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TUNGSTEN DEPOSITS OF THE NIGHTINGALE DISTRICT PERSHING COUNTY, NEVADA

BY

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TUNGSTEN DEPOSITS OF THE NIGHTINGALE DISTRICT, PERSHING COUNTY, NEVADA

By Ward C. Smith and Philip W. Guild

ABSTRACT

The tungsten deposits of the Nightingale district are just within the western border of Pershing County, Nev., and in the Nightingale or Truckee Range, which lies east of Winnemucca Lake. The Tertiary volcanic rocks of the district rest unconformably upon intrusive granodiorite and steeply dipping metamorphosed limestones and slates of unknown age. The tungsten deposits are of the contact-metamorphic type: The ore consists of scheelite-bearing tactite, a dark silicate rock that was formed by metamorphism of limestone at the granodiorite contact. Scheelite (calcium tungstate) is the only valuable mineral. The gangue minerals are epidote, quartz, pyroxene, garnet, calcite, tremolite, molybdenite, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, apatite, and sphene. The bodies of tactite are generally tabular, and they extend downward steeply, because both the limestones and the granodiorite contact dip vertically or nearly so. The largest tactite body of the district is at the Nightingale mine; it attains a maximum thickness of 60 feet and is nearly a thousand feet long, but only for part of its length is it thick enough and rich enough to be potentially minable. That it continues downward below the mine workings, which extend to a depth of 128 feet, is shown by nine drill holes put down by the Bureau of Mines, United States Department of the Interior, in 1940, all of which encountered tactite at depths of 260 to 350 feet. The mine has produced about 12,000 tons of ore, and its ore bodies contain the principal reserve of the district. In 1938 the reserves of the entire district were estimated to be about 50,000 tons of ore averaging between 0.25 and 0.50 percent of WO_3. Later diamond drilling by the Bureau of Mines indicated that the principal tactite body continues to at least twice the depth hitherto explored by the mine workings.

INTRODUCTION

The Nightingale tungsten district centers in the Nightingale mine, which is in sec. 25, T. 25 N., R. 24 E., Mount Diablo base and meridian, just within the western border of Pershing County, Nev. (fig. 2). The district extends for about 3 miles along

