Magnetite Deposits at Tuxedni Bay Alaska

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By ARTHUR GRANTZ

MINERAL RESOURCES OF ALASKA

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By Arthur Grantz

ABSTRACT

Magnetite deposits on an island in Tuxedni Bay occur in contact-metamorphosed volcanic and sedimentary rocks near their contact with a quartz-diorite batholith, which underlies large areas of the adjacent Aleutian Range. The deposits are pyrometasomatic in origin and probably are localized by northeast-trending fractures. The eastern deposit is a low-grade disseminated deposit occurring in hornfels. The western deposit occurs as a massive lens of magnetite and garnet with a marble hanging wall and a hornfels footwall. The western deposit may contain about 75 percent magnetite. The deposit is lenticular and can be followed along strike for 55 feet in outcrop. Magnetic effects indicate that it extends an additional 55 feet to the northeast, where it is concealed beneath a cover of soil and vegetation. Where it is exposed in a sea cliff, the deposit is 30 to 35 feet thick.

INTRODUCTION

Tuxedni Bay is on the west side of Cook Inlet about 120 miles southwest of Anchorage, Alaska. (See fig. 7.) The bay is very shallow except for Tuxedni Channel, which separates Chisik Island from the mainland. Tuxedni Channel is a secure anchorage. The land adjacent to tidal flats is rugged, and slopes are generally steep. Iliamna Volcano (altitude 10,016 feet) and Redoubt Volcano (altitude 10,197 feet) are both within 15 miles of Tuxedni Bay. Very heavy brush covers slopes to an altitude of about 2,000 feet. Spruce timber may be found along the shores of Cook Inlet from Chinitna Bay to Johnson River and northward from Tuxedni Bay; however, most of the spruce occurs below 750 feet altitude.

The magnetite deposits are located on an island near the head of Tuxedni Bay. The island is 9¼ miles N. 60°–65° W. of the northern tip of Chisik Island and may be reached by means of small boats or small seaplanes. However, trips should ordinarily be attempted only at high tide and under favorable weather conditions. Most of Tuxedni Bay is dry at low tide, and even at high tide most of the bay is shoal. Swift tidal currents and changeable winds at the head of

Tuxedni Bay necessitate caution in landing by seaplane or visiting the area by small boat.

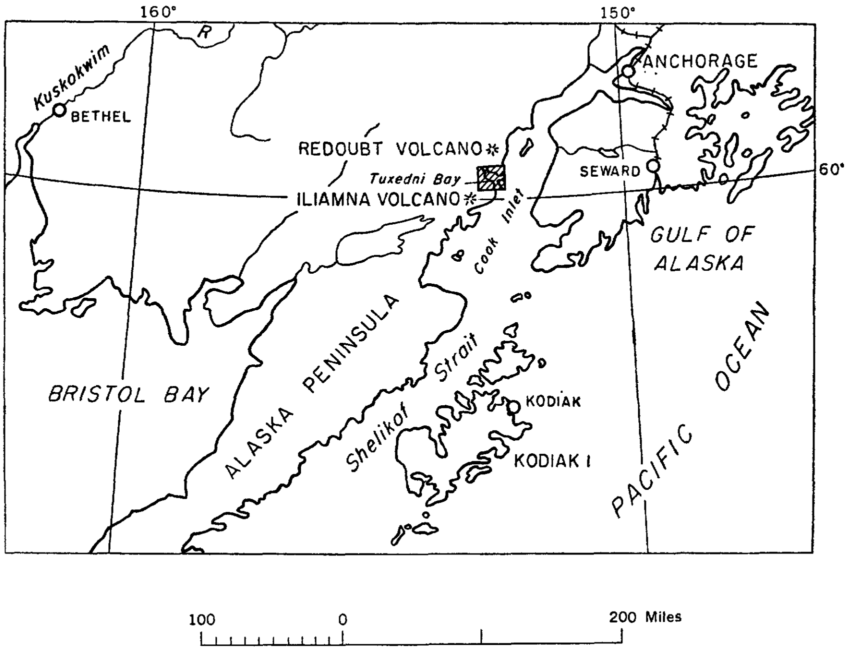

FIGURE 7.—Index map of southwestern Alaska, showing location of area studied.

