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# EXAMINATION OF THE SINUK IRON DEPOSITS
# SEWARD PENINSULA, ALASKA

by John J. Mulligan with a section by Harold D. Hess

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UNITED STATES DEPARTMENT OF THE INTERIOR
Stewart L. Udall, Secretary

BUREAU OF MINES
Frank C. Memmott, Acting Director

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# EXAMINATION OF THE SINUK IRON DEPOSITS SEWARD PENINSULA, ALASKA

BY

John J. Mulligan1/

With a Section by Harold D. Hass

## ABSTRACT

The Sinuk iron deposits are outcrops and residual concentrations of botryoidal and loosely cellular limonite and goethite about 25 miles northwest of Nome on the Seward Peninsula, Alaska. The iron minerals occur in a belt of metalimestones south of the Stewart River and are most abundant in the area between the headwaters of Cripple River and the hills on the west side of the Sinuk River. The surface concentrations have been estimated to include in excess of 600,000 tons of rock containing 10 to 45 percent iron and about 0.005 percent manganese dioxide in a limestone gangue.

The botryoidal and mammillary limonite of the Sinuk deposits resembles material found on known sulfide outcroppings in the Seward Peninsula area. The Sinuk and similar iron deposits of the Seward Peninsula differ from the usual gossans; boxwork structure is absent or very rare and typical oxides derived from sulfide deposits are scarce. However, sulfide minerals occur in the Sinuk area and analyses of the elements associated

1/ Mine examination and exploration engineer, Area VIII Mineral Resource Office, Bureau of Mines, Juneau, Alaska

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with the iron oxides suggest that the Sinuk iron deposits overlie deposits of lead and zinc sulfides with some copper and silver and little or no gold. The deposits occur in limestones and are roughly alined along crenulated anticlines that strike about N 10° W. No estimate of the grade and extent of the primary deposits was possible.

## INTRODUCTION

The Sinuk iron deposits (fig. 1) have been of perennial interest to groups interested in the development of mineral industries on Seward Peninsula, Alaska although generally they are considered to be too small either to constitute an important national reserve of iron or to attract capital as an iron mining venture. The interest centers on evidence suggesting that the deposits may be gossans or "iron hats" capping sulfide bodies. This report is a compilation and interpretation of information on the Sinuk iron deposits. In addition to the results of a Bureau preliminary examination, it includes sample analyses data originally furnished by early prospectors, descriptions of the deposits by various Geological Survey geologists, and ore reserve calculations by the former Department of Mines, Territory of Alaska.

## ACKNOWLEDGMENTS

Acknowledgment is made to the Dividion of Mines and Minerals, Department of Natural Resources, State of Alaska, for ore reserve estimates, and to both the Division of Mines and Minerals and Division of Lands for data on claim ownership. Acknowledgment is made to the Bureau of Land Management for data on patented claims; and to the Geological Survey for

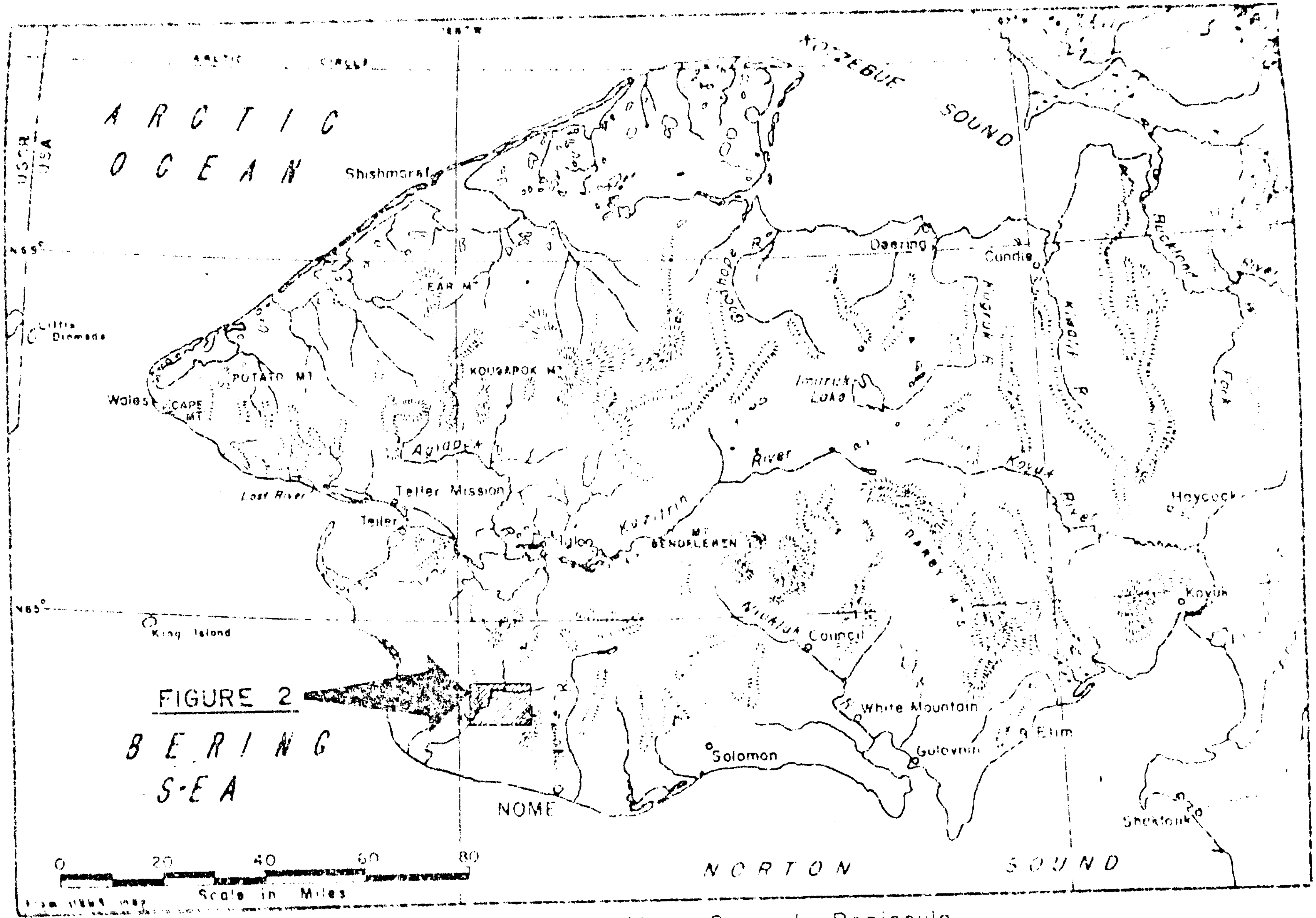


FIGURE 1.-Index Map, Seward Peninsula.

aerial photographs, base maps of the area, and the bulletins listed in the bibliography and quoted in this report.

## LOCATION AND ACCESSIBILITY

The Sinuk iron deposits are on the Seward Peninsula, Alaska about 25 miles northwest of Nome and about 14 miles inland from the Bering Sea coast. The principal prospects are south of the Stewart River between the headwaters of Cripple River and the hills west of the Sinuk River (fig. 2). The ususal means of access is by the Nome-Teller road which passes near the Cub Bear and Galena prospects. The road starts from Nome, is gravel surfaced, and has been completed to the Sinuk River. Tracked-type tractors or other vehicles designed for cross-country travel are essential if transportation is required between the various deposits in the Sinuk iron area. Ordinary four-wheel-drive trucks could travel over part of the area, but would be of limited use unless trails were constructed.

