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TIN-BEARING PEGMATITES OF THE TINTON DISTRICT LAWRENCE COUNTY, SOUTH DAKOTA

A PRELIMINARY REPORT

BY

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TIN-BEARING PEGMATITES OF THE TINTON DISTRICT, LAWRENCE COUNTY, SOUTH DAKOTA

A PRELIMINARY REPORT

By Ward C. Smith and Lincoln R. Page

ABSTRACT

The Tinton district, which is in the northern part of the Black Hills, Lawrence County, South Dakota, produced 105,039 pounds of tin between 1903 and 1927.

The oldest rocks in the district are pre-Cambrian quartz-mica, graphite, and hornblende schists, and pegmatite dikes injected parallel to the foliation of the schists or nearly so. The pre-Cambrian rocks are unconformably overlain by the sedimentary rocks of the Cambrian Deadwood formation. All these are cut by Tertiary intrusive rocks, divisible into three groups, which are, in order of age (1) monzonite and syenite porphyries intruding the pre-Cambrian schists as steeply dipping dikes and invading the Deadwood formation as flat-lying sills and laccoliths; (2) pseudoleucite- and nepheline-bearing dikes; and (3) lamprophyre dikes.

The deposits of potential tin ore are cassiterite-rich lenses in certain of the pegmatite dikes. The cassiterite appears to have formed contemporaneously with the oldest and most abundant variety of pegmatite, which is of magmatic origin. Several other varieties of pegmatite were formed as a result of successive replacements by solutions, and some of these contain tantalum and lithium minerals that have been mined.

Practically all the lode tin mined in the district has come from the Rough & Ready mine. On other properties only small deposits have been uncovered by prospecting. The probable reserves in ore bodies now partly developed in the Rough & Ready mine are estimated at about 215 tons of metallic tin. Inasmuch as the probable cost of mining and milling the ore would be more than twice the present market price of tin, the deposits cannot be mined commercially under present conditions.

INTRODUCTION

The Tinton district centers around the town of Tinton, on Nigger Hill, in western Lawrence County, S. Dak., less than a mile from the Wyoming boundary line (fig. 85). It is accessible by surfaced highway and gravel road from Lead, 25 miles east, and by gravel road from Spearfish, 23 miles north, but during the heavy winter snows and spring thaws the last 12 miles into Tinton are for short periods almost impassable. The district

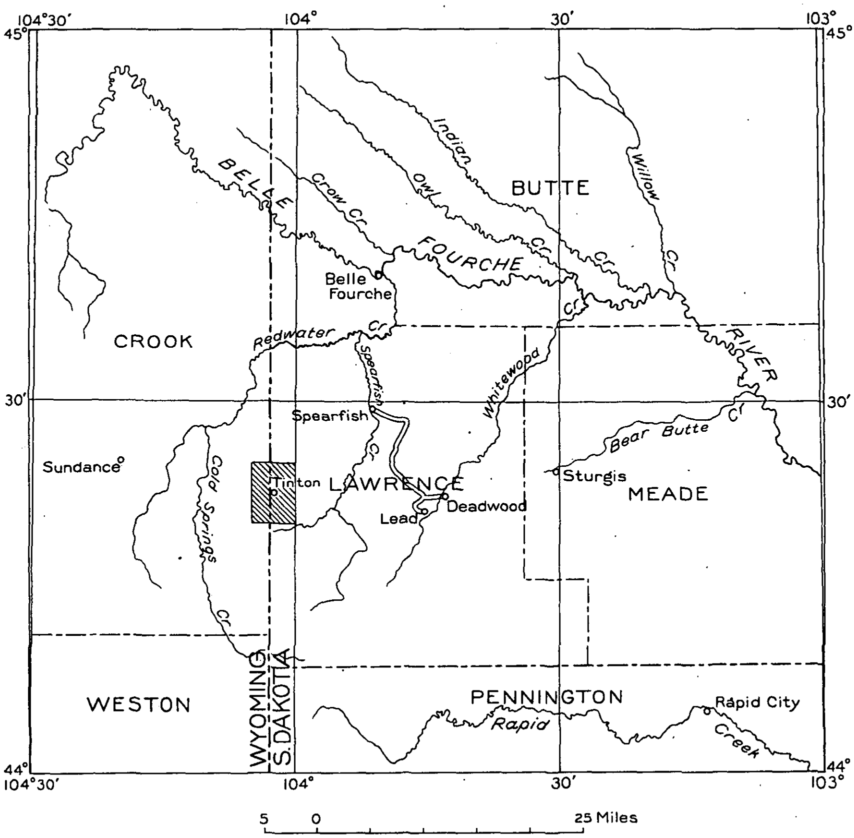

Figure 85.--Index map showing the location of the Tinton district, S. Dak.

