or Washington or both to consult the files in order to learn what has already been found out about many districts or minerals in Alaska. A most useful project would be to make available to the public in some convenient form, revised, if possible, but if not as a reproduction of the original map or report, the existing data on as many regions as possible.

The first activity of the Bureau of Mines in Alaska was the appointment of a Territorial Inspector of Mines. Later a mining experiment station was established at Fairbanks and maintained until the opening of the university nearby permitted passing over the responsibility for this service to the new institution. From time to time the Bureau made studies and tests of Alaskan coals for the Navy, the Alaska Railroad, and other branches of the Government, and it organized and directed work in mine safety. For a while it administered various duties in connection with the leasing of coal lands and the conduct of resulting mining operations but later relinquished these to the Geological Survey and the Territorial Department of Mines. It now maintains in Alaska only the services it offers throughout the country as a whole in relation to mine safety and quality of coal, though in the course of the war and the search for strategic minerals the Bureau established a district engineer at Juneau, recruited a staff, and took up active work in exploration of mineral deposits and covered a number of districts. This work is being maintained on a reduced scale.

One major handicap under which producers in Alaska operate is distance from market. Farmers, for example, have no place to sell their surplus crops except in the local market, which is limited by the small number of consumers who are not themselves producers. Any shipment of agricultural products from Alaska to the mainland would meet competing products which had come a shorter distance and probably at less cost. This is aside from the fact that facilities for marketing local products are inadequate and even rudimentary. The Fairbanks flour mill found it impossible to compete even in the local market, and fruit and vegetables from Palmer meet severe competition in the railroad belt from similar products from Puget Sound, which, by reason of cold-storage warehouses and other facilities, are prepared to make deliveries the year around, whereas the Palmer deliveries are seasonal only. Such handicaps as those just mentioned can be overcome by provision of suitable facilities whenever the quantities produced become sufficient to warrant, but distance from general markets and dependence on local markets will always be a handicap.

In the field of minerals, since gold has formed the main product of the mines so far, these marketing problems have not been felt, but it has been and is a large factor in delaying mining of other minerals. The amount of coal mined is limited to that needed to supply local demand. The only other mineral that has been shipped in quantity has been copper ore, and the movement from Kennecott to Tacoma was only possible because the size and richness of the ore body were sufficient to warrant the owning corporation in providing its own facilities in the form of mills, railway, ships, and furnaces. This is not often possible for owners of small mines of copper or other ores. Formerly, and to a limited extent still, there were operated throughout the western mining States a number of sampling and ore-purchasing establishments which bridged the gap between small producers of ore and the large smelting companies. Where such an establishment was present miners or prospectors could bring in their ore in large or small lots, have it sampled and, if they preferred, receive pay for it at once at full smelter prices. If they preferred they could pay for the sampling and then shop around among the smelting companies for the best offer. It was customary, however, for the sampling company to guarantee the accuracy of their work by offering to pay cash for the ore at smelter prices on the assay. It was possible for them to do this, and at a profit, since each ore had a different value according to the instant need of each smelter. One plant having a large amount of siliceous gold or silver ore might need lead or copper ores to balance, or the reverse might be true. By mixing thevarious lots so as to bring them to the standard desired by the smelter, the sampler was able to overcome penalties or even to convert them into premiums. Out of the margin so created, they were able to finance their purchases, cover their overhead, and make a profit. Substantial fortunes were founded or enlarged in this way, and a high service rendered to the industry, particularly to small producers, since, by prompt receipt of cash for ore as mined, they, in turn, were able to finance their labor and supply bills and so make their prospects pay currently for development. One of the benefits flowing from this system was the careful study and perfection of sampling methods and machines and a better feeling in the industry created by the assurance of fair dealing as between buyers and sellers. Accurate sampling of variable ore is difficult and requires great care and intellectual honesty. It was not uncommon for a mining company, even when it had a contract for the whole output with a single smelter, to run the ore through an independent sampling works for the assurance it gave that full value would be received.

It was occasionally argued that, since the sampling company offered to buy the ore at its ascertained value calculated from current smelting schedules, an inducement existed favorable to low sampling. This could hardly have obtained for any considerable time, since low sampling would promptly be discovered when sampled lots were sold to a smelter. Even a suspicion of systematic unfairness would put a sampler out of business, since his stock in trade is his accuracy and integrity. However, some of the best-known of the sampling companies no longer buy ore, preferring not to have any possible interest in the result, except to make it as accurate as possible. It is pleasant to record that in such cases the smelters receiving ore through such a plant generally will pay for it on the basis of the independent sampling.

Most of the sampling and ore-buying companies in the Western States have now gone out of business, and the smelters generally buy their own ore direct from the miners. It seems probable that it is mainly because each company wishes to feel assured that it is getting what the manager considers to be its share of the mine output. With the larger mining companies producing steadily, this direct sale is apt to be an advantage rather than the reverse, but the small and the occasional producer in outlying districts finds it a handicap. This is especially true with the producers of base and unusual metals in a territory such as Alaska where prospectors have limited capital and the need for a quick turn-over is strong. In the absence, too, of local buyers and because the prospectors frequently lack knowledge of markets, producers are further handicapped, and development undoubtedly is slowed down. During World War II, this gap was bridged by the Metals Reserve Company, which bought direct for the Government. The Territorial Commissioner of Mines was designated as agent; deliveries in Alaska were accepted, and purchase depots were set up at Fairbanks, Anchorage, Nome, and Ketchikan. Attractive prices and terms were scheduled, ore was brought to a total value of about a half million dollars, and local development was stimulated. While under peace conditions it would probably be undesirable to continue exactly the same operations by Metals Reserve in Alaska, it does seem desirable that some thought be given to opening up local market facilities for Alaska mineral producers.