## PROPERTY AND OWNERSHIP

Thirty-five or more claims have been held at various times since the discovery of the Sinuk iron deposits; twelve of these were patented. In recent years no assessment work has been recorded for any of the unpatented claims. No one was found in possession when the deposits were examined. The names and approximate locations of claims known to have been held in the area are shown in figure 2. All the patented claims are on the Monarch prospect. Table 1 lists the patented claims and their owners, if known.

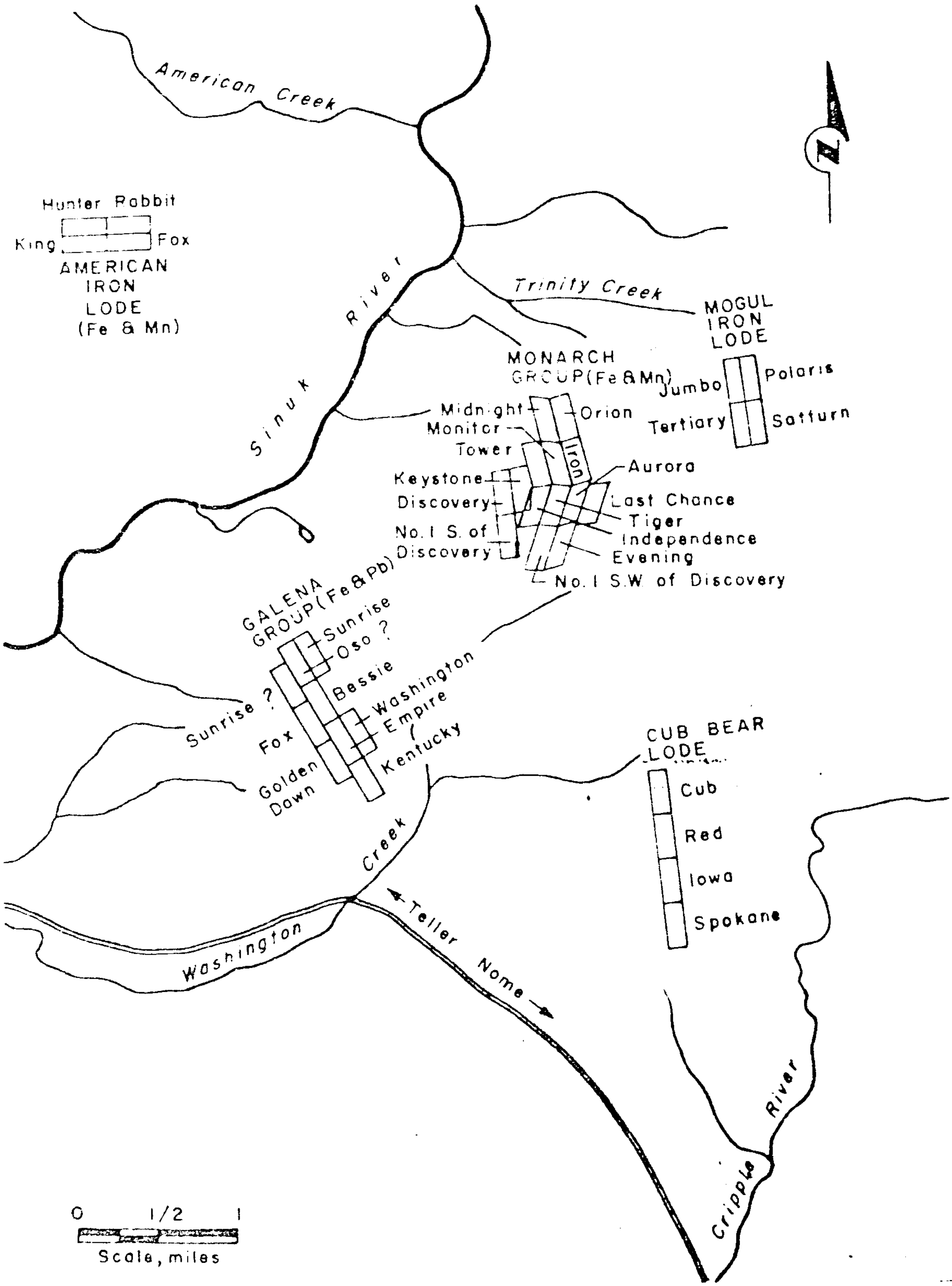


FIGURE 2.- Principal Claims, Sinuk Iron Area.

TABLE 1. - Patented lode claims, Monarch group, Sinuk iron deposits

| Name | Mineral Survey No. | Owner |
|---|---|---|
| Monitor | 503 | Irene E. Esch |
| Tiger | | Do. |
| Discovery | | Do. |
| Aurora | | Do. |
| Independence | | Hazel Campbell |
| No. 1 S. of Discovery | | Do. |
| Tower | | Do. |
| Iron | | Unknown |
| Last Chance | | Do. |
| No. 1 SW of Discovery | | Do. |
| Evening | | Do. |
| Keystone | | Do. |

## LABOR SUPPLY AND LIVING CONDITIONS

Unskilled, semiskilled, and some skilled labor can be obtained from Nome and Teller with populations of about 2,300 and 200, respectively. A high proportion of the population is available for employment owing to the unfavorable conditions affecting gold mining and the lack of other industry in the area. Most community services are available in Nome including grocery and hardware stores, garages and repair shops, grade and high schools, churches of most denominations, a theater, three hotels, and restaurant accommodations. There are two general stores in Teller.

There is no housing on or near the Sinuk iron deposits; the only shelter is a dilapidated 8- by 12- foot frame cabin on the Galena claims. Light uninsulated frame cabins, or tents, usually skidmounted so they can be towed by tractor from place to place, are commonly used in the area and give ample shelter during the summer field season. Substantial well-insulated buildings would be needed for year-round operation.

## CLIMATE AND WATER SUPPLY

The climate is typically sub-Artic. The summer field season extends from June through September. Occasional freezing weather or snow may be expected at any time during this period, particularly in early June or late September. During the remainder of the year, freezing weather prevails although there may be warm spells. Weather data for Nome, Alaska is in table 2.

TABLE 2. - Weather data,1/ Nome, Alaska

| | |
|---|---|
| Average annual temperature | 26.3° F |
| Average total annual precipitation | 18.7 in. |
| Average total annual snowfall | 63.2 in. |
| Highest recorded temperature | 84° F |
| Lowest recorded temperature | -47° F |
| Prevailing wind direction | North |
| Average velocity | 10.2 m.p.h. |
| Highest recorded velocity | 75 m.p.h. |
| Number of days per year when the minimum temperature is 32° F or lower | 241 |

1/ Data furnished by the U.S. Weather Bureau.

Water for exploration work, such as diamond drilling, is a serious problem at all times because of the low annual rainfall and the location of the outcrops on high porous limestone ridges. A typical limestone sink was noted in the valley of Washington Creek and an equally typical spring was noted between the Galena group of claims and the Sinuk River (fig. 2). The spring and the Sinuk River should furnish adequate water for any mine camp and milling operation. The smaller streams probably could not be depended on for year-round water supply.