covers a hilly area of 16 square miles. Geologically, it includes most of a minor uplift on the northwestern flank of the great Black Hills dome. The pre-Cambrian schists and pegmatites that are exposed in the central part of the area are cut by Tertiary intrusive rocks and are encircled by outward-dipping Paleozoic sedimentary rocks.

Gold, tin, and recently tantalum and lithium minerals have been mined in the district. In the gold placers located by the pioneers in 1876, cassiterite was soon identified, and its bedrock occurrence in pegmatite seems to have been known at least as early as 1886, when a sample lot of 6½ tons of tin ore is said to have been shipped.[1/] Interest in tin became lively in 1902 and 1903, when the tin excitement of the southern Black Hills was also at its peak; at that time the Nigger Hill district was thoroughly prospected and many claims were patented. In 1908 and 1909 the Tinton Reduction Co. shipped a few tons of ore from the area. During 1927 and 1928 the Black Hills Tin Co. built the present camp at Tinton, constructed and equipped a mill, and prepared for large-scale mining, but operations were almost immediately abandoned.

The amount of tin mined in the district since 1902 is shown in the following table.

Tin produced at Tinton, S. Dak.[1/]

Year	Company	Concentrates (short tons)	Tin		Value
			Percent	Pounds	
1903	Tinton Mining Co....	40	62.5	50,000	$14,000
1909	Tinton Reduction Co.	24	34.82	16,714	4,832
1910	........do..........	50	50	38,000	12,600
1927	Black Hills Tin Co..	.57	65	325	200
		104.57		105,039	$31,632

1/ U. S. Bur. Mines Rept. Inv. 3404, p. 1, 1938.

Tantalum was mined by the Fansteel Metallurgical Co. during 1936-38 from the Giant-Volney pegmatites just west of Tinton on a minor crest of Nigger Hill known as Tantalum Hill. The ore mineral is columbite, an iron and manganese columbate-tantalate. During the same period a few tons of amblygonite (lithium-aluminum fluo-phosphate) was mined and shipped.

1/ Hess, F. L., and Bryan, Barnabas, Jr., The pegmatites at Tinton, S. Dak.: U. S. Bur. Mines Rept. Inv. 3404, p. 1, June 1938.

The geologic features of the Tinton region were studied by Darton and Smith,[2] and their conclusions were published by the Geological Survey in 1905. As their base map was on a scale of 1:125,000 (approximately 2 miles to the inch), their geologic map is much generalized, but they described the rocks and the structure of Nigger Hill at considerable length. In 1938 Hess and Bryan [3] published a detailed description of the Tantalum Hill (Giant-Volney) pegmatite.

Because of its tin deposits, the Tinton district was examined by the Bureau of Mines and the Geological Survey during 1939 and 1940 as a part of their investigation of strategic mineral reserves. Gardner [4] in a report on a preliminary examination of the district described the principal tin prospects and estimated the tin reserves.

The areal geology of the Tinton district was mapped in 1939 by W. C. Smith, assisted by E. L. Griffin from May 17 to July 31 and by R. G. Wayland from July 6 to July 31. L. R. Page worked at Tinton from November 29, 1939, to June 30, 1940, in cooperation with the Bureau of Mines engineers who drilled and sampled the Rough & Ready and the Giant-Volney pegmatites. Page examined and interpreted the drill cores and sample cuts, and mapped in detail the area tested by the Bureau of Mines. The present preliminary report gives the results of the field work done by the Geological Survey but includes also estimates of reserves based on data obtained by the Bureau of Mines.