The field investigation upon which this report is based was made from September 8 through September 10, 1951. Its purpose was to determine the nature and possible extent of a reported magnetite deposit at Tuxedni Bay. Mapping of the island, upon which the previously reported western deposit is located, revealed the presence of the eastern deposit. The interior of the island was not mapped.

The present investigation was made while the writer was assisting John K. Hartsock in a study of the petroleum possibilities of the area between Iniskin and Tuxedni Bays. The writer was assisted during the field work in the vicinity of the magnetite deposits by R. Werner Juhle and drew heavily from Juhle's report on Iliamna Volcano and its basement [1] for information on the geology of upper Tuxedni Bay. The following geologic description of the Tuxedni Bay area is in large part abstracted from Juhle's report, and figure 8 of the present report was adapted from part of plate 1 of Juhle's report.

GEOLOGY

The rocks underlying the Tuxedni Bay area are predominantly of Mesozoic age. Sedimentary rocks of Late Triassic age are the oldest

[1] Juhle, R. W., 1955, Iliamna volcano and its basement: U. S. Geol. Survey open-file preliminary report.

that have been recognized in the area. They are overlain by volcanic rocks of Early Jurassic age and these, in turn, are overlain by marine sedimentary rocks of Middle and Late Jurassic age. Continental sedimentary rocks of early Tertiary age, and volcanic rocks of later Tertiary and probably Quaternary age, overlie the Mesozoic rocks both to the north and to the south of Tuxedni Bay. Tertiary rocks are not shown in figure 8 because their extent in the map area is small and they do not crop out within 5 miles of the magnetite deposits.

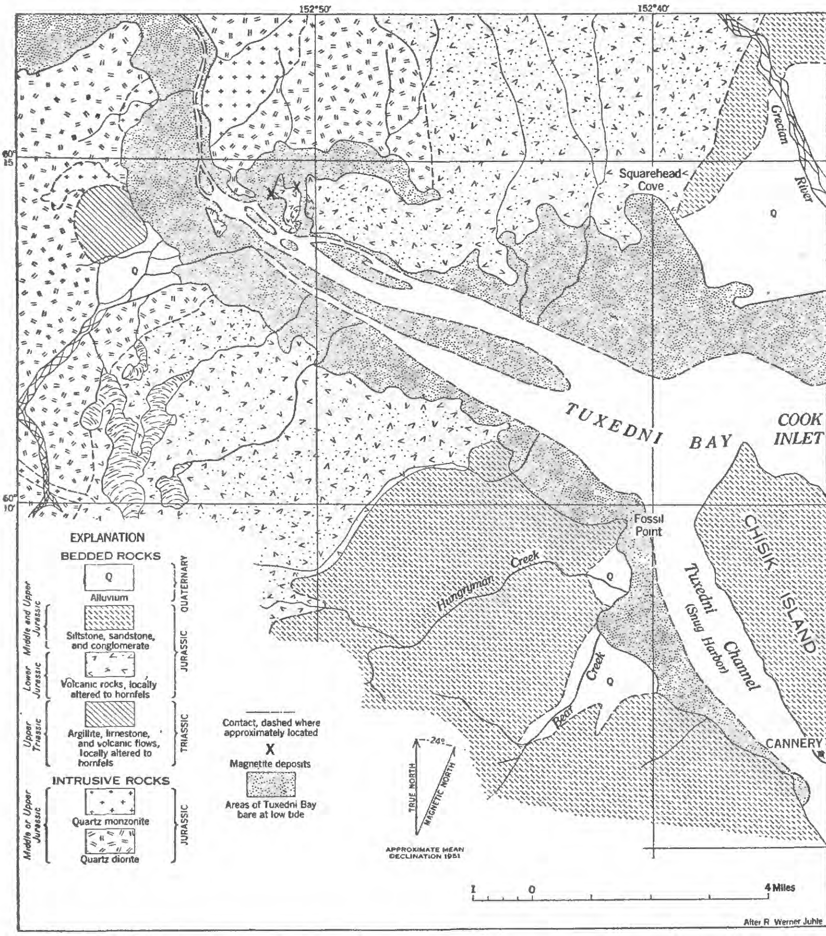

FIGURE 8.—Generalized geologic map of the Tuxedni Bay area, showing the location of magnetite deposits.