## PHYSICAL FEATURES

The Sinuk iron deposits are south of the Kigluaik Mountains on rounded limestone ridges rising from altitudes of about 200 feet in the valley bottoms to about 1,200 feet at the summits. The principal iron outcroppings are on ridges at altitudes between 600 and 1,000 feet. The summits of these limestone ridges are covered with frostbroken rock debris and support, at most, only a sparse scattering of vegetation. A thick mat of tundra grasses and light brush covers the valley floors and extends partway up the hillsides. On the hillsides, vegetation is most abundant over shale and schist bedrock. There are no trees in the area.

Granitic boulders and debris, presumably glacial erratics, are found even near the summits of the hills; the valleys contain much glacial gravel. There are no glaciers in the area at present. The glacial erratics and gravels resemble rocks exposed in the Kigluaik Mountains.

Animal and insect life are typical of the sub-Artic tundra regions. Animals seen during the field examinations included a herd of semitamed reindeer, 3 grizzly bears, two wolverines, a fox, about 50 ground squirrels, a few hundred willow and rock ptarmiga, and hundreds of nesting plovers, Jaegers, and similar birds. Mosquitoes are abundant in the brushy valleys from mid-June to late August.

## HISTORY

The Sinuk iron deposits have been known since the early 1900's but have produced no ore. In 1913, Theodore Chapin of the Geolgical Survey wrote:

> . . . For years there have been indefinite plans either to

> open the property and ship the high-grade ore or to erect a plant on the ground for its treatment.

This statement if equally true today. Interest in the deposits revived recently because of the completion of the Nome-Teller road from Nome to the vicinity of the deposits.

Three Geological Survey geologists have visited the Sinuk iron area and reported their findings: Henry M. Eakin in 1914, J. B. Martie in 1916, and S. H. Gathcart in 1920. An Alaska Territorial Department of Mines assayer-engineer, A. B. Shallit, worked in the area from July 26 to September 20, 1941, examining the iron deposits and estimating the amount of readily recoverable iron available. Their reports are listed in the bibliography. The descriptions of the deposits by the Geological Survey geologists and the ore reserve estimates by the Department of Mines engineer have been included in this report.

The representatives of many mining companies have examined the Sinuk iron prospects; some within the past few years. However, there is no evidence of recent exploration or development work. The workings found were hand-dug pits, trenches, andshallow shafts; all had sloughed and apparently all were about 40 or 50 years old. A few relatively new claim monuments were the only evidence of more recent work.

## QUOTED REPORTS ON INDIVIDUAL DEPOSITS

The descriptions of the individual deposits that follow are quoted from publications listed in the bibliography and identified in the text. These descriptions are included here because they were compiled from scattered references in out-of-print publications not widely available for

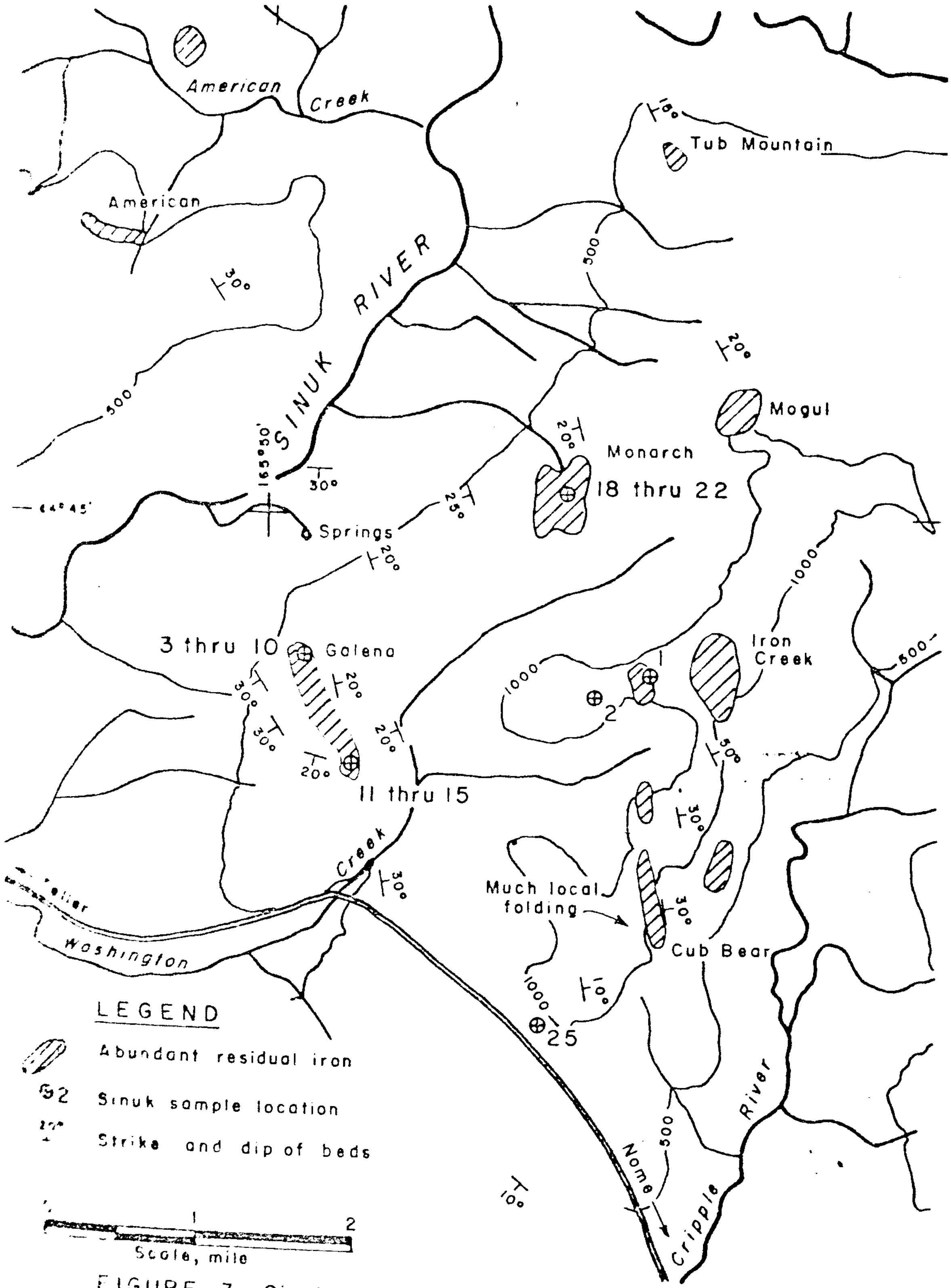


FIGURE 3.-Sinuk Iron Area. *Adapted from USGS map*

reference. The approximate location of claims mentioned in the reports are shown in figure 2. The deposits are shown in figure 3.