The writers are indebted to Mr. R. J. Beatty, Jr., and Mr. Earl Schulz, of the Black Hills Tin Co., for freely giving valued information and for providing quarters at the camp, and to Mr. James A. Noble, of the Homestake Mining Co., for helpful advice and for air photographs that were used in the earlier part

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2/ Darton, N. H., and Smith, W. S. T., U. S. Geol. Survey Geol. Atlas, Sundance, Wyo.-S. Dak., folio (No. 127), 12 pp., 1905.
3/ Hess, F. L., and Bryan, Barnabas, Jr., op. cit., 19 pp.
4/ Gardner, E. D., Tin deposits of the Black Hills, South Dakota: U. S. Bur. Mines Inf. Circ. 7069, pp. 47-71, April 1939.

of the mapping. They also wish to thank Mr. W. F. Jahn, of the Bureau of Mines, for constant cooperation during the detailed work, Mr. D. F. Hewett and Mr. W. T. Schaller, of the Geological Survey, for many valuable suggestions, and Miss Jewell Glass, also of the Geological Survey, for her assistance with mineralogical studies.

GEOLOGY

General stratigraphy and structure

The oldest rocks in the Tinton district (pl. 90) are pre-Cambrian quartz-mica schists, in part graphitic,[5] interlayered with hornblende schists, part of which were originally igneous rocks and part of which appear to have been sedimentary rocks. Intrusive into the schists are pre-Cambrian pegmatite dikes. Some of these contain cassiterite and some also spodumene, amblygonite, and columbite and consequently are of direct economic interest. The schists and pegmatites are unconformably overlain by the conglomerates, sandstones, and shales of the Cambrian Deadwood formation, and these in turn are overlain, conformably or nearly so, by younger Paleozoic limestones and shales. All the rocks are cut by Tertiary intrusive bodies. The oldest of these are monzonite and syenite porphyries, which cut through the pre-Cambrian schists and pegmatites as vertical or steeply dipping dikes and spread between the beds of the Deadwood formation as flat-lying sills or laccoliths. Pseudoleucite- and nepheline-bearing rocks were injected later, and dikes of biotite and augite lamprophyres last of all. The formation and rock names here used are taken from the Sundance folio; none of the rocks except tin ore specimens have been studied microscopically by the present authors.

5/ Darton, N. H., and Smith, W. S. T., op. cit., p. 1.

Pre-Cambrian rocks

Schists.--The pre-Cambrian schists are exposed in the central part of the Tinton area (pl. 90). A well-exposed section of them can be seen along Bear Gulch, and many masses of schist stand out along the sharper ridges, but in most of the area the schists are deeply weathered and their distribution must be traced by their characteristic dark micaceous or hornblendic soil.

The unweathered quartz-mica schists are fine-grained dark brown, gray, or black rocks that are distinctly layered and are easily split into thin plates. Quartz is generally the predominant mineral, but the proportion of quartz varies widely. Brown biotite is the principal mica, but sericite is common and green mica was seen in a few specimens. Some layers of graphitic quartz-mica schist grade into layers of graphite schist.

The hornblende schists are dark green to black and are composed chiefly of hornblende, with small amounts of plagioclase, quartz, and biotite. The bodies of hornblende schist that are believed to represent intrusive rocks contain considerable feldspar, are uniform in composition, and are rather coarse grained, particularly in their centers. Although the rock that constitutes these bodies splits readily, it is not layered, and its outcrops appear massive. Other bodies, which may originally have been sedimentary rocks, are interlayered with quartz-biotite schists; they are finer-grained and contain less plagioclase than the metamorphosed intrusive rocks.

The layering in the quartz-mica schist and in some of the hornblende schist and the foliation in all the schist, strikes from due north to N. 20° W. and dips 45°-70° W. In addition to schistosity, the schists have a well-defined linear structure that pitches 20°-45° NW. This linear structure is especially distinct in the hornblende schist, where it is marked by the alinement of elongated grains of hornblende.

Pegmatites.--The schist is cut by a great number of pegmatite dikes, which are easily recognized as coarsely crystalline white or gray rocks composed mainly of feldspars, quartz, and muscovite; they will be described in some detail on later pages. The dikes are a few inches to 300 feet wide and as much as 1,500 feet long. They are largest and most numerous north and northwest of Tinton, where they are well-exposed in many prospects along the crest of Nigger Hill. Being more resistant than the schists, they generally stand in slight relief, and even where weathering has been most thorough they may be traced by their characteristic float of coarse quartz and muscovite.

Nearly all the pegmatite dikes are parallel to the prevailing schistosity in both strike and dip; but some dip more steeply and a few more gently. The pegmatite bodies near Tinton are known to pitch northwest, more or less parallel to the linear elements in the schist, and this is probably true of many other dikes in the district.