Quartz diorite and granophyric quartz monzonite, probably of Middle Jurassic age, intruded the Lower Jurassic and older rocks. Hornfels, marble, and (locally) tactite were formed near the borders of the intrusives. With the possible exception of the very earliest beds, the Middle Jurassic and younger bedded rocks have not been intruded by granitic rocks. Where the sedimentary rocks of Middle Jurassic or younger age have been intruded by mafic dikes, they are baked only where they are immediately adjacent to the dike borders.

BEDDED ROCKS

Argillite, limestone, and interbedded andesitic lava flows, probably of Late Triassic age, crop out at the head of Tuxedni Bay. The base of the Upper Triassic section has not been recognized; however, its position may now be occupied by the quartz diorite of the adjacent Aleutian Range.

The Upper Triassic rocks grade conformably upward into volcanic rocks of probable Early Jurassic age. The contact between the two series of rocks has been arbitrarily placed at the base of the first thick tuff bed above the argillite beds. The lower part of the Lower Jurassic volcanic sequence consists chiefly of andesitic breccias and flows, but it contains some interbedded argillite. The upper part of the Lower Jurassic volcanic sequence is composed primarily of water-laid rocks of pyroclastic origin and tuffaceous marine sedimentary rocks. Fossiliferous marine sedimentary rocks of Middle and Late Jurassic age overlie the Lower Jurassic volcanic rocks with apparent conformity. Siltstone predominates, but many thick units of graywacke sandstone and arkosic sandstone and some thick beds of conglomerate occur.

Continental sedimentary rocks of early Tertiary age overlie the Upper Jurassic marine sedimentary rocks with low angular unconformity. These rocks are exposed along the northwest shore of Cook Inlet, both north and south of Tuxedni Bay.

Between Chinitna and Tuxedni Bays and north of Tuxedni Bay, mafic flows and associated pyroclastic rocks in many places overlie the truncated surfaces of the folded and faulted Triassic and Jurassic rocks. Both basaltic andesite of middle or late Tertiary age and extensive andesitic flows and breccias of late Tertiary or Quaternary age were reported by Juhle. The basaltic andesite crops out in limited areas immediately west of Squarehead Cove on the north shore of Tuxedni Bay and 2¼ miles west of Fossil Point on the south shore of Tuxedni Bay. Both Iliamna Volcano, which lies between Chinitna and Tuxedni Bays, and Redoubt Volcano, which lies north of Tuxedni Bay, have been active in historic times (Coats, 1952, p. 38 and table 2).

INTRUSIVE ROCKS

The bedded rocks have been intruded by the biotite-hornblende-quartz diorite batholith of the Aleutian Range. This intrusive was emplaced during Middle or early Late Jurassic time (possibly as early as early Middle Jurassic time). Dikes and stocks of pink granophyric quartz monzonite have intruded the quartz diorite and, in places, the bedded rocks near the borders of the quartz diorite. The monzonite was emplaced after most the quartz diorite had solidified and may have been a late differentiate of the quartz diorite magma.

Mafic dikes, sills, and pipes intrude the Upper Jurassic and older rocks at many places in the Tuxedni Bay area. With the exception of dikes that are related to the diorite and monzonite intrusives, only those dikes and pipes that are related to the flows of Iliamna Volcano and vicinity can be dated at this time.

STRUCTURE

Most fold axes and major fractures in the bedded rocks strike within 10° of N. 35° E. in conformity with the regional strike of the eastern border of the quartz diorite batholith. This structural trend is also present in the vicinity of the magnetite deposits, both of which strike from N. 35° E. to N. 45° E. and are parallel to the predominant strike of the bedding, fractures, dikes, and replacement zones in the marble and volcanic host rocks.