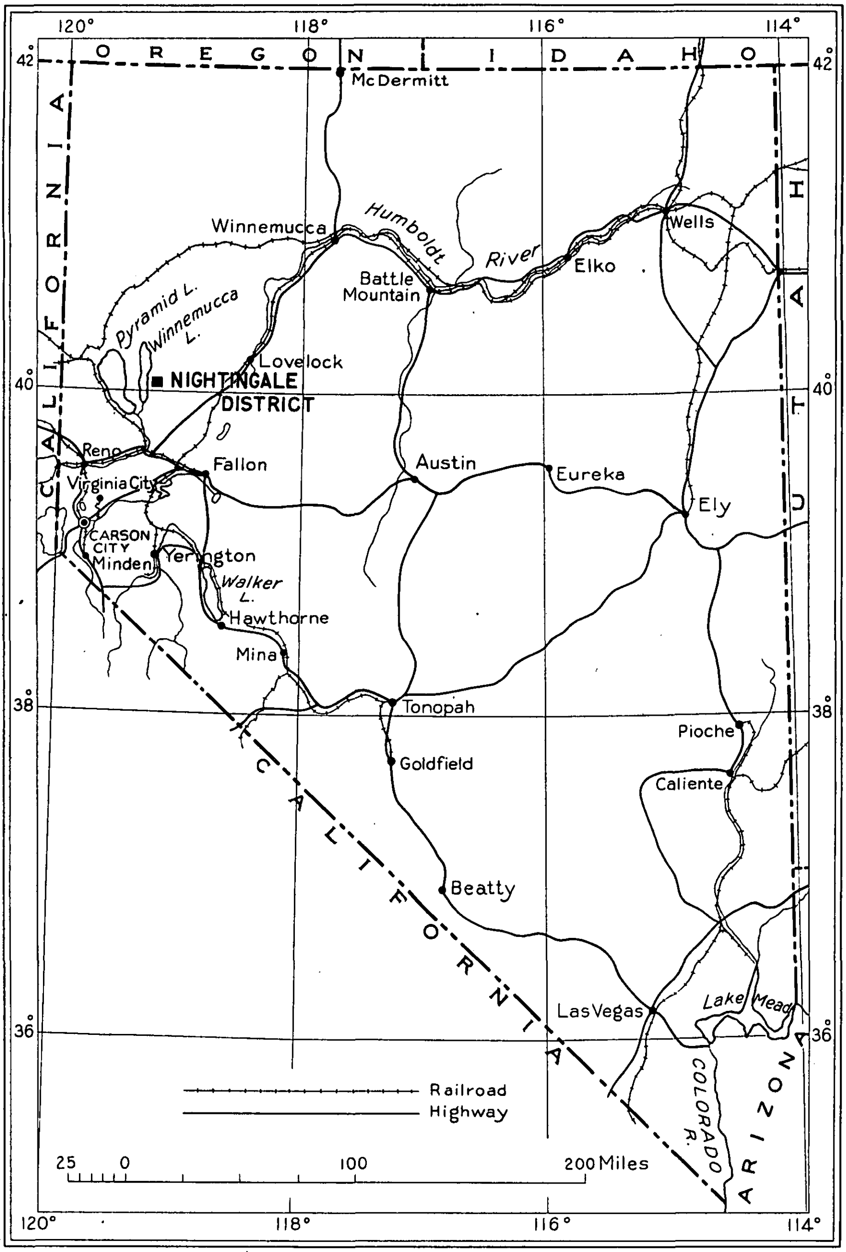

Figure 2.—Index map of Nevada showing location of Nightingale tungsten district.

the north-trending crest of the barren range that borders the eastern shore of Winnemucca Lake. This range is now known locally as the Nightingale Range, although in the early days it was called the Truckee Range and is thus designated on the southeastern part of the Granite Range topographic map.

The district is easily accessible from the south and east by way of two gravel roads that extend from U. S. Highway No. 40 through the valley of Sage Hen Creek and up the gentle surface of a pediment that forms the eastern slope of the Nightingale Range in the vicinity of the district. One of these roads is from Hot Springs, 20 miles south, and the other from Toulon, a station on the Southern Pacific Railroad, 40 miles east. A third road, rarely used because it is steep, difficult, and sometimes impassable, extends from the district down the sharply dissected western slope of the Nightingale Range into the south end of the Winnemucca Lake basin.

In this region and at the altitude of the district, which ranges from 5,500 to 6,500 feet, winter is rarely severe enough to impede mining or transportation for more than a day or two at a time. The dryness of the climate, however, severely limits the water supply, and although Linton Well, a mile east of Nightingale, has always hitherto provided ample water for camp needs and has supplied the tungsten mill during short periods, its capacity to supply water for continuous milling has never been adequately tested.

The principal tungsten deposits at Nightingale were discovered in 1917 by Alex Ranson and his associates,[1/] who sold them in 1929 to the present owner, the Gold-Silver-Tungsten Co., Inc., of which J. G. Clark of Boulder, Colo., is president. This company built a mill which was designed to handle 100 tons of ore a day, but which except for short trial runs has never been operated. Small lots of ore from the district have been shipped to the tungsten mill at Toulon at various times since 1918. No

1/ Hess, F. L., and Larsen, E. S., Contact-metamorphic tungsten deposits of the United States: U. S. Geol. Survey Bull. 725-D, p. 282, 1921.

detailed record of production is available, but according to Clark,[2] $200,000 worth of concentrates have been produced from the district.

The writers' study of the district was a part of the investigation of strategic-mineral deposits in which the Geological Survey and the Bureau of Mines, United States Department of the Interior, are cooperating. In September 1938, the topography and areal geology of the district were surveyed, on a scale of 1:12,000, by Ward Smith with the assistance of George P. Sopp. From December 1939 to April 1940, during the course of a drilling and sampling project by the Bureau of Mines, Philip W. Guild examined diamond-drill cores and sample cuts, and prepared detailed geologic maps of the underground workings and of the area in the vicinity of the Nightingale mine.

It is a pleasure to acknowledge the cordial hospitality of the property owners, the many courtesies received from Mr. Alex Ranson, superintendent at Nightingale in 1938, the constant cooperation of Mr. W. O. Vanderburg and Mr. J. H. East, Jr., engineers in charge of the Bureau of Mines exploration project, and, last but not least, the beneficial criticism of Mr. H. G. Ferguson and Mr. F. C. Calkins of the Geological Survey.

GEOLOGY

Rock units

The Nightingale district well exemplifies the geological features that are typical of the Nightingale Range. The youngest rocks—excluding the Recent alluvium and fanglomerate covering several small areas—are faulted and tilted Tertiary basalt flows and tuffaceous beds. These rest unconformably upon metamorphosed limestones and shales, which have been invaded by a large intrusive body of granodiorite and small bodies and dikes

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2/ In Vanderburg, W. O., Reconnaissance of mining districts in Pershing County, Nevada: U. S. Bur. Mines Inf. Circ. 6902, p. 24, Oct. 1936.

of quartz monzonite. The tungsten deposits are scheelite-bearing masses of dark silicate rock that were formed from limestone by intense metamorphism at the granodiorite contact.