## Monarch Prospect

The Monarch group (3), 2/ including 14 claims, or about 300

2/ Underlined numbers in parentheses refer to items in the bibliography at the end of this report.

acres, lies on the limestone ridge that trends eastward between Sinuk River and Washington Creek. It covers the ridge top for about 3,000 feet and extends laterally for over a mile. Within this property the ridge crest is broken by two gaps at an elevation of about 1,000 feet above sea level, in which are thechief deposits of iron ore. Elsewhere the limestone is more or less iron-stained and may contain small ore veinlets, but the average iron content of the limestone masss may be too low to permit its being classed as ore.

The east gap is mantled by a heavy residual deposit of limonite and hematite, derived from the weathering of unusually abundant ore veins that cut the underlying limestones. The residual ores have also slumped down into the head of the gulch that leads northward from the gap, where they occur in considerable amounts. The veins in bedrock beneath the gap are apparently numerous, and range in width from a few inches to about 30 feet. They are approximately vertical, but their persistence either vertically or horizontally, is not determinable from the exposures.

In the west gap there is no important accumulation of residual ore. The underlying limestone is cut, however, by a wide stockwork of limonite and pyrolusite veinlets. No heavy veins were seen at this locality.

The residual deposits of the east gap have been developed over an area approximately 600 by 800 feet, in open cuts that range from a few yards to several hundred feet in lenght. A shallow shaft and a short drift have been driven into the deposit in the head of the northerly gulch, 50 feet below the gap level. An open cut at the south margin of the gap has uncovered a mass of undisturbed limonite, apparently a vein 30 feet in width, cutting the limestone country rock.

In the west gap several short open cuts have been made in loosened bedrock material which contains numerous veinlets of limonite and pyrolusite. Elsewhere on the claims the iron-stained limestone detritus has been thrown out of open cuts without revealing any high-grade ore.

The residual ore of the east gap has a loose granular texture and a high iron content, and is unusually free from injurious impurities. Two samples taken by the writer, one from an open cut at the east margin of the deposit and the other a composite sample from a line of open cuts 400 feet long across its center, were found to contain 53 and 55 percent of metallic iron, respectively. The complete analysis of the composite sample, which is probably fairly representative of the whole deposit, is as follows:

Analysis of composite sample of iron ore from Monarch group of claims.

(Analyst, R. C. Wells, United States Geological Survey.)

| | | | |
|---|---|---|---|
| $SiO_2$ | 5.53 | $TiO_2$ | None |
| $Al_2O_3$ | 1.34 | $P_2O_5$ | .13 |
| $Fe_2O_3$ | 78.30 | S | Trace |
| MgO | .10 | MnO | 1.37 |
| CaO | 1.97 | BaO | Trace |
| $H_2O$ | 10.40 | | |
| | | | 100.24 |
| $CO_2$ | 1.10 | | |

The iron, manganese, phosphorus, and sulphur contents of the ore calculated from this analysis areas follows: Fe, 54.81; Mn, 1.06; P, 0.057; S, trace.

No samples were obtained from the veins from which this residual material has been derived. The character of the ores in the undisturbed veins was therefore not determined.

Only qualitative analyses of samples taken from the west gap were made. They contain limonite and pyrolusite in about equal amount. The veinlets appear to comprise only a small part of the general mass of the stockwork, so that the iron and manganese content of minable material is probably not high.

The development work done so far on the Monarch property has failed to furnish an adequate basis for estimating the quantity of ore available in either the residual deposits or the underlying veins. The size and extent of the veins for the most part can only be conjectured. The area of the residual deposits is fairly well outlined, but their depths have not been generally demonstrated. However, it seems certain that the residual high-grade ores aggregate at least several hundred thousand tons. Apparently they cover an area 600 by 800 feet to a depth of several feet. In places shafts 12 feet deep are said to have been sunk in ore. Although ore occurs in the head of the northerly gulch 50 feet or more below the level of the east gap, it is unsafe to assume that the divide is underlain by ore to this depth, for this ore is apparently not in place, but has slumped down into the head of the gulch from the gap above. Obviously additional prospecting will be required to determine accurately the reserves of high-grade residual ores and to demonstrate the availability of the undisturbed vein ores. The stockwork of the west gap will also require careful investigation to determine its value. The relatively high manganese content of the veinlets and the reported association of gold with the manganese strengthene the possibility that this deposit may prove of commercial value.

The limestones on the property away from the gaps contain from 5 to 40 percent of iron. The average content is probably nearer the lower figure, and if this proves true, it seems doubtful that much of this material can be considered as commercial ore.

The Monarch group (4) of fifteen patented and three unpatented claims lies on the divide between Sinuk River and Washington Creek at the head of a small tributary of Sinuk River known as Iron Creek. This and four other groups of iron claims near by have been described by Eakin (3), and little development work has been accomplished since the time of his visit in 1914. The writer examined with considerable care the outcrops and development work on the Monarch claims and, so far as concerns their economic possibilities, has little to add to the generalizations and recommendations made by Eakin.

The country rock is limestone, which has been crecciated and replaced by limonite. Hematitie is present only as a subordinate constituent. A specimen of the ore taken from a trench at the head of Iron Creek shows on a polished surface massive limestone with numerous angular inclusions of iron-stained limestone, residual fragments of the shattered country rock. Pyrolusite, in places intergrown with calcite, is present in veinlets that cut the limonite and the replaced limestone. These relations and the probable genesis of this iron deposit will be discussed more fully in a leter paper on the iron resources of Alaska. For this report it is sufficient to say that the iron ore now exposed on the ridge and in Iron Creek is a residual concentration, a surficial enrichment of an underlying lode. The iron content of this lode at depth can not be judged from the surface indications; in fact, it is entirely possible that this deposit is only a surface capping, or "iron hat," covering some other metalliferous deposit. The occurrence of galena and sphalerite with limonite in the Galena group near by, the presence of similar limonitic material in considerable amount in a silver-lead lode in the Inmachuk basin, and the constant association of limonitic material and other iron minerals with most of the gold lodes on the peninsula might be cited as evidence of this possibility.

The best showing of iron ore is in a saddle on the ridge at the head of Iron Creek, at what is designed by Eakin the "east gap," in contradistinction to the "west gap," a similar saddle a short distance to the southwest. At his locality two shallow trenches aggregating 350 or 400 feet in length have exposed a continuous body of iron ore, chiefly limonite with a small amount of hematite. This limonitic ore is botryoidal in character but inclined to be porous, with fair-sized open spaces. It is considered by the owners of the property to be the best iron ore on the property. An analysis of this ore shows the content of iron and manganese to be respectively 54.81 and 1.08 per cent. Phosphorus is low, being only 0.057 per cent; sulphur is present only as a trace; and titanium is entirely absent.

The following analyses (2) furnished by the owners of the claims were made by the WesternSteel Corporation, of Seattle, on samples said to be representative of the ore in various cuts:

| Iron | Silica | Phosphorus | Manganese |
|---|---|---|---|
| 58.76 | 2.14 | 0.026 | 0.44 |
| 53.92 | 8.65 | .022 | .74 |
| 59.86 | 3.85 | .010 | .38 |
| 57.55 | 4.82 | .015 | .76 |
| 37.19 | .90 | .004 | .90 |
| 15.29 | 2.70 | .017 | 11.22 |

The following report was made by the Pacific Coast Testing Laboratory on samples submitted to it by the owners of the property:

| Iron | Silica | Phosphorus | Manganese | Lime |
|---|---|---|---|---|
| 53.88 | 7.07 | 0.047 | 0.83 | -- |
| 45.34 | 4.15 | .049 | .89 | -- |
| 34.76 | 1.00 | .038 | .92 | 23.00 |

Some gold is also reported, but no assay returns are available for publication.