MAGNETITE DEPOSITS

Two deposits of magnetite are exposed on a small island of metamorphosed volcanic rock at the edge of the tidal marsh at the north shore of Tuxedni Bay. (See figs. 8 and 9.) The eastern deposit, magnetite disseminated in hornfels, is exposed almost down to marsh level in the hillside on the northern shore of the island. The western deposit, a massive lens of magnetite and garnet with a marble hanging wall and a hornfels footwall, is exposed in a sea cliff at the extreme western end of the island.

The western deposit was staked and samples were taken as early as the summer of 1916. However, the only development of this deposit still apparent in 1951 was a prospect hole about 5 feet wide and 3 to 5 feet high, which had been driven about 13 feet horizontally beyond the end of a sea cave. No development of the eastern deposit was noted.

The western deposit of this report is the same one referred to in previous reports on magnetite at Tuxedni Bay (Martin, 1920, p. 35; Brooks, 1921, p. 42; Moffit, 1927, p. 55–56 and pl. 4). Although the location of the magnetite deposit as shown by Moffit (1927, pl. 4) is not identical with the location given in this report, the two descriptions refer to the same deposit. The deposit was not visited by Moffit, but it was described to him by Roy A. Trachsel, of Anchorage, who was the owner of the deposit at that time.

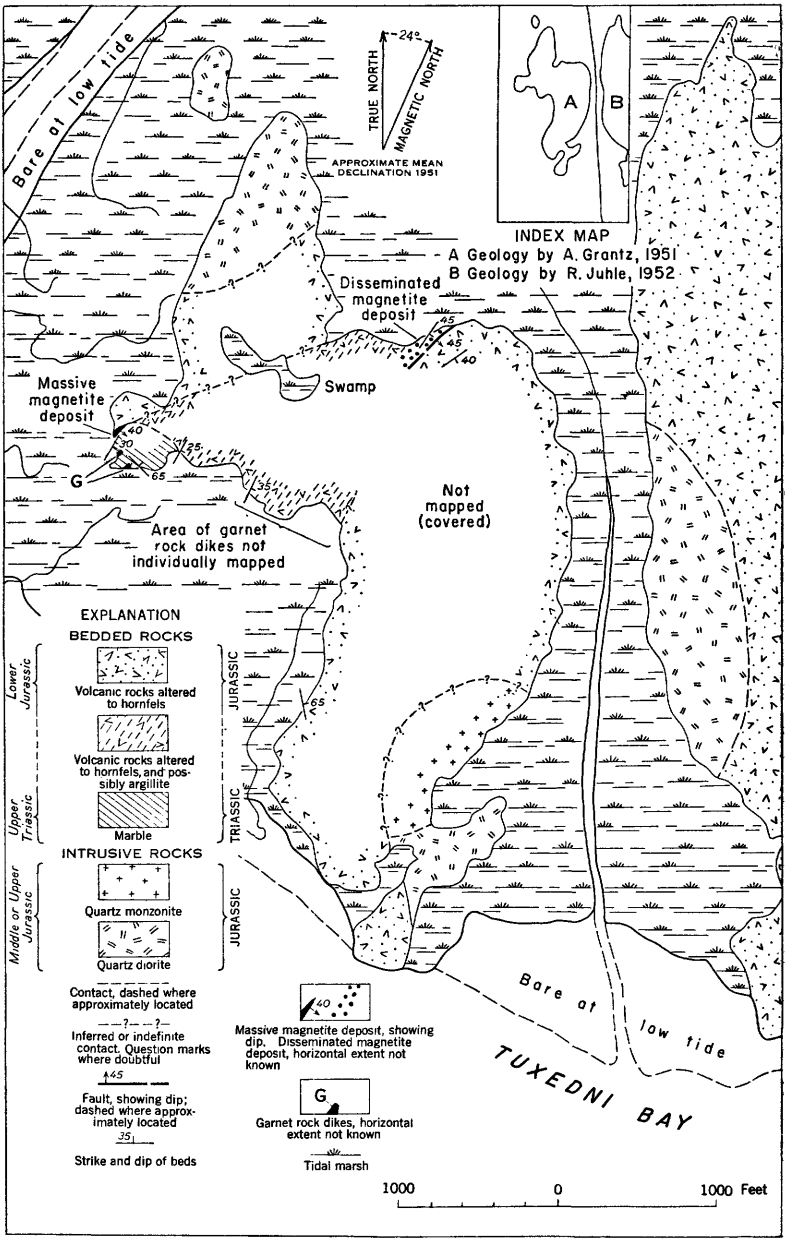

FIGURE 9.—Geologic map of the area near the magnetite deposits at Tuxedni Bay.