The Tertiary basalt flows and tuffaceous beds form the ridge culminating in Nache Peak, in the southwestern part of the district (pl. 2). Similar volcanic rocks cover nearly all of the southern half of the range, although even within the small area of the district, the layers vary in lithology and thickness. At Nache Peak, for example, eroded basaltic lava flows a thousand feet thick rest with slight unconformity upon a thousand feet of volcanic breccia, tuff, and tuffaceous conglomerate, whereas west of the Nightingale mine the clastic beds below the basalt are only 400 feet thick. (Compare sections C-C' and B-B', pl. 2.) Just west of the district basaltic flows and clastic beds are interlayered. The Tertiary rocks are separated from the underlying granitic intrusive bodies and metamorphosed sedimentary rocks by a major unconformity, the lowermost Tertiary beds apparently having been deposited upon a surface at least as rugged as the present one.

The granodiorite exposed in the eastern half of the district is the marginal part of an intrusive body which extends more than 15 miles northward and forms the northern part of the Nightingale Range. The granodiorite is a gray crystalline rock of medium grain, made up chiefly of the light-colored minerals plagioclase, orthoclase, and quartz. The plagioclase, which has a composition near $Ab_{70}An_{30}$ (oligoclase-andesine), is the most abundant mineral. Biotite and hornblende make up about 10 percent of the rock. The accessory minerals are apatite, sphene, and zircon, and there are minor quantities of the secondary minerals sericite, calcite, pyrite, chlorite, and epidote.

The granodiorite and the sedimentary rocks are cut by small dikes and irregular intrusive bodies of quartz monzonite and quartz diorite aplite and pegmatite. The dikes are locally known as "spar dikes."

The sedimentary rocks exposed in the northwestern part of the district and in a narrow strip in the south are part of a section of nearly vertical beds, of unknown thickness, which continues westward to Winnemucca Lake, a distance of about 4 miles. These are the oldest rocks in the district. They have been tentatively referred [3/] to the Triassic because lithologically they are similar to some of the fossiliferous Triassic rocks in the Eugene Range, which lies 80 miles northeast of Nightingale, but no fossils have been found in them.

The sedimentary rocks are mainly slaty shales, with interbedded crystalline limestones (see section A-A', pl. 2); one outcrop of cross-bedded quartzite was found just west of the district. The slaty rocks, where they are metamorphosed, grade into siliceous hornfels and mica schist, which are common near the granodiorite but also occur far from it. Near the granodiorite, the limestones grade into the silicate rocks which, in their most intensely metamorphosed parts, contain the tungsten ore bodies of the district.

Structure

The sedimentary rocks strike about N. 30° W. and dip between 75° E. and 75° W. Only in some isoclinal folds near the Nightingale mine and in a few similar but very small contortions elsewhere is there any deviation from this prevailing attitude in the district. The axes of the folds, and also the linear structures which are strongly developed in many of the beds, pitch about 75° NW. or SE. The closely spaced joints which are conspicuous in the rocks are directly related to bedding and linear structure, the three most regular sets being respectively (1) parallel to the bedding, (2) normal to the bedding and

3/ Hess, F. L., and Larsen, E. S., op. cit., p. 282.

parallel to the linear structure, and (3) normal to both bedding and linear structure.

The main granodiorite contact trends in general a little west of north, across the Triassic (?) beds at a small angle, though for short distances it runs either parallel to the beds or sharply across them. The downward course of the contact is probably about as irregular as the surface trace but is necessarily represented in simplified form on the accompanying geologic sections. The contact is nearly vertical at the Nightingale mine, where it has been reached by diamond-drill holes at depths as great as 350 feet (see pl. 5), and it seems to be equally steep in shallow workings elsewhere in the district.

The sedimentary rocks and the granodiorite contact are everywhere nearly vertical, and so, in general, are the tactite bodies. The large tactite body at the Nightingale mine is typical: It is tabular in shape and has granodiorite as one wall and barren light silicate rock as the other, and the direction in which it extends downward is usually determined by the dip of the granodiorite contact rather than by the dip of individual beds of limestone. North of the Nightingale mine, the Bureau of Mines trenches expose small tactite bodies formed from the altered ends of thin beds of limestone. These also are tabular, but they lie between adjoining beds of hornfels, which constitute the hanging and foot walls, and in plan they extend outward from the granodiorite, parallel to the bedding, for a distance determined by the width of the tactite zone. The dip of the bedding largely determines the direction in which thin beds like these extend downward.