It has been suggested that particularly favorable opportunity exists in Southeastern Alaska for an ore sampling and purchasing depot conducted along the lines common a few years ago in the West. In this district there is a considerable number of small mines and prospects from which under encouragement an important tonnage of ores may well be developed. Gold, silver, copper, lead, zinc, antimony, tungsten, and various other ores are known to be present but in what quantity can only be determined by mining. The various prospects are, in general, near the shore line and easily accessible from Ketchikan by water. If a local market could be made for the ores, with prompt cash settlement for small lots, it is believed that mining would be markedly stimulated. It is thought that a survey of the situation may well show such probabilities of profit that private capital may be attracted to the project, but the general benefits to be realized are so numerous and large that, if no one cares to assume the risk as a personal venture, consideration might well be given to trying here what has often been urged, namely, a purchasing agency financed as a Territorial or Federal project.

Attention has already been called to the need of a better market for zinc ores on the Pacific coast and to the impending demand there for slab zinc. While Alaska deposits will probably contribute to such an enterprise in time, the immediate demand for a zinc reduction works is broader and the supply of ore would be drawn from a number of the Western States. Even under present conditions there are important producers of zinc ore in the West, and substantially half the United States production comes from them. At present it is only at Trail, British Columbia, Kellogg, Idaho, and Great Falls and Anaconda, Mont., that there are zinc reduction works, although concentrates and other immediate products are produced at Utah smelters. The Kellogg, Anaconda, and Great Falls plants depend on electrolytic reduction, which yields high-grade premium-priced metal but is probably unduly expensive for making ordinary Prime Western slab zinc, such as is used in galvanizing. It is suggested that a careful survey of the situation might well reveal a sound basis for the establishment of a plant on the Pacific coast using one of the other types of reduction process. This would stimulate zinc mining not only throughout the West but in Alaska, and zinc is one of the metals in which there is postwar deficiency.

The stimulation and better organization of prospecting in Alaska are subjects that have received some consideration but warrant more. The old prospectors who found gold throughout the Territory are dying off or retiring, and those available have only limited knowledge of ores other than of gold. The University of Alaska, in cooperation with various local and Federal agencies, has endeavored to broaden their knowledge and to attract new men to the field by means of lectures, laboratory demonstrations, and short winter courses of study in the various districts. This work has been helpful, and a hundred or more have at times been enrolled in such courses in particular cities. The Department of Mines maintains assay offices at several points where service is free or at small charge. Its staff is available for consultation and advice on any phase of mining and is widely appreciated. The Federal Bureau of Mines and the Geological Survey act also as advisers to prospectors, and the Bureau has been active in trenching, drilling, and sampling. None of the agencies, however, quite fills the gap being left by the dropping out of the old prospectors and the need for developing the base-metal industries.

The Territorial Department of Mines presented to the 1945 legislature a well-worked-out plan for field stations, somewhat like the C. C. C. camps, for training newcomers in the various arts that any successful prospector must learn. It proposed also a system for directed prospecting backed by limited subsidy in the form of grubstakes. Such a plan has been operated successfully in Canada, and it is to be regretted that the legislature, by a very narrow vote, rejected it for Alaska. This is particularly to be deplored because of the expected influx of ex-soldiers having many of the desirable traits of future citizens but lacking the special knowledge needed in this particular vocation. It is highly desirable that this or some similar project be reviewed and given careful consideration, especially by those concerned with reestablishment in industry of the returning veterans.

Alaska is truly a large and attractive country with many undeveloped resources, but the number of bonanzas anywhere in the world is small and much hard work on small or moderate sized deposits will be necessary to develop the wealth of the Territory. Industrial and social changes in the States have opened more attractive opportunities nearer home to many of those who in an earlier generation would have pioneered our northern territory. Changes, it is true, have also taken place in Alaska, although as yet not enough to smooth away many of the difficulties. Roads have been constructed, a main-line railroad has been built, and air travel has made the whole Territory easily accessible. One can now go by modern plane from Seattle to Nome in a long day; and remote mines and prospects, formerly reached only by dog sled in winter, may now be visited or supplied at any time. It is no longer necessary to wait over a winter to start development. It can be begun in a period of days rather than months, and with modern tools, the bulldozer, light compressor, and small air drills, much of the back-breaking work of the earlier miners has been eliminated. This increasing mechanization of mining is especially important in Alaska in view of the high wages obtained there as a result, in large measure, of war activities. Things move rapidly in these days, and it may well prove true that development will come fast, but nonetheless exceptional things are still exceptional, and ore bodies of great size or great richness fall into this category. A surer base for industry is the slower development as needed of smaller mines and of the less-well-known ores of the common and rare metals. It is pleasant to record that these, together with water power, coal, and possibly petroleum, are all available in the Territory.