Most of the pegmatite outcrops are long, narrow, and rather straight and appear to be sections of elongate bodies that pitch northwest. The outcrops of a few pegmatite bodies have a branching pattern, which may express either the divergence of offshoots from a principal mass or the coalescence of converging lenses. This branching pattern is well exemplified on the Rough & Ready and the Giant-Volney properties (pl. 91), where exploration has shown that it is not uncommon for one dike to divide and reunite or for several dikes to coalesce. In other places, groups of elongate lenses that are separate at the surface may connect below the surface to form larger masses; others may merely taper out at depth. The abundance and large size of the pegmatite dikes northwest of Tinton suggest that there was in that direction a source from which the pegmatitic material rose, following the direction of least resistance up the pitching structural lines of the schist. Pegmatite dikes, or their feeders, may thus converge northwestward and downward and coalesce at depths roughly comparable to the distances between the dikes on the present surface.

Paleozoic sedimentary rocks

The oldest of the Paleozoic sedimentary series is the Cambrian Deadwood formation, which is separated by an unconformity of the first magnitude from the schists and pegmatites and is overlain without marked unconformity by limestones of the Ordovician Whitewood and Carboniferous Englewood formations. The Deadwood formation, which is 300 feet thick and consists of conglomerate, sandstone, and shale, is prevailingly red or red-brown, the shale being darkest; and the soil derived from the formation also has a characteristic reddish color. Limestones of the younger formations are exposed in the extreme southeastern corner of the district, but on the geologic map (pl. 90) these are included with the Deadwood formation as undifferentiated Paleozoic rocks.

In striking contrast to the intensely metamorphosed steeply dipping schists, the Paleozoic strata are only locally metamorphosed and dip gently in all directions away from the Tinton area, which is in the center of a relatively small dome on the northwest flank of the Black Hills uplift.

Tertiary intrusive rocks

Monzonite and syenite porphyries.--The oldest and most abundant of the Tertiary intrusive rocks are monzonite and syenite porphyries. Wide dikes of these extend through the central schist area, which is bordered on the north, east, and south by nearly horizontal sills and laccolithic intrusions. Examples of dikes connecting with sills may be seen on Potato Creek. The porphyries are resistant to weathering and tend to form ridges, crests, and crags such as The Needles, 2 miles northeast of Tinton. The porphyries show considerable diversity of texture and mineral composition, but in general they are gray or gray green and contain numerous phenocrysts of light feldspar and black hornblende. The deeply weathered porphyry is covered with thin soil composed of yellow or brown granules of feldspar-rich rock but with none of the mica characteristic of the soils on the pre-Cambrian rocks.

Pseudoleucite- and nepheline-bearing rocks.--The bulk of Mineral Hill,[6] shown on the western margin of the Tinton topographic map, is made up of pseudoleucite- and nepheline-bearing rocks that range in composition from pyroxenite to syenite. These rocks are so complex in structure and so poorly exposed that no attempt was made to map the various types individually, and only the limits of the complex are outlined on the map (pl. 90). Outside the Mineral Hill area are a few thin dikes of pseudoleucite porphyry, distinguished from the monzonite porphyry dikes by equidimensional phenocrysts of pseudoleucite, but they are not shown on the geologic map of the district (pl. 90).

Lamprophyres.--Many lamprophyre dikes are shown on the detailed maps of the Rough & Ready and Giant-Volney claims (pls. 91 and 92), but as most of them are less than 2 feet thick only a few are shown on the map of the district (pl. 90). On weathering the typical lamprophyre breaks down into angular iron-stained dark-green to black blocks. Fresh surfaces of the rock show scattered crystals of biotite or augite and small round to oval patches of conspicuous white calcite in a fine-grained matrix.