Post-ore faults which displace the rocks a few feet are exposed in the mine workings and prospects, but no fault of large displacement was found.

Contact metamorphism

The limestones of the Nightingale district display features that are characteristic of such rocks in contact-metamorphic [4/] tungsten deposits. The limestones along the grandiorite contact are more or less altered to silicate rocks, dark silicates predominating nearest to the contact and light silicates farther away. Of these zonally distributed rocks, only the dark silicate material, or tactite,[5/] as it is commonly called, contains scheelite in any considerable quantity.

The limestone that is least metamorphosed is blue gray, white, or mottled. The rock is crystalline, and some contains grains up to a quarter of an inch in size, though some is fine-grained and chalky. The bedding is plainly marked at most outcrops by alternate fine and coarse layers, by colored bands, or by intervening slaty and hornfelsic layers. The limestone consists almost entirely of calcite, though much of it contains scattered needles of tremolite, and much of it is veined with calcite stringers.

The light silicate rock is, typically, pale green, fine-grained, and notably compact and hard. The distinctive minerals are tremolite and diopside, but calcite and quartz are also major constituents; the relative proportions of all these minerals vary widely. Grains of garnet, epidote, wollastonite, and pyrite are sparsely scattered throughout the rock.

The tactite is a dark green and brown, medium-grained, heavy rock which owes its color to plentiful epidote and garnet, although quartz is its most abundant mineral. One tactite body consists mainly of hornblende. All the tactite contains much

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4/ See Hess, F. L., and Larsen, E. S., op. cit., pp. 248-255.
"Pyrometasomatic," another term for deposits like these, designates the process by which they were formed.

5/ Hess, F. L., Tactite, the product of contact metamorphism: Am. Jour. Sci., 4th ser., vol. 48, pp. 377-378, 1919.
"Skarn," the older term for such rocks, is rarely used in Nevada mining districts.

calcite and pyroxene, more or less scheelite (the calcium tungstate ore mineral), some tremolite, a little pyrrhotite, molybdenite, chalcopyrite, arsenopyrite, and pyrite, and microscopic grains of titanite and apatite. All of these minerals are unevenly distributed, so that selected specimens of tactite may show great differences in mineral composition.

The epidote (clinozoisite?) appears pale green in hand specimens but nearly colorless in thin section. The garnet (pyrope-almandite, index 1.75-1.76) is pink or red, and transparent to opaque. Both minerals are of varieties low in iron, and the proportion of iron introduced during the process of alteration appears to have been rather small. The other silicate minerals in the tactite indicate addition of silicon, aluminum, magnesium, iron, sulfur, and tungsten.

The granodiorite next to the tactite is also somewhat altered, for it contains much pyroxene, epidote, and quartz, grains of sulfide minerals and some of calcite, and microscopic grains of apatite that are peculiar in having cloudy centers and clear margins. Apparently such apatite grains formed in two stages, for their centers are like the cloudy grains in the unaltered granodiorite, whereas their clear marginal parts resemble the clear apatite in the tactite. The aplitic dikes in the contact zone are also partly altered to quartz-epidote rock. All these minerals appear to have been formed after crystallization of the intrusive rocks, through addition of material by the same solutions that altered the adjacent limestone.

The solutions that appear to have been the essential agents of the process probably rose from a deep source, their route controlled by the structure of rocks in the contact zone and their most intense mineralizing effects localized in the chemically susceptible limestones. The tungsten introduced by these solutions was deposited almost entirely in the metamorphosed parts of the limestone, forming the ore bodies; in only a few places is there scheelite in the granodiorite, and none was seen in the dikes.

TUNGSTEN DEPOSITS

Introduction

The tungsten deposits of the district fall naturally into three groups: The first includes the largest deposits at the Nightingale mine in the center of the district; the second, a small group, is at the south end of the district, on the Garfield Force property and the High Grade claim; the third, which includes several shallow prospects, is at the north end of the district.

The deposits at the Nightingale mine have yielded about 12,000 tons of ore and the Garfield Force property about 2,000 tons.[6] This is practically all that has been mined in the district. The principal reserves of potential ore are at the Nightingale mine, and accordingly the sampling and diamond drilling of the Bureau of Mines in 1939-40 was confined to the mine and a small area nearby, a detailed map of which, prepared by Guild, forms plate 3. The salient features of the tungsten deposits are best exemplified at the Nightingale mine.