GEOLOGY NEAR THE MAGNETITE DEPOSITS

Contact metamorphism has altered the rocks in the vicinity of the magnetite deposits to hornfels and marble (fig. 9). Garnet rock occurs locally, and small bodies of magnetite or garnet-magnetite rock were found at two places. Evidently the metamorphism is related to the nearby quartz diorite batholith. The outcrop pattern of the quartz diorite indicates that the diorite underlies the magnetite deposits at shallow depth.

Although the original nature of the rocks has been obscured by metamorphism, most of the strata on the island are believed to be of volcanic origin. However, in a northeast-trending zone which lies roughly between the two deposits, some argillite may be interbedded with the volcanic rocks. Adjacent to the western deposit is a small area of white medium-grained marble that has been completely recrystallized by contact metamorphism. The recrystallized grains range from 2 to 6 millimeters in diameter, but streaks of very coarse marble contain grains as much as 2.5 centimeters in diameter. Magmatic additions to the marble consist chiefly of a few massive dikes of garnet rock and a few small veinlets of magnetite. Streaks of well-disseminated small garnet crystals and of fine-grained magnetite occur in the marble in a few places. Juhle[2] reports that idocrase is present in the marble.

WESTERN DEPOSIT

The western deposit is in a skarn zone and consists of a massive lens of high-grade magnetite, and massive garnet rock that in places contains disseminated magnetite. Exposures are limited to a high sea cliff, two sea caves cut into the sea cliff, and a short prospect hole driven horizontally beyond the end of the southern sea cave. There are no surface exposures inland from the sea cliff in the vicinity of the deposit.

The garnet-magnetite body is irregular in shape. It strikes approximately N. 40° E., and the dip averages about 40° SE. The body is about 30 to 35 feet thick and is exposed in the sea cliff for about 55 feet in the dip direction. The deposit may be followed for 55 feet along the strike in the sea caves and the prospect hole. A reconnaissance dip-needle traverse indicated that the magnetic anomalies, caused by the presence of the magnetite, end about 110 feet back from the cliff face. The contact of the deposit with the marble hanging wall is sharply defined. Very little disseminated magnetite or garnet occurs in the marble. The contact of the deposit with the hornfels footwall is less well defined because the hornfels near the contact

[2] Op. cit.

contains disseminated garnet in places. Contacts between the garnet rock and the magnetite, although gradational in places, are locally well defined. A dike of garnet cuts the massive magnetite with sharp contacts.

The contact between the marble of the hanging wall and the hornfels of the footwall of the western deposit probably was formed prior to, or contemporaneously with, the mineralization. Magnetite and garnet rock has completely replaced the marble-hornfels contact in the exposures at the western deposit, and therefore direct evidence concerning the nature of the marble-hornfels contact was not observed. The proximity of the marble to the probable metavolcanic hornfels, however, suggests the possibility of a fault contact, although no faults were observed either in the western deposit or between the western deposit and the country rocks. Such a fault could have provided a channelway for the mineralizing solutions and could account for the localization of the deposit in the contact zone between the marble and the hornfels. The attitude of the deposit is similar to the predominant attitude of the bedding and fractures in the area as well as to the attitude of the eastern deposit.

Evidence for postmineral movement in the marble is afforded by a very thin vein of magnetite that occurs in the marble about 50 feet south of the deposit. This vein has been broken, and the pieces have been rotated—the marble having flowed around the broken pieces.