Relation to pegmatites.--On the small-scale generalized geologic map and sections of the Sundance folio [7] the central

6/ See Darton, N. H., and Smith, W. S. T., op. cit., geologic map.
7/ Darton, N. H., and Smith, W. S. T., op. cit., p. 12 and geologic map.

part of the Nigger Hill uplift is represented as a flat-lying porphyry sheet in which are many inclusions of pre-Cambrian schists and pegmatites. It is suggested in the text, accordingly, that if the pegmatites are inclusions in the porphyry they may extend only to a limited depth. The larger-scale more detailed map in the present report (pl. 90), on the contrary, represents the country rock of the central area as consisting essentially of pre-Cambrian schists and pegmatites cut by many long porphyry dikes. Most of the large porphyry dikes, like those of pegmatite, follow the pre-Cambrian schistosity, and, although a few large dikes and many small ones cut across the schistosity and hence across the pegmatites, no large body of pegmatite seems to be wholly enclosed in porphyry. This was pointed out by Hess and Bryan,[8/] who concluded "that the pegmatites still stand on their own bases and that the depth to which they extend is not more than locally modified by the porphyries." This conclusion is obviously more encouraging to miners than the earlier view.

Quaternary deposits

Small patches of terrace gravel border Beaver Creek upstream from Beaver Crossing, and larger areas occur in Bear Gulch at Seventy Flats. Along the present stream channels are narrow strips of Recent wash.

Petrography of the pegmatites

General relations

A general description of the pegmatites seems indispensable to an understanding of the tin, tantalum, and lithium deposits, for the ores are inseparably linked with the pegmatites in origin. The dikes are composed of several varieties of pegmatite,

8/ Hess, F. L., and Bryan, Barnabas, Jr., op. cit., p. 3.

each representing a different stage in the alteration of a pegmatite that appears to have crystallized from a magma.[9] The effects of the altering solutions were not uniform. Some early-formed parts of the dikes remained unchanged, other parts were wholly replaced, and still others were replaced repeatedly. The total volume of pegmatite was increased, also, by deposition of new material. The tin ores are local concentrations of cassiterite formed during crystallization of the primary pegmatite. It is possible, however, that the magmatic pegmatite was not all formed at the same time--the cassiterite-bearing dikes, in particular, may have been injected at a time different from that of the dikes barren of cassiterite.

The description and interpretation that follow are based mainly on study of the large bodies of pegmatites on the Rough & Ready, Giant, and Volney claims, but they probably apply, wholly or in part, to other dikes in the district.

The minerals found in the pegmatites, and their approximate compositions are shown in the following list.

Minerals of the pegmatites

Major constituents:	
Oligoclase feldspar	sodium-calcium aluminum silicate.
Albite feldspar	sodium-aluminum silicate.
Microcline feldspar	potassium aluminum silicate.
Quartz	silica.
Muscovite	potassium aluminum silicate.
Ore minerals:	
Cassiterite	tin dioxide.
Columbite	columbate-tantalate of iron and manganese.
Spodumene	lithium-aluminum silicate.
Amblygonite	lithium-aluminum fluo-phosphate.
Minor constituents:	
Apatite	calcium-fluorine phosphate.
Tourmaline	boron-aluminum silicate containing magnesium and iron.
Beryl	beryllium aluminum silicate.
Lithiophilite	iron-manganese-lithium phosphate.

With respect to age the minerals may be classified in groups formed in the following order: (1) oligoclase-quartz-muscovite

[9] See Hess, F. L., and Bryan, Barnabas, Jr., op. cit., p. 3.

pegmatite, apparently containing cassiterite as a primary constituent, (2) tourmaline-bearing pegmatite and quartz-tourmaline veins, (3) albite-quartz pegmatite, (4) spodumene-quartz pegmatite, (5) amblygonite lenses, (6) columbite-quartz-albite lenses (7) microcline-quartz pegmatite, (8) albite-quartz-muscovite veinlets, and (9) quartz veins. This arrangement of the minerals in successive age groups is based principally on field observations of the textures of the pegmatites.

Oligoclase-quartz-muscovite pegmatite

Most of the dikes in the district consist of oligoclase-quartz-muscovite pegmatite--or, briefly oligoclase pegmatite--mixed with more or less albite-quartz and microcline-quartz pegmatite. Oligoclase pegmatite forms the bulk of the dikes in the Rough & Ready mine and the marginal part of the large Giant-Volney dike.

A typical dike has a border of fine-grained quartz and oligoclase and a foliated, coarse-grained middle in which abundant muscovite is mixed with the quartz, oligoclase, and minor minerals. In large dikes, the middle part is layered. Gradations between layers, some of them abrupt, occur along a dike as well as across it, so that the length and depth of a layer cannot be predicted in advance of exploration.