Nightingale mine

The Nightingale mine workings are near the eastern edge of sec. 25, T. 25 N., R. 24 E. All of this section is owned by the Gold-Silver-Tungsten Co., Inc., which also owns 2 patented claims adjoining the section on the east and holds 10 claims lying to the north. The mine camp is situated on one of the patented claims.

The mine workings include three tunnels, known as the Machine Shop, Ranson, and Lidstone tunnels, and a vertical shaft

6/ Estimated from dimensions of stopes.

connecting, at a depth of 128 feet, with a north-trending level about 500 feet long. The shaft is between the Machine Shop tunnel and the Ranson tunnel, and the 128-foot level extends under these tunnels. The Lidstone tunnel is 500 feet north of the shaft; it connects with a drift 280 feet long and with a caved winze which is said to extend down to a second, much shorter drift 30 feet below the tunnel level. Details of the workings are shown on the accompanying map (pl. 4).

Most of the mine workings were developed after 1929, when the Gold-Silver-Tungsten Co., Inc. acquired the property from Alex Ranson and his associates, who discovered the main deposit in 1917. Although a small tonnage of ore was mined in 1918,[7] most of the ore that has been mined was probably taken out after 1929, and treated in the mill constructed by the company.

The Nightingale mine workings are situated along a part of the principal granodiorite contact that trends north and thus obliquely transects limestone beds that strike, on the average, about N. 20° W. Both the granodiorite contact and the limestone beds dip steeply, and the tactite bodies that extend along the contact are nearly vertical. The limestone at the mine is thicker than at any other place in the district, but part of the apparent thickness is the result of isoclinal folding. The limestone beds to the north and south are thin and interlayered with hornfels and schist.

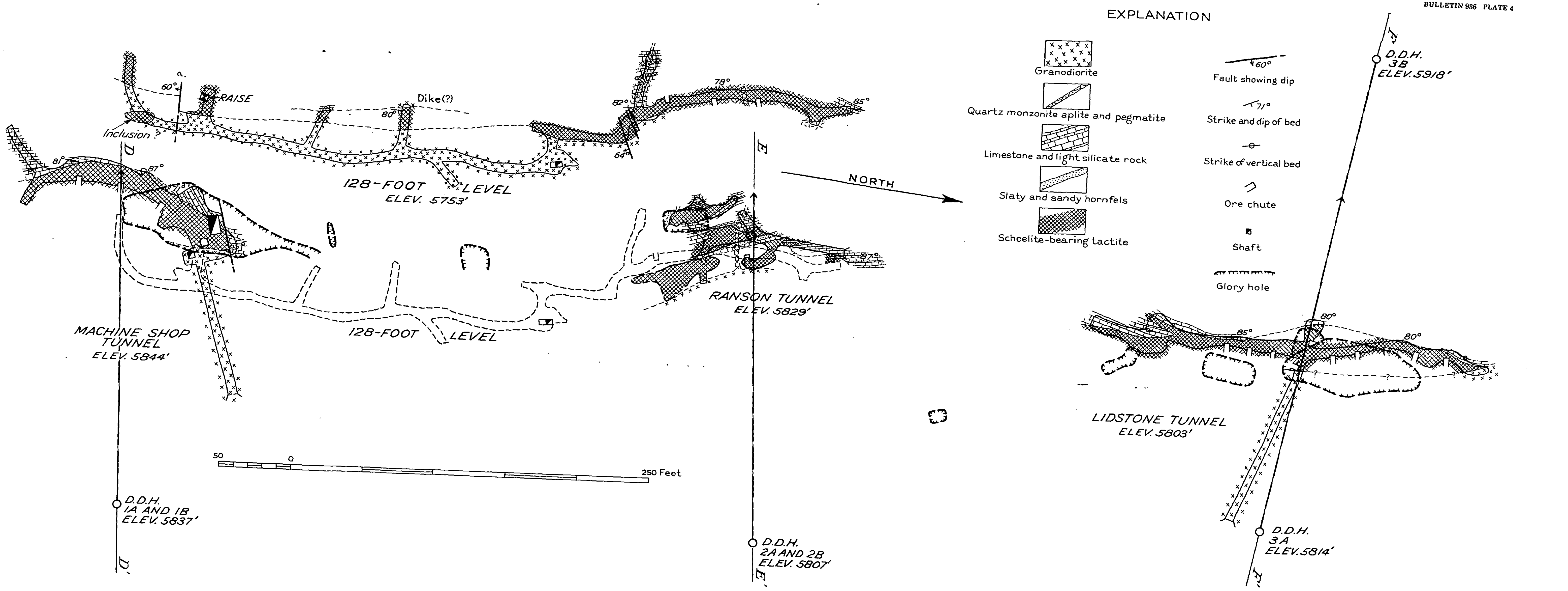
Irregular bodies of quartz monzonite are intrusive into the metamorphosed sediments close to the main granodiorite body, and aplite and pegmatite dikes cut both the sedimentary rocks and the granodiorite. Except for one body that cuts off the ore in a stope above the Ranson tunnel, the larger quartz monzonite bodies have not been encountered in the underground workings.