## Galena Prospect

The Galena group (3), which was not visited by the writer, consists of nine claims situated 2 miles southwest of the Monarch property. Several open cuts, shafts, and short drifts are reported to have been made on the property, uncovering a number of veins and small stockworks bearing limonite and galena. No large bodies of ore are reported to have been developed up to midsummer, 1914, but sufficient encouragement had been given by the findings to stimulate further development work, which was then in progress.

The Galena group (4), consisting of nine claims, is about 2 miles southwest of the Monarch group on the divide between Sinuk River and Washington Creek. These claims, though prospected chiefly for their iron content, have also surface indications of both lead and zinc, in the form of galena and sphalerite.

It appears that the ore-bearing solutions have followed in large measure one or more of a system of joint planes in the country rock. On the Sunrise claim, one of this group, the country rock is crystalline limestone, the cleavage of which strikes east and dips 25° S. This limestone is cut by a number of joint planes, the more prominent of which had the following strikes and dips; N.40° E., 65° NW.; N. 80° E., 70° N.; N. 15° W., 90°. Disseminated galena in a quartz gangue occurs along the vertical joint plane. This ore is said to show considerable values in gold.

An open cut on the Oso claim shows disseminated sphalerite, with a little pyrite, in the crystalline limestone. The extent of the zinc mineralization is not known. In a pit at another locality on the Oso claim the same system of jointing as above described was exposed, and vein quartz, with some iron-stained vein material, occurs along a joint plane striking N. 10° W. and dipping 75° N. Lilac-colored fluorite was also seen in this pit, but its exact relation to the mineralization could not be determined.

On the Fox and Williams claims disseminated galena accompanied by quartz was observed in limestone and calcareous schist.

Considerable botryoidal limonite was seen on the dump at a prospect on the Kentucky claim.

## Cub Bear Prospect

The Cub Bear group (3) includes four claims located end to end along the croppings of iron-ore veins cutting across the limestone ridge between Washington Creek and Cripple River. The blossom of the veins, where it shows through the vegetation at intervals, consists of the usual iron-stained limestone detritus mixed with limonite nodules and vein fragments. A few shallow pits have been dug, revealing limonite-hematite veins as much as several feet in width. Large blocks of ore taken fromsome of the pits exhibit botryoidal and mammillary froms and fibrous texture and are essentially pure limonite with possibly a very little accessory hematite. No estimate of the amount of ore in the deposit or of its availability for mining is possible at the present stage of development.

The Cub Bear group (5) of iron claims lies near the head of Cripple River on the divide between Cripple River and an eastern tributary of Washington Creek, at an elevation of about 1,000 feet. The developments consist of 12 trenches 20 to 30 feet long and 3 feet deep. The country rock is chiefly limestone, with a little interbedded schist. The mineralization occurred in a well-defined saddle between two knolls. The limestone of the eastern knoll strikes N. 10° E. and dips 15° E.; that of the western knoll strikes N. 10° E. and dips 20° W. Structurally the mineralization occurred along the crest of an anticline. The mineralized zone is exposed only by the trenches, as tundra covers the saddle. The trenches are aligned about N. 5° E., which is approximately the strike of the country rock. Six openings are made on the north of the saddle, and six on the south. The trenches on the south expose limonite chiefly, with some hematite. The material is essentially iron-stained limestone, through which some small veinlets of iron oxide occur. The rock is badly fractured and seamed with incompletely filled veinlets of calcite. Only surface debris is exposed by the pits, and no rock of ore grade is seen on this side of the saddle. On the north side several of the trenches have exposed massive botryoidal limonite of good quality. A cellular limonite is also present on the dumps, and manganous oxide in small amounts occurs with it. The quantity of ore on the dumps does not exceed a few tons. No ore in place is exposed.

The occurrence is very poorly exposed by the workings and elsewhere is covered by moss. Mertie reports sulphides to be present with the ore at the Mogul group of claims and suggests that the iron may merely be gossan material capping a sulphide vein. It is not possible to say whether this represents the gossan of a sulphide vein or not. No sulphide was seen. The zone of mineralization is probably 50 to 100 feet wide and, as observed, seems to occur along the shattered crest of a fold, which suggests that the iron oxide may be but a deposit resulting from the circulation of ground waters along this zone.

## American Prospect

The American group (3) includes four claims situated at the base of a limestone ridge west of Sinuk River, below American Creek, 2 miles northwest of the Monarch property. The locations are said to cover an "iron-ore bed" over 50 acres in extent. The only development work done consists of a few pits 6 to 8 feet deep, and no analyses have been made of the ore. The locality was not visited by the writer.

## The Mogul Prospect

The Mogul property (3) consists of four claims situated on the Sinuk River and Washington Creek divide about 1 1/2 miles east of the Monarch property. No development work has been done here, the locations being made on the strength of a few acres of the blossom of ore veins that cut the limestones locally. Evidence of the veins is found in heavily iron-stained limestone detritus that has a scant admixture of limonite nodules and vein fragments. There is little evidence as to the size and extent of the veins or the possibilities of commercial development.

## Iron Ore Reserves (6)

The following figures (table 3) are not accurate measurements of the ore reserves of this district. They are approximations commensurate with the purpose of this report and are set forth only as indicative of what more detailed exploration might reveal. As depth factors of less than four feet were used for most of the estimates, the addition of only a few feet in depth would often double the following figures. In order to alter their present economic significance, however, these estimates would have to be increased by several hundred times.

TABLE 3. - Residual ore estimates 1/

| | |
|---|---|
| MONARCH GROUP | |
| 30 to 45% iron | 50,000 long tons |
| 15 to 25% iron | 500,000 long tons |
| GALENA GROUP | |
| 30 to 45% iron | 100 long tons |
| 10 to 20% iron | 10,000 long tons |
| AMERICAN IRON GROUP | |
| 20 to 40% iron | 40,000 long tons |
| CUB BEAR GROUP | |
| 30 to 45% iron | 100 long tons |
| 10 to 20% iron | 10,000 long tons |
| MISCELLANEOUS | |
| Mogul property | |
| 10 to 20% iron | 5,000 long tons |
| Tub Mountain | |
| 10 to 20% iron | 8,000 long tons |
| Iron Creek and vicinity | |
| 20 to 40% iron | 12,000 long tons |
| 10 to 20% iron | 20,000 long tons |

These estimates are for long tons of iron ore, not for tons of metallic iron.

1/ Data from report by A. B. Shallit (6).

## BUREAU OF MINES WORK

### Nature and Extent

The Sinuk iron deposits were examined by the Bureau of Mines as part of a continuing program of investigation of mineral resources in the Seward Peninsula area. The examination included compilation of the available reports and data on the deposits; study of vertical aerial photographs of the area; reconnaissance by air and on foot; and laboratory analyses of typical specimens. Over a period of 4 years, several brief visits were made as time and circumstances permitted. Particular emphasis was placed on evidence that might indicate the primary source of the iron oxides. Typical specimens for laboratory analyses were taken from prospect pits, road cuts, and outcrops. Specimen descriptions and type of analyses are listed in table 4. The places where the specimens were taken are shown in figure 3. The analyses data are in tables 5 through 8.