The layers differ in grain size or mineral composition or both. Grains in the coarser material are as much as several inches in length. In the fine-grained pegmatite, long, thin lenses of minerals are interlayered to form a gneissic rock that appears coarsely layered even though the individual grains within the lenses may be very small. Part of the fine-grained pegmatite seems to have been crushed and recrystallized. This was also noted by Darton and Smith.[10] The general mineral

10/ Darton, N. H., and Smith, W. S. T., op. cit., p. 4.

composition of a layer depends not only on the mineral composition within lenses but also on the relative number of lenses of definite composition, for example, quartz and oligoclase. Most layers differ from one another only in the relative proportions of main rock-forming minerals--oligoclase, quartz, and muscovite--but some are distinctive because they contain an unusual amount of a minor mineral, such as tourmaline or cassiterite.

The relative amounts of the minerals differ widely in various parts of the pegmatite. Oligoclase ranges from 5 to 95 percent, and quartz, the chief complementary mineral, has a similar range. Muscovite attains a maximum of 30 percent, but in most places it makes up less than 5 percent of the rock. Cassiterite is nowhere more than a minor mineral as compared with the chief constituents; the richest ore seen contains about 2 percent of cassiterite.

The quartz-rich layers and lenses in the pegmatite are relatively simple mineralogically. Oligoclase, muscovite, and a little apatite are the minor constituents everywhere present, and tourmaline is abundant in places. Cassiterite is sparse. The oligoclase-rich layers are more complex. In addition to quartz, muscovite, tourmaline, and apatite in various proportions, they contain minerals rare in the more quartzose material, and they contain most of the cassiterite, which is sufficient in some of the oligoclase rock, though not in all, to form potential ore bodies. Potash feldspar, apparently orthoclase rather than microcline, was seen with oligoclase in two thin sections; further study is necessary to determine its relations. Many stubby grains of amblygonite an inch or two long are thinly coated with small muscovite flakes and stained with an unidentified blue alteration product. Columbite accompanies the cassiterite. Beryl is the rarest mineral. One cluster of white beryl crystals associated with much tourmaline, cassiterite, columbite, and spodumene was found in oligoclase pegmatite in the main adit of the Rough & Ready mine. Hess and Bryan [11] reported a single crystal from the Giant-Volney pegmatite. The mineral probably is a product of late replacement. Albite-quartz pegmatite and spodumene-quartz pegmatite form thin lenses in the oligoclase pegmatite.

Tourmaline-bearing pegmatite and quartz-tourmaline veins

The place of tourmaline in the pegmatite sequence is uncertain. In the oldest pegmatite are scattered crystals of tourmaline, and tourmaline forms as much as 30 percent of a few layers. It also occurs in albite-quartz pegmatite. Along contacts between dikes of primary oligoclase pegmatite and quartz-mica schist at the Rough & Ready mine tourmaline is abundant both in narrow and irregular selvages of the dikes and in the adjoining schist. Tourmalinization here might seem to have been effected by the pegmatite. The fact, on the other hand, that quartz-tourmaline veins an inch or two thick cut the pegmatite indicates that at least part of the tourmaline is later. Possibly some of the tourmaline concentrations in the primary pegmatite are products of replacement. The tourmaline in the selvages of the dikes is brown schorlite and that in the middles is blue indicolite; this may or may not mean that there are two different generations of tourmaline.

Albite-quartz pegmatite

Large masses in the complex pegmatite on the Giant-Volney claims and many lenses in dikes of oligoclase pegmatite elsewhere consist of albite-quartz pegmatite, in which cassiterite, tourmaline, apatite, and fine-grained muscovite occur as minor constituents.

11/ Hess, F. L., and Bryan, Barnabas, Jr., op. cit., p. 18.

Albite and oligoclase were first distinguished microscopically. The oligoclase is seen in thin sections to be concentrically zoned, having cores of $Ab_{83}An_{17}$ and rims of $Ab_{90}An_{10}$. The albite grains are unzoned, and their composition is near $Ab_{95}An_{5}$. After the first identifications had been made microscopically, it was found possible to distinguish the albite-bearing rocks from the oligoclase-bearing rocks megascopically in the Rough & Ready and Giant-Volney pegmatites, which were examined in detail. The albite-quartz pegmatite is finer-grained than the oligoclase-bearing pegmatite, and its minerals are intimately intergrown rather than separated in layers, although the rock shows an indistinct layering, evidently a vestige of the gneissic structure of the oligoclase-quartz-muscovite pegmatite that it replaced. These field characteristics cannot be relied upon in other pegmatites without preliminary microscopic tests. A few such tests have shown that both oligoclase and albite are widespread in the district, but it was impracticable to work out the details of their distribution.