7/ Hess, F. L., and Larsen, E. S., op. cit., p. 282.

Character of the ore.--The ore is tactite, the mineralogy of which has been described. Texturally, the typical ore is granular, crystalline, and layered, although its layering is much less distinct than that of the limestone from which it was derived. The grains in typical ore are a quarter of an inch or less in diameter, though a few lenses contain much larger grains: scheelite crystals an inch across and epidote crystals 2 inches long were seen in one lens. Most of the disseminated scheelite grains are more or less equidimensional and show something of the characteristic pyramidal form of scheelite, but some are flat through having grown principally along bedding planes. The scheelite is white or cream-colored, with a glassy luster. Although it closely resembles the associated quartz and calcite in ordinary light, it is readily distinguished by its bluish-white fluorescence under ultraviolet light.

The richest specimens of scheelite are found in a few small lenses in the tactite that consist of very coarse grained quartz, epidote, and scheelite, with some calcite. One such lens seen in the north end of the 128-foot level of the main workings was not over a foot thick and perhaps 2 feet long. Another a foot thick and about 8 feet long was seen in the south end of the Lidstone tunnel. In these lenses, the scheelite is in imperfectly shaped crystals as much as an inch in diameter. The epidote crystals, which are generally well shaped, are as much as 1/4 inch in diameter and 2 inches long, and the quartz grains, which are less clearly defined, seem to be equally large. Although such lenses are rich in scheelite, there are too few of them to enhance appreciably the grade of the disseminated ore.

The disseminated ore consists of alternate fine-grained and coarse-grained layers, and in the layers there are differences in mineral composition, including differences in the amount of scheelite. A layer as much as a foot thick and containing on the average as much as 2 percent of WO_3 would be an exception-



GEOLOGIC MAP OF THE NIGHTINGALE MINE WORKINGS ally thick layer of high-grade tactite; most of the streaks rich in scheelite are much less than a foot thick, and as these alternate with leaner streaks the average grade through minable widths is low. The alternation of rich and lean streaks that are all commonly thin necessitates mining without much selection. Successive layers rich in one mineral or another have ill-defined gradational boundaries and uneven thicknesses. The layering is the result of metamorphism having followed original bedding closely but not exactly.

As a rule, the coarser the grain of the ore the greater its value. This is partly because coarse-grained tactite generally is of higher grade than the fine, partly because it can be milled with less loss of scheelite. Tactite is tough and hard, and as scheelite is one of its most easily crushed minerals the fine grinding necessary to free the most finely divided scheelite causes a relatively high loss in the slimes.

Localization of ore.--The scheelite is abundant only in tactite, which is limestone that has been altered at the granodiorite contact, and this well-known fact is the most useful guide in looking for ore. The proportion of scheelite in the tactite is far from uniform, but why some masses or parts of masses are richer than others is not understood. Possibly some large structural feature—curves in the beds or in the contact, for example—permitted the mineralizing solutions to circulate with especial freedom in some places and consequently caused especially abundant deposition of scheelite. Small structural and textural features such as joints, coarse grains, or fractured brittle minerals seem to have had little or no influence. Slight chemical or mineralogical differences in the original limestone may have influenced the deposition of scheelite, but they apparently have determined only minor details and not the larger pattern of distribution. In short, there apparently is no reliable guide to rich ore shoots within the tactite masses.

Grade and size of ore bodies.--Although small parts of some tactite bodies at Nightingale contain over 2 percent of WO_3, other parts contain none, and the average grade of large masses is probably less than 0.50 percent. If the largest tactite bodies were mined completely, without omission of their leaner parts, their average content of WO_3 would probably be about 0.25 percent. The foregoing estimates are based merely upon inspection, by ultraviolet light, of the tactite now exposed. No records of the grade of the ore that has been mined are available, and the assays of samples taken by the Bureau of Mines have not been published.