A suite of 16 typical specimens from the iron prospects were evaluated petrographically. Results are in a section at the end of this report. It is interesting to note that this evaluation was made before road building operations uncovered a lead-zinc deposit with fluorite, copper, and silver in an iron-stained area adjacent to the Cub Bear prospect (specimens Sinuk 25-A through -J).

TABLE 4. - Specimen description and analyses 1/

| Specimen number | Specimen description | Type of analyses 2/ |
|---|---|---|
| Sinuk 1 | Limonitic float from Washington Creek-Iron Creek divide. | Petrographic |
| Sinuk 2 | Limonitic float from hill between Washington and Ashland Creeks. | Do. |
| Sinuk 3 | Botryoidal limonite and calcite, Galena prospect. | Do. |
| Sinuk 4 | Quartz-calcite vein material, Galena prospect. | Do. |
| Sinuk 6 | Quartz vein material, Galena prospect. | Do. |
| Sinuk 7 | Limonite associated with quartz, Galena prospect. | Do. |
| Sinuk 8 | Quartz vein material, Galena prospect. | Do. |
| Sinuk 9 | Quartz vein material, Galena prospect. | Do. |
| Sinuk 10 | Prospect pit dump material, Galena prospect. | Do. |
| Sinuk 12 | Limonitic float, Galena prospect. | Do. |
| Sinuk 13 | Massive limonite, Galena prospect. | Do. |
| Sinuk 14 | Quartz vein material, Galena prospect. | Do. |
| Sinuk 15 | Limonitic float, Galena prospect. | Do. |
| Sinuk 18-A)<br>Sinuk 18-B)<br>Sinuk 18-C)<br>Sinuk 18-D) | Typical specimens, Monarch prospect. | Mineral identification. |
| Sinuk 19 | Brecciated limestone, east divide, Monarch prospect. | Paragenesis. |
| Sinuk 20 | Limonitic float from south side of east divide, Monarch prospect. | Do. |
| Sinuk 21 | Limonite-calcite float from the center of the east divide, Monarch prospect. | Do. |
| Sinuk 22 | Typical "iron ore," Monarch prospect. | Chemical |
| Sinuk 25-A)<br>through )<br>Sinuk 25-J) | Typical specimens from borrow pit on north side of Nome-Teller road on Cripple River-Washington Creek divide near Cub Bear prospect. | Mineral identification. |

1/ Specimen locations are shown on figure 3. Specimens 5, 11, 16, and 17 were not analyzed; they are museum specimens or duplicates of samples analyzed.

2/ All specimens except Sinuk k8, 22, and 25 were analyzed spectrographically.

TABLE 5. - Mineral identification, Monarch prospect. Sinuk iron deposits[1/]

| | Specimens | | | |
|---|---|---|---|---|
| | Sinuk 18-A | Sinuk 18-B | Sinuk 18-C | Sinuk 18-D |
| Spectroscopic: | | | | |
| Bi, In | - | - | - | - |
| Cu, Sn, Pb | - | - | - | - |
| Zn | T | - | - | T |
| Mn | - | X | X | T |
| Fe | X | X | X | X |
| Minerals: | | | | |
| Calcite | M | P | P | P |
| Goethite[2/] | 99 | M | S[3/] | |
| Limonite | | | M | M |
| Manganese dioxide | | M | | |
| Muscovite | | F | | F |
| Fluorescence | - | - | - | - |
| Radioactivity | - | - | - | - |

1/ P - Predominant Over 50 percent
A - Abundant 10 - 50 percent
S - Subordinate 2 - 10 percent
M - Minor .5 - 2 percent
F - Few .1 - .5 percent
T - Trace Less than .1 percent

X - Detected in sample
\- Sought but not detected
Numerals - percent.

2/ The goethite probably is water deposited.
3/ Contains manganese.

TABLE 6. - Analysis of typical "iron ore" Monarch prospect

| Sample number | Percent | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acid Sol. Fe | Acid Insol. Fe | Calc. Total Fe | Cu | V | Mn | S | P | $SiO_2$ |
| Sinuk 22 | 52.9 | 0.26 | 53.16 | <0.02 | <0.005 | 0.27 | <0.004 | <0.001 | 4.12 |

TABLE 7. - Spectrographic report, Sinuk iron specimens[1/]

| Element[2/] | Sample number Sinuk- | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 10 | 12 | 13 | 14 | 15 | 19 | 20 | 21 |
| Ag | G | - | F | G | - | - | F | F | G | F | F | G | G | G | - | - |
| Al | C | C | D | D | E | E | D | D | D | D | C | E | D | D | D | D |
| As | - | - | D | - | - | - | D | - | - | D | - | - | - | - | - | - |
| B | - | F | - | F | - | - | F | F | F | - | - | - | - | - | F | - |
| Ba | - | - | D | D | - | - | - | - | - | E | D | - | E | E | - | - |
| Be | - | G | G | G | G | G | G | G | G | G | G | - | G | G | G | - |
| Ca | E | C | D | B | E | D | E | B | A | A | D | A | D | A | E | A |
| Co | F | E | F | F | F | - | - | - | - | F | F | - | F | - | - | F |
| Cr | E | E | - | E | - | - | E | E | E | - | E | - | E | - | E | - |
| Cu | F | F | F | F | F | F | F | F | F | F | E | F | F | G | F | G |
| Fe | A | B | A | B | A | A | C | C | C | B | A | B | A | D | A | A |
| Mg | C | D | E | E | E | E | E | E | E | E | D | B | E | D | E | D |
| Mn | D | E | C | D | D | D | E | E | E | D | C | D | D | D | D | E |
| Mo | F | F | - | F | - | - | - | - | F | - | - | - | - | F | - | - |
| Na | - | D | - | - | - | - | E | - | E | - | - | - | - | - | - | - |
| Ni | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E |
| Pb | E | E | D | E | E | E | D | B | E | D | C | E | E | E | E | E |
| Sb | - | - | - | - | - | - | E | E | - | E | - | - | - | - | - | - |
| Si | A | A | C | A | A | C | A | A | A | B | B | E | E | E | C | C |
| Sr | - | - | - | - | - | - | - | - | - | - | F | - | - | F | - | - |
| Ti | E | C | E | E | F | E | E | E | E | F | E | F | F | F | E | E |
| V | E | D | F | F | F | F | F | F | F | F | F | F | - | - | - | F |
| Zn | - | - | C | D | A | D | E | E | E | A | C | A | A | E | - | - |
| Zr | - | E | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

1/ A More than 10 percent
B 5 to 10 percent
C 1 to 5 percent
D 0.1 to 1 percent
E 0.01 to 0.1 percent
F 0.001 to 0.01 percent
G Less than 0.001 percent
\- Not detected

2/ Au, Bi, Cd, Ga, Ge, Hf, Hg, In, Ir, Li, Nb, Os, P, Pd, Pt, Ra, Rh, Ru, Sn, Ta, Te, Tl, W, Sc, and Y were sought but not detected.