The marble in the hanging wall of the western deposit apparently influenced the composition of the garnet deposited in or adjacent to it (see p. 103) and may have influenced the deposition of the magnetite. The magnetite in the western deposit is predominantly massive, whereas in the eastern deposit, which is entirely in hornfels, the magnetite is disseminated.

Magnetite is the only ore mineral present, although traces of pyrite and probably chalcopyrite can be found locally. No other sulfides were noted, and chemical analyses of samples taken from the deposit show that the sulfur content is low. Copper and gold are absent or are present only in traces.

The chief gangue mineral is garnet. Traces of other silicate minerals, including chlorite, clinopyroxene (diopside-hedenbergite), and probable idocrase occur in the garnet-magnetite body. The garnet occurs as a minor constituent in the massive magnetite lens and as a massive dike cutting the lens. Large masses of garnet rock lie adjacent to the areas of massive magnetite (fig. 10), and locally these masses contain as much as 50 percent of disseminated magnetite. In other places, however, the garnet rock adjacent to the massive magnetite contains only traces of other silicates or magnetite. An irregular mass of garnet rock lies in the marble hanging wall immediately adjacent to the lens of massive magnetite. Where associated with the magnetite, the garnet is grayish to moderate yellowish green and contains between 70 and 90 percent andradite (the calcium-iron garnet). Where associated with limestone, the garnet tends to be grayish or yellowish brown and contains between 60 and 70 percent andradite. The remaining percentage of both varieties of garnet is composed of grossularite (the calcium-aluminum garnet) and probably several percent of almandite (the iron-aluminum garnet). Qualitative chemical tests indicated that some of the manganese in the magnetite deposits (table 1) occurs in the associated garnet.

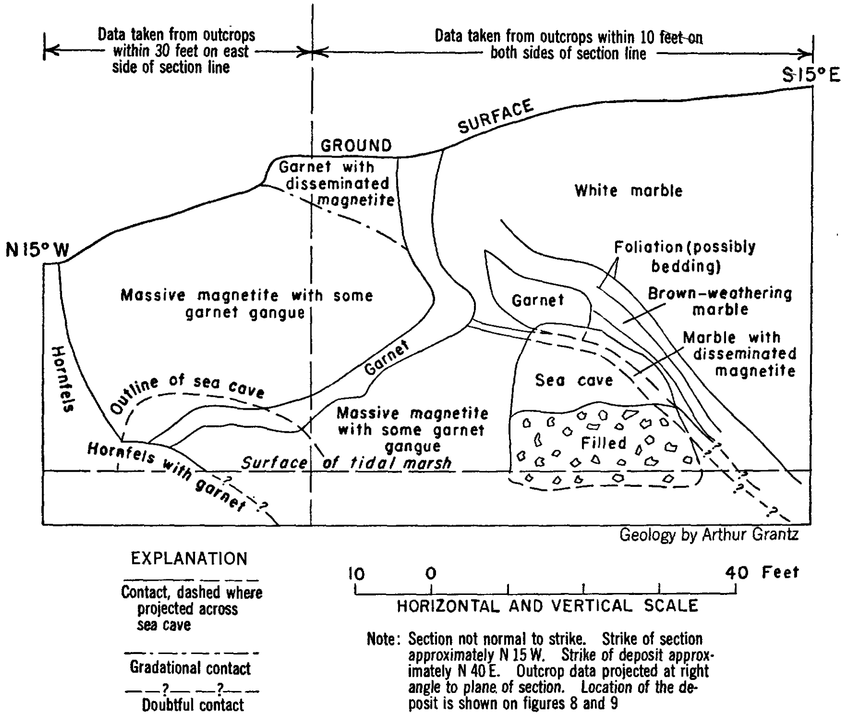

FIGURE 10.—Generalized cross section of the western magnetite deposit as exposed along sea cliff.