The size of the ore bodies that have been mined is indicated in the table that shows the dimensions of the largest stopes at the Nightingale mine. The maximum widths given in the table are not likely to be exceeded in any new ore body, for these stopes extend from granodiorite on one side to barren light silicate rock on the other, the full width of the tactite zone. Further mining might extend the horizontal lengths, because the stopes end in tactite, at least some of which seems to be as rich as any seen in the mine.

Dimensions of stopes at the Nightingale mine and approximate amount of ore mined.

Location of stope	Dimensions (in feet)				Approximate amount of ore mined (tons)
	Width		Length		
	Maximum	Average	Horizontal	Vertical	
Machine Shop tunnel.......	30	10	120	50	5,000
North end of 128-foot level........	15	7	70	80	3,000
South end of Lidstone tunnel.......	20	10	130	35	3,500

Diamond drilling has proved that the tactite extends downward 190 feet below the south end of the 128-foot level (see section D-D', pl. 5). Here the principal tactite zone is

20 feet thick, and two thinner layers are separated from it by light silicate rock. The tactite zone is 17 feet thick at a place 240 feet below the north end of the 128-foot level (section E-E'). The thickness of the ore at these depths encourages the hope that it may continue downward for some distance farther. The ore is apparently of the same general character as in the shallow holes and mine workings, with moderately rich layers separated by almost barren tactite.

Under the Lidstone tunnel the main ore zone is apparently pinched off by granodiorite at a depth of 160 feet (section F-F'). Several other narrow tactite zones were encountered there, but they seem to be of low grade. Drill holes along section G-G', 630 feet north of the Lidstone tunnel, also revealed several tactite zones separated by beds of hornfels. As the sections show, some pairs of holes were drilled at angles that would, theoretically, cause the holes to intersect. The marked differences in the cores at these theoretic intersections indicate that the holes were far from straight. Even if the holes were close together, some differences probably would arise from the lenticular layering or pinching of the limestones.

Lenticular tactite bodies are characteristic of the northern part of the Nightingale mine area, which decreases the chance of finding an important ore body there.

The same thick bed of limestone that forms the Lidstone and main ore bodies doubtless extends continuously, along the granodiorite, through the distance of 180 feet between them, and it probably is the most promising untested ground in the district.

Garfield Force property

The Garfield Force property lies at the southern end of the district, in the NW. ¼ sec. 31, R. 25 E., T. 25 N. The tunnel, from which 2,000 tons of ore was mined in 1938, is about a mile S. 10° E. of the Nightingale camp, at an altitude of 5,450 feet.

The tunnel is a 40-foot crosscut driven northeastward into a mass of tactite formed from vertical limestone which strikes N. 25° W. The granodiorite contact appears to be parallel to the bedding. The stope extends 50 feet along the contact and is 10 to 25 feet wide. The tactite now exposed through this width seems to contain, on the average, less than one-half of 1 percent of WO_3, but one 2-foot layer possibly contains as much as 1 percent. The grade of the ore that was mined is not recorded. The ore is mostly garnet and quartz, with the scheelite grains rather small in size.

The ore-bearing limestone layer cannot be traced closely on the surface; it seems to be cut off by granodiorite a short distance south of the tunnel stope, but it extends at least 1,000 feet northwestward. In the northwest part there are three shafts, the deepest about 40 feet in depth. The rock on the dump of one shaft is an unusual variety of tactite, composed mainly of dark green pyroxene with some garnet and specks of scheelite and molybdenite.

No estimate of potential tonnage can be given for this property because of the small amount of prospect work and the poor surface exposures. The apparently low grade of the ore now exposed is a discouraging feature.

North end prospects

There are several small prospects at the northern end of the district, 3,000-5,000 feet north of the Nightingale camp, all owned by the Gold-Silver-Tungsten Co. In this area thin beds of limestone are cut by a very irregular granodiorite contact at several places (pl. 2). The beds are only partly altered to tactite and, except at two places, they contain practically no scheelite.

One of the altered beds is on the Mammoth claim; it is prospected by two 25-foot shafts, 4,500 feet N. 20° W. of the Nightingale camp. The shafts are in a vertical layer, about 30 inches thick, of partly altered limestone that strikes N. 30° W. In the north shaft the layer contains scattered grains of scheelite, some of which are nearly an inch in diameter. The coarsely granular character of the rock makes any estimate of grade merely a guess, but the rock may contain as much as 1 percent of WO_3. The second shaft, 50 feet south of the first, exposes leaner tactite. The tactite from these shafts is distinguished by an abundance of well-formed pale-red garnets embedded in quartzose lenticular layers. Most of the rock is crystalline calcite; the amount of epidote is noticeably small. Although the layer is thin and the scheelite spottily distributed, the deposit seems worth further prospecting, with a reasonable hope of finding good ore.