TABLE 8. - Mineral identification, borrow pit, Washington Creek-Cripple River divide 1/

| Samples Sinuk 25- 2/ | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Spectroscopic: | | | | | | | | | | |
| Ag | T | T | T | T | - | - | T | - | - | - |
| Cu | T | T | T | T | - | - | T | T | T | X |
| Pb | X | X | X | X | T | N | X | X | T | X |
| Zn | X | T | X | T | T | X | X | X | T | X |
| Bi, In, Sn | - | - | - | - | - | - | - | - | - | - |
| Minerals: | | | | | | | | | | |
| Azurite | | | | | | | | | | T |
| Calcite | | F | | | A | P | T | | | A |
| Cerussite | | S | F | M | T | | S | | | |
| Chalcocite | | | | | | | | | | - |
| Chlorite | | | T | T | | | | A | | |
| Covellite | | | | | | | | | | T |
| Chalcopyrite | - | - | - | - | - | - | - | - | - | - |
| Fluorite | A | | | F | | | | A | | |
| Galena | - | S | M | S | T | - | S | - | - | T |
| Goethite | T | A | | A | P | A | A | S | S | M |
| Hornblende | | | T | | | | | | | |
| Magnetite | | | | | | | T | | | |
| Malachite | | | | | | | | | | F |
| Muscovite | | F | T | M | | | | | | |
| Pyrite | T | | | | | | | | | T |
| Quartz | P | P | P | P | A | S | P | A | P | A |
| Scheelite f | - | - | - | - | - | - | - | - | - | - |
| Sphalerite | T? | | | | | | | | | T? |
| Topaz | T | | M | T | | | | | | |

1/ P - Predominant: Over 50 percent
A - Abundant: 10 - 50 percent
S - Subordinate: 2 - 10 percent
M - Minor: .5 - 2 percent
F - few: .1 - .5 percent
T - Trace: Less than .1 percent
f - Fluorescent
N - Notable amounts less than .1 percent
X - Detected in sample
\- Sought but not detected

2/ Sinuk 25-A, B, C, D, and G; Fragments of a vein of quartzose rock which has been subjected to cataclastic deformation. Cataclasts consist of fluorite or goethite fragments. The goethite may have been derived from earlier pyrite. Galena occurs as stringers derived (perhaps) from the crushing of earlier coarser fragments.

Sinuk 25-E and F: Gossan composed of coarse aggregates of goethite intimately mixed with calcite. Coarse porphyroblastic growth areas of quartz are connected to each other by very fine quartz veinlets.

Sinuk 25-F, H, and I: Goethite or calcite rock of cataclastic origin with water-deposited calcite deposited in some solution cavities.

Sinuk 25-J: Calcite-quartz rock with a limited amount of gneissose foliation expressed by thin irregular folded planes of sulfide minerals and oxidation products.

# DESCRIPTION OF THE DEPOSITS

## General Nature

The Sinuk iron deposits occur in a thick series of metalimestones interbedded with thin schist beds. Some sections of the metalimestone series are thinbedded; others are relatively thick bedded; all are contorted locally and much broken and jointed. The metalimestones have been correlated with the Nome group of metasediments which are considered to be of Paleozoic age. The Sinuk iron deposits include surface concentrations and fracture filling of botryoidal, mammillary or loosely cellular limonite and goethite usually associated with calcite, quartz, a small amount of hematite, and some pyrolusite. Iron-stained schist fragments sometimes occur with the iron oxides. Similar limonitic float occurs scattered irregularly through the area.

The known lode deposits in the Nome group of metasediments may be classed as predeformation and postdeformation deposits. The predeformation deposits are not well known. Most lode prospects in the Nome area are postdeformation deposits; the usual location is on or near the crest of an anticline, but some are found in less readily explainable zones of deformation or faulting. Lode deposits in schist usually contain stibnite, chalcopyrite, pyrite, and gold; deposits in limestone usually contain galena and sphalerite with minor amounts of silver and sometimes copper. Botryoidal or mammillary limonite is a common feature of the weathered outcroppings of the sulfide deposits in limestone; gossans with casts and pseudomorphs of the original minerals are rare. The reason is not known. Weathering processes may differ from processes in the more temperate zones where gossans have been described.

The Sinuk iron deposits are in limestone and both galena and sphalerite have been found on the Galena prospect and near the Cub Bear prospect. Lead and zinc also can be detected spectroscopically in many samples that have no recognizable lead or zinc minerals. The primary deposits probably contain galena and sphalerite and possible other sulfides. Fluorite was found with the lead and copper minerals near the Cub Bear lode and has been reported on the Galena prospect. Fluorite is not commonly associated with sulfides in the Nome gold belt; but it is common and widespread in the Lost River tin area about 60 miles to the northwest. There is no evidence to indicate the grade of the primary deposits.

The principal Sinuk iron deposits appear to be alined along two crenulated anticlines. Scanty exposures, local reversals of dip, and contorted beds cast doubt on this interpretation, but the bulk of evidence suggests that the Cub Bear, Iron Creek, Monarch, Mogul, and Tub Mountain prospects are alined along an anticline whose axis strikes N 10° W. The Galena and possibly the American lodes are on a parallel anticline.

## Petrographic Evaluation

By

Harold D. Hess3/

3/ Formerly supervisory geologist, Petrographic Laboratory, Division of Mineral Resources, Bureau of Mines, Albany, Oregon

### Iron Creek Prospect

Sample: Sinuk 1

Field description: Iron float specimen

Petrographic description: This sample is a chlorite schist containing essentially chlorite, some limonite and quartz, small amounts of biotite, sericite, and manganese oxides, and a very small amount of clay. The quartz occurs as a clear fine-grained crystalline material filling small vugs. The limonite is unevenly distributed through the sample as a powdery orange-brown material, apparently an alteration product of an unknown primay iron mineral.

Evaluation: There is no indication of boxwork structure or other evidences of sulfide mineralization.

Sample: Sinuk 2

Field description: Outcrop specimen

Petrographic description: This sample consists of two specimens, a limestone and a sericite schist.

The limestone is buff-colored and finely crystalline. It contains essentially calcite with a small amount of earthy limonite disseminated through the sample and compacted limonite filling cavities. Also present are very small amounts of manganese oxide (in fracture), quartz, and sericite.

The sericite schist contains essentially sericite (with some very fine-grained intergrown rutile) and a ferromagnesian silicate mineral with a small amount of limonite, both earthy and compacted. Also present are irregular zones of milky quartz.

Evaluation: No sulfides were observed and there is no limonite boxwork structure to indicate the former presence of sulfides. The compact limonite filling small cavities in the limestone probably was precipitated from iron-bearing acidic solutions upon contact with the calcite.

Galena Prospect

Sample: Sinuk 3

Field description: Limonite and calcite specimens

Petrographic description: This sample contains essentially brown, dense, botryoidal limonite with radial fibrous structure. Small spaces between botryoidal masses are filled partially with white calcite and orange-brown limonite. Also present are small amounts of quartz and manganese oxide and very small amounts of clay minerals. The sample is very lightly magnetic, however, no magnetite was observed. Although 0.1-1.0 percent lead and 1-5 percent zinc were detected spectrographically, no galena or sphalerite were observed. Spectroscopic analysis of selected concentrates strongly indicates that the lead and zinc are very intimately associated with the limonite, possibly chemically combined. The sample contains no boxwork structure.