Grab samples believed to be representative of high-, medium-, and low-grade portions of the massive magnetite lens of the western deposit were collected for assay and chemical analysis during the present investigation. (See tables 1 and 2.) Also shown in these tables are two analyses and an assay of samples from the deposit that were furnished to the Geological Survey by Roy A. Trachsel, of Anchorage, and that were published by Moffit in 1927. All the analyzed samples from the western magnetite deposit contain 50 percent or more of iron as metal, with no more than a few percent of the iron occurring

TABLE 1.—*Analyses of samples from the magnetite deposits at Tuxedni Bay, Alaska*

Determinations	A	B	C	D	E	F
Loss on ignition				.11		
SiO_2	11.4	7.3	1.4	4.34	2.80	37.4
Al_2O_3	1.9	1.8	.72	1.20		5.7
FeO	17.0	21.4	25.1			9.1
Fe_2O_3	53.2	58.8	67.8			26.7
Fe_3O_4				88.89		
MgO	1.6	2.2	1.4	1.12		1.4
CaO	11.0	6.2	1.4	1.55		19.4
Na_2O	.14	.14	.15			.15
K_2O	.08	.08	.11			.08
TiO_2	.31	.42	.44			.38
P_2O_5	.64	.11	.02			.08
P	[a](.28)	[a](.05)	[a](.009)	.05	.064	[a](.035)
MnO	1.2	1.7	1.6			.40
Mn	[b](.9)	[b](1.3)	[b](1.2)	2.06		[b](.31)
Cr_2O_3	<.02	<.02	<.02			<.02
S	.98	.03	.20	.59	.11	.01
Fe	[c](50.4)	[c](57.7)	[c](66.9)	(64.27)	67.82	[c](25.8)
Totals	99.47	100.2	100.36	99.91		100.82

[a] Calculated from P_2O_5. [b] Calculated from MnO. [c] Calculated from FeO and Fe_2O_3.

NOTE.—Sample A: Representative sample of low-grade portions of the massive magnetite lens of the western magnetite deposit. Collected by Arthur Grantz. Analysis by S. M. Berthold and E. A. Nygaard, U. S. Geological Survey.

Sample B: Representative sample of medium-grade portions of the massive magnetite lens of the western magnetite deposit. Collected by Arthur Grantz. Analysis by S. M. Berthold and E. A. Nygaard.

Sample C: Representative sample of high-grade portions of the massive magnetite lens of the western magnetite deposit. Collected by Arthur Grantz. Analysis by S. M. Berthold and E. A. Nygaard.

Sample D: Sample probably from the massive magnetite lens of the western magnetite deposit. Described by F. H. Moffit, U. S. Geol. Survey Bull. 789, p. 55–56, 1927. Analysis by Kansas City Testing Laboratory, Kansas City, Mo., October 14, 1920.

Sample E: Sample probably from the massive magnetite lens of the western magnetite deposit. Described by F. H. Moffit, U. S. Geol. Survey Bull. 789, p. 55–56, 1927. Analysis by Abbot A. Hanks, San Francisco, Calif., February 25, 1921.

Sample F: Sample from the eastern magnetite deposit. Collected by Arthur Grantz. Analysis by S. M. Berthold and E. A. Nygaard.

in garnet or possibly other silicate minerals. However, for use as iron ore all samples contain an undesirable amount of sulfur, and four of the samples contain an undesirable amount of phosphorus. The highest phosphorus content and the highest sulfur content are in the same sample.

EASTERN DEPOSIT

This deposit consists of magnetite disseminated in hornfels that was probably derived from volcanic rocks. The magnetite occurs in two parallel zones. The upper zone is about 30 feet thick and is separated from a lower zone by 20 feet of country rock. The lower zone is at least 10 feet thick, but its base is not exposed. The strike length of the deposit is not known. The mineralized zones are exposed only in a small area near the shore of the island. To the northeast the deposit is covered by tidal marsh, and to the southwest it is covered by soil and heavy vegetation. The mineralized zones strike approximately N. 35°–45° E. and dip approximately 45° SE. Bedding and fractures in the vicinity of the deposit have simliar trends and may have controlled the locus of mineralization.

TABLE 2.—*Assays of samples from the magnetite deposits at Tuxedni Bay, Alaska*

Determinations	A	B	C	D	E	F
Gold (ounce per ton)	--------	--------	--------	None	0.01	--------
Silver (ppm)	0	0	0	--------	Trace	0
Copper (ppm)	65	30	70	--------	--------	5
Copper (percent)	--------	--------	--------	--------	0.40	--------

Note.—Sample A: Representative sample of low-grade portions of the massive magnetic lens of the western magnetite deposit. Collected by Arthur Grantz. Analysis by Hy Almond, U. S. Geological Survey.