The other deposit that contains considerable scheelite is 1,500 feet N. 60° W. of camp, where a trench about 60 feet long has been opened along a tactite mass, 5 to 10 feet wide, characterized by coarse garnets in quartz. Selected specimens were estimated to contain as much as 10 percent of scheelite, but the average grade of the body is undoubtedly low. The deposit is noteworthy because it lies 250 feet from the nearest outcrop of granodiorite. Possibly the intrusive rock extends westward below the deposit, or perhaps a fissure through the intervening hornfels allowed mineralizing solutions easy passage to the limestone mass.

The most northerly prospect of the group also lies on the Mammoth claim, about 750 feet N. 60° W. of the two shafts. It consists of an open cut 30 feet long leading to a 10-foot adit. The cut follows a garnetized layer 4 feet thick, which is part of a limestone bed that continues, unaltered, for 300 feet northwestward on the surface. In the adit, which was driven along the strike, the garnetized layer ends in granodiorite. No scheelite was seen in the garnetized rock, the garnet grains of which are remarkable for their size—some attain a diameter of 2 inches—and their concentrically layered structure.

About 4,500 feet N. 25° W. of camp and near the center of the Scheelite Extension claim, which adjoins the Mammoth claim on the south, there are two tunnels and a shaft in altered but barren limestone. The western tunnel is 30 feet long; it is in gray limestone and contains many thin layers of light silicate rock but none of tactite. The tunnel on the south is 20 feet long, and it curves inward, going from south to southwest, along contorted layers of light silicate and hornfels which are cut by several thin dikes of granodiorite. The shaft is about 40 feet deep and untimbered. The rock on its dump contains some garnet and epidote, and much quartz and calcite, but no scheelite. The limestone prospected by these workings extends northward about 600 feet to a shallow pit on the Mammoth claim.

On the Don claim, about 3,500 feet N. 30° W. of camp, there are three tunnels, all extending southwestward on partly altered limestone that strikes N. 45° E. and dips 55°-60° NW. The lowest tunnel is in dark silicate rock for its whole length of 50 feet; the silicate rock contains only a few specks of scheelite. The middle tunnel, 25 feet long, is in crystalline limestone containing sporadic clusters of garnet crystals and some layers of light silicate rock. Some coarse-grained epidote rock is on the dump. No scheelite was seen. The highest tunnel extends through a 30-foot mass of crystalline, garnet-bearing limestone and 60 feet of granodiorite, and ends in hornfelsic slate that strikes N. 40° W. and dips 55° SW. No scheelite was found in the rocks exposed.

A fourth tunnel on the Don claim, 300 feet west of the three just described, is in limestone that strikes N. 5° W. and dips 75° W. The limestone may be traced southward to the Nightingale mine area. The limestone also continues northward beyond the tongue of granodiorite, for more than a thousand feet.

RESERVES

Because it is unlikely that ore containing less than about 1 percent of WO_3 could be mined profitably in this district with the price of tungsten concentrates $25 per unit or less, the ore bodies are only of potential value at present.

The principal reserve of potential ore lies along the granodiorite contact between the south end of the Machine Shop tunnel and the north end of the Lidstone tunnel. The parts of the tactite above the 128-foot level of the mine may be regarded as partly developed ore. The diamond drilling by the Bureau of Mines indicated that additional ore lies below the 128-foot level, for the drill holes reach scheelite-bearing tactite 190 and 240 feet below the workings. The drilling was not extensive enough to do more than indicate that the tactite zone continues to more than twice the depth of the mine workings.

If the district contains any deposits larger or richer than those now exposed, it seems likely that they will be found in the segment of the contact zone partly tested by the Nightingale mine workings and the trenches and drill holes of the Bureau of Mines. The only ground near the workings that has not been tested already lies north of the main workings and under the south end of the Lidstone tunnel. The prevailing steepness of the contact encourages the hope that the ore bodies will not be cut off by intrusive granodiorite at shallow depths.

No reserves are developed in the prospects elsewhere in the district, but presumably small lots of ore would be mined from them if the Nightingale mill were running and using the ore. These prospects are all on small tactite bodies, and could not contribute many tons of ore.

In 1938 the reserves of the district were estimated as 50,000 tons of partly developed ore containing, on the average, less than 0.50 percent and perhaps as little as 0.25 percent

WO_3.[8/] The results of the subsequent tests of the principal ore body made by the Bureau of Mines in 1940 have not been published.

8/ Estimates of grade are based on inspection under ultraviolet light only.