Sample: Sinuk 4

Field description: Quartz and calcite vein filling

Petrographic description. This sample consists essentially of sugary quartz and earthy limonite. Some quartz is white and nearly free of impurities, but most of it is iron stained. Some light brown calcite is distributed through the rock, mainly in poorly defined, irregular veinlets. Trace amounts of muscovite and clay also are present. Although 0.01-0.1 percent lead and 0.1-1.0 percent zinc were detected spectrographically, no galena or sphalerite were observed. No boxwork structure was noted.

Sample: Sinuk 6

Field description: Quartz vein material

Petrographic description: This is a fine-grained quartz-calcite rock which contains a considerable amount of sphalerite. Limonite-stained, finely crystalline calcite is veined by a fine-grained mixture of quartz and sphalerite. Essential amounts of limonite occur as isolated dense, dark brown and earthy orange-brown masses; also, some earthy limonite occurs as a coating or staining agent. Small amounts of chlorite and opal also are present.

Sample: Sinuk 7

Field description: Limonite-quartz specimens

Petrographic description: These specimens consist essentially of a dark brown, dense but cellular limonite in which some of the openings have been filled or partially filled with calcite. One of the specimens contains a large veinlet of milky quartz. Also present are small amounts of earthy orange-brown limonite and black manganese oxide and a very small amount of sphalerite. The limonite shows only a slight development of botryoidal surfaces, and no boxwork structure was observed.

Sample: Sinuk 8

Field description: Quartz vein specimens

Petrographic description: This sample consists of two highly altered schists which are crisscrossed with small, irregular veinlets of quartz. The samples contain essentially quartz, some of which is very fine-grained and friable, with lesser amounts of limonite, small amounts of muscovite, and very small to trace amounts of epidote, chlorite, clay, and graphite. Although 0.1-1.0 percent lead was detected spectroscopically, no galena was observed, and no boxwork structure was noted.

Sample: Sinuk 9

Field description: Quartz vein

Petrographic description: This sample consists of white, sugary quartz which contains irregular stringers of pale-yellow calcite and clay. Small amounts of sericite and earthy limonite are disseminated throughout the quartz. Fine-grained galena and hematite occur together in small veinlets. Of the samples examined, this one has the highest lead content. No box-work structure was apparent.

Sample: Sinuk 10

Field description: Dump specimens

Petrographic description: The sample is a dark gray to brown limestone with part of the surface showing evidence of solution and redeposition of small calcite crystals. Hematite and limonite occur on fracture surfaces. Sample contains essentially calcite, some quartz (in thin veinlets) and hematite, and small amounts of limonite, chlorite, and clay. No boxwork limonite was observed.

Sample: Sinuk 12

Field description: Limonite float

Petrographic description: This sample consists of two specimens, a lime-stone and a calcite-limonite rock.

The limestone is finely crystalline, consisting of alternating layers of white and brown limonite-stained calcite. The sample contains essentially calcite, a small amount of limonite, and trace amounts of chalcedony and clay.

The calcite-limonite rock essentially consists of calcite and dark brown and yellow-brown earthy limonite, a lesser amount of sphalerite, and very small amounts of quartz and clay minerals. No boxwork structure was observed in either sample.

Sample: Sinuk 13

Field description: Limonite

Petrographic description: This sample consists essentially of dense botryoidal limonite, exhibiting a radial fibrous structure. Part of the surface is thinly coated with black manganese oxide, and part has a varnished appearance. A very small amount of calcite is present, occurring in a small veinlet. Trace amounts of clay are present. Although this sample contained 0.1-1.0 percent lead and zinc, no sphalerite or galena were observed. No boxwork structure was noted.

Sample: Sinuk 14

Field description: Quartz vein material

Petrographic description: This sample consists of two specimens of iron-stained, finely crystalline limestone veined by milky quartz. One specimen contains a considerable amount of sphalerite and the other is barren. Also present is some earthy limonite and a trace amount of clay. A poorly developed cellular structure was present in the limonite, but it did not offer any evidences of relict sulfides.

Sample: Sinuk 15

Field description: Limonite float

Petrographic description: This sample consists of three different specimens. One is a highly altered chlorite schist containing essentially limonite, chlorite, and calcite with some manganese oxide and sericite. The second contains essential amounts of drusy hemimorphite and earthy, brown and orange-brown limonite, some quartz, calcite, and sphalerite, a small amount of manganese oxide, and a trace amount of clay. The third specimen is a dark brown, dense botryoidal limonite with some associated calcite and manganese oxide and small amounts of quartz and sphalerite. No limonite boxwork structure was noted.

Sample: Sinuk 19

Field description: Brecciated "country rock," east divide

Petrographic description: This sample is a brecciated, finely crystalline limestone, fractured and recemented by small amounts of secondary calcite, manganese oxide, and limonite. The brecciated pieces consist essentially of white- or cream-colored calcite with trace amounts of associated quartz and limonite.

Sample: Sinuk 20

Field description: Limonite, south side of east divide

Petrographic description: This rock is composed essentially of dark brown, dense, botryoidal limonite, exhibiting a radial, fibrous structure. Small amounts of earthy calcite are deposited on one surface. The limonite contains small, irregularly distributed voids that are filled or coated with very small amounts of muscovite, limonite, quartz, tourmaline, biotite, chlorite, clay, calcite, and amphibols. No boxwork structure was observed.

Sample: Sinuk 21

Field description: Limonite and calcite, center of east divide

Petrographic description: This sample consists of white, coarsely crystalline, secondary calcite intergrown with dense, dark-brown, massive limonite containing small, irregularly distributed voids. Also present are small amounts of manganese oxide and sericite. No boxwork structure was noted.

Evaluation: No sulfide minerals were detected microscopically, and spectrographic analyses showed no particular concentration of base metals. Although these samples probably were taken from a limestone area, there was no evidence of boxwork structure or other signs of sulfide mineralization.

## General Conclusions

On the basis of this examination, the following conclusions were made:

1. None of the samples exhibited indigenous limonite boxwork structures.

2. Samples from the Galena prospect showed distinctive evidence of sulfide mineralization. The Galena suite consists of 11 samples, 1 containing as much as 5-10 percent lead and 4 containing 10 percent zinc. Several samples were composed of compact botryoidal limonite, probably precipitated from iron-bearing acidic solutions made alkaline by contact with limestone. However, no indigenous limonite boxwork structure was observed. Apparently these specimens were collected in an area of interbedded crystalline limestone and schist. This would suggest the possibility of complex geologic structure, both of the metamorphic rocks and of the mineralized zones.

3. No primary or secondary copper minerals were detected and spectrographic analyses did not show a concentration of copper. All evidences indicate that the samples represent primarily an area of lead-zinc mineralization.[4/]

[4/] Sample Sinuk 25 (tables 4 and 8) which contains copper was collected later.

4. Mineralization may be confined largely to the limestone rather than to the interbedded schists.

5. The absence of boxwork structure together with the presence of essentially unaltered primary sulfides and other criteria indicate that conditions requisite to the formation of true gossans in this area have been unfavorable; therefore, the existence of underlying zones of oxidation or supergene enrichment would appear unlikely.

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