Spodumene-quartz pegmatite

Spodumene-quartz pegmatite forms a large body near the middle of the Giant-Volney pegmatite dike and scattered lenses in the Rough & Ready dikes. Spodumene-quartz pegmatite at the Giant-Volney claims has plainly replaced earlier pegmatite. It is predominantly a fine-grained intergrowth, indistinctly layered like the albite-quartz rock, from which it is distinguished by an intricate criss-cross pattern of spodumene-quartz and quartz veinlets. Minor portions preserve in varying degrees the coarse texture of the oligoclase-quartz-muscovite pegmatite and contain large relict crystals of muscovite and plagioclase.

Amblygonite lenses

Lenses of amblygonite several feet thick have been mined in the Giant-Volney pegmatite. They are recognizable by the cleavage faces of larger crystals and by their envelopes of fine-grained muscovite, identical in character with those surrounding the small stubby grains of amblygonite in the Rough & Ready pegmatite. The largest mass appears to have been more than 20 feet long and 4 to 8 feet thick. It lay at the west margin of the glory hole, between spodumene-quartz rock and oligoclase pegmatite. The location of other masses is indicated on the detailed geologic map (pl. 91). Hess and Bryan [12/] pointed out that some spodumene accompanies each amblygonite mass, and they believed that the amblygonite was formed by replacement of spodumene. The small amblygonite grains scattered through the oligoclase pegmatite of the Rough & Ready mine probably were also formed by replacement, although they were not observed to be everywhere associated with spodumene.

Columbite-quartz-albite lenses

Irregular lenses of columbite-quartz-albite rock containing clusters of columbite crystals as much as 3 inches long were mined from the Tantalum Hill glory hole and underground workings in 1936. Underground examinations could not be made because the workings were flooded, but one lens seen in the glory hole appears to have been formed by replacement of spodumene-quartz pegmatite. Hess and Bryan [13/] reported that columbite is concentrated in a set of northwest-striking cracks in spodumene-quartz pegmatite and that masses of columbite replace that rock as well as microcline and amblygonite.

12/ Hess, F. L., and Bryan, Barnabas, Jr., op. cit., p. 15.
13/ Idem, p. 16.

Microcline-quartz pegmatite

Microcline-quartz pegmatite forms a body 400 feet long and 100 feet wide in the Tantalum Hill dike and relatively small masses in other pegmatite dikes. The microcline, which is the dominant mineral, contains irregular blebs of quartz and is cut by tiny veinlets of albite. Because of the disagreeable odor that some of it emits when broken, Hess and Bryan [14] referred to it as fetid microcline or necronite. The structure of the microcline-quartz rock appears relatively simple, because the crystal cleavage of the microcline is uniformly oriented for distances as great as 6 feet.

Layered structure apparently inherited from the older pegmatite that had been replaced was seen in a few places, but the best evidence for the late formation of some of the microcline is that its cleavage, in masses exposed on Tantalum Hill, locally cuts across the layers of albite-quartz and spodumene-quartz pegmatite. It is possible, however, that a large part of the microcline-quartz aggregate on Tantalum Hill did not replace old pegmatite but is a new body added to the older parts of the dike. Small amounts of microcline in other pegmatite bodies may have an earlier place in the sequence of pegmatite development.

Albite-quartz-muscovite veinlets and quartz veins

Tiny veinlets made up of albite, quartz, and muscovite cut all the pegmatite minerals, and they in turn are cut by quartz veins, which represent the final products of the mineralizing solutions.

Summary

The probable order in which the several varieties of pegmatite were formed and the distribution of minerals among the varieties are shown in the following table.

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[14] Hess, F. L., and Bryan, Barnabas, Jr., op. cit., p. 8.

Sequence of pegmatite varieties and distribution of minerals among the varieties 1/

	1	2	3	4	5	6	7	8	9
Oligoclase..........	N	...	...	...	...	...	...	...	...
	...	...	R	...	...	...	...	...	...
	...	...	N	...	...	N	...	N	...
Albite..............	...	...	...	R	...	...	R	...	...
	X	...	...	X	...	...	X	...	...
	...	...	...	...	...	...	N	...	...
Microcline..........	...	...	...	...	...	...	...	...	...
	X	...	...	...	...	...	...	...	...
	N	N	N	N	N	N	N	N	N
Quartz..............	...	...	R	R	R	...	R	...	...
	X	...	X	X	X	...	X	...	...
	N	...	N	...	...	...	...	N	...
Muscovite...........	...	...	R	R	...	...	...	...	...
	X	...	X	X	...	...	X	...	...
Cassiterite.........	N	...	...	...	...	N?	...	...	...
	...	...	R	R	...	R?	...	...	...
	N?	...	N?	N?	...	N	...	...	...
Columbite...........	...	...	...	...	...	...	...	...	...
	X	...	X	X	...	...	...	...	...
	...	...	...	N	...	...	...	...	...
Spodumene...........	...	...	...	...	...	...	...	...	...
	X	...	X	...	...	...	...	...	...
	...	...	...	...	N	...	...	...	...
Amblygonite.........	...	...	...	...	...	...	...	...	...
	X	...	X	X	...	...	...	...	...
Lithiophilite.......	X	...	...	...	...	...	...	...	...
	N	...	N	...	...	...	...	...	...
Apatite.............	...	...	R	...	...	...	...	...	...
	X	...	...	...	...	...	...	...	...
	N?	N	N	...	...	...	...	...	...
Tourmaline..........	...	...	R	...	...	...	...	...	...
	X	...	...	...	...	...	...	...	...
Beryl...............	X	...	...	...	...	...	...	...	...

1/ The numbered columns correspond to the varieties of pegmatite, arranged in order of formation. N designates minerals newly formed at the stage represented by the corresponding variety of pegmatite, R, minerals that are probably relict, and X, minerals that may have been formed later by replacement.

1. Oligoclase-quartz-muscovite pegmatite.
2. Small quartz-tourmaline veins.
3. Albite-quartz pegmatite.
4. Spodumene-quartz pegmatite.
5. Amblygonite lenses.
6. Columbite-quartz-albite lenses.
7. Microcline-quartz pegmatite.
8. Albite-quartz-muscovite veinlets.
9. Quartz veins.

As indicated by the symbols, each variety includes not only its own characteristic minerals but also minor quantities of relict minerals and minerals possibly introduced by replacement after the main body of the rock was formed.

The primary constituents of the oldest pegmatite appear to be oligoclase, quartz, muscovite, cassiterite, apatite, and perhaps tourmaline. Movements in the partly crystallized material produced foliation, uneven distribution of minerals, and local granulation. The rock also contains albite, spodumene, amblygonite, lithiophilite, columbite, and microcline, but inasmuch as all except lithiophilite are known to have been abundantly formed elsewhere by replacement, their presence here may be a result of the same process. These minerals are concentrated in oligoclase-rich rather than quartz-rich rock, probably because oligoclase was more susceptible to replacement than the other original minerals. Much of the quartz also may be of replacement origin. The minerals in the cassiterite-rich lenses that constitute the potential ore bodies are unevenly distributed, partly because of original unevenness of distribution and partly because of uneven replacement.

MINERAL RESOURCES

Cassiterite, columbite, and amblygonite have been mined from the Tinton pegmatites, which also contain potentially valuable spodumene, albite, and microcline. Cassiterite is of chief interest here, and the other minerals are considered only insofar as they are associated with cassiterite and as they affect the value of potential tin ore bodies.

Distribution of cassiterite

All major attempts to mine tin have been directed to the primary deposits in the pegmatite dikes, although some tin concentrates have been recovered from stream gravels as a by-product of gold placer mining. Few dikes in the district contain enough cassiterite to be potential sources of tin. Although the authors saw about 240 pegmatite dikes during their areal mapping, they found cassiterite in only about 40. In many of these there are only a few scattered grains, but possibly a dozen contain local concentrations of cassiterite in layers or lenses. Although these deposits are not minable at a profit under present conditions they constitute a possible future source of tin. They may thus be called potential ore bodies--or, for brevity, simply ore bodies, with the understanding that the term is employed in this liberal sense. The richest of these bodies is in oligoclase-quartz-muscovite pegmatite; others are in tourmalinic pegmatite and albitic pegmatite