Sample B: Representative sample of medium-grade portions of the massive magnetite lens of the western magnetite deposit. Collected by Arthur Grantz. Analysis by Hy Almond.

Sample C: Representative sample of high-grade portions of the massive magnetite lens of the western magnetite deposit. Collected by Arthur Grantz. Analysis by Hy Almond.

Sample D: Composite of eight samples from the massive magnetite lens of the western magnetite deposit. Collected by Arthur Grantz. Analysis by Dwight L. Skinner, U. S. Geological Survey.

Sample E: Sample probably from the massive magnetite lens of the western magnetite deposit. Described by F. H. Moffit, U. S. Geol. Survey Bull. 789, p. 55–56, 1927. Analysis by Bogardus Testing Laboratories, Seattle, Wash., July 25, 1916.

Sample F: Sample from the eastern magnetite deposit. Collected by Arthur Grantz. Analysis by Hy Almond.

The magnetite in the eastern deposit is disseminated in a gangue in which garnet is the most abundant mineral; epidote, diopside, chlorite, plagioclase, and other silicates also are present. No sulfides were noted. An analysis of the richest sample obtained from the upper zone of the deposit contained 25.8 percent of iron and 0.01 percent of sulfur. However, about one-fifth of the iron may occur in silicate minerals. The exposed portion of the lower zone of the deposit contains even less magnetite; samples from this zone were not analyzed. The magnetite content of the deposit as a whole was estimated in the field to be about 10 to 20 percent.

ORIGIN OF THE DEPOSITS

The association of the magnetite with andradite-rich garnet, epidote, diopside, chlorite, plagioclase, idocrase, and a trace of iron and copper sulfides and its occurrence in irregular replacement zones and lenses is characteristic of magnetite deposits of pyrometasomatic origin. A large quartz diorite batholith crops out within 1,000 feet of the deposits and probably underlies the deposits at shallow depth. The quartz diorite has an iron content of about 6 percent, and the deposits are probably genetically related to it; the granophyric quartz monzonite, which also outcrops in the area, has an iron content of only about 0.73 percent.[3]

[3] Op. cit.

TENOR AND RESERVES

Although, as stated above, the field-estimated grade of the exposed parts of the eastern deposit is about 10 to 20 percent of magnetite, a selected sample from this deposit contained 25.8 percent of iron. Each reported analysis of the western deposit, however, shows more than 50 percent of iron, with one analysis showing 67.8 percent. Sulfur and phosphorus, which were shown by the analyses to be present in all the samples from the western deposit, occur in most of the samples in amounts that are undesirable in iron ore. Samples from both deposits were assayed for copper, silver, and gold by the U. S. Geological Survey, but these metals were present only in traces or were absent. No sample of the deposit or of the adjacent country rock produced significant radioactivity, as measured with a portable field-type Geiger counter. Massive garnet, as found in the western deposit and elsewhere on the island, is not of the quality generally preferred for abrasive garnet.

The small outcrop area of marble (the presence of which may have controlled deposition of massive magnetite of minable grade), the probable presence of quartz diorite at shallow depth, and the tendency for such deposits to be irregular and lenticular in shape, would all have a bearing on an estimate of the size of the western deposit. The depth of mud fill beneath the tidal marsh, which covers the western deposit beyond the sea cliff, and the slope of bedrock beneath the mud fill might determine how far the deposit extends to the southwest. The reserves of magnetite that may be inferred to be present in the western deposit above the level of the tidal marsh, and within the limits of outcrop data, are only several thousand tons.

A reconnaissance examination of the shore of the peninsula that lies immediately east of the island failed to find evidence of mineralization other than sparsely disseminated pyrite. The area of argillite and limestone of Late Triassic age that occurs west of the island, across Tuxedni Bay, was briefly visited in 1951, but no evidence of mineralization was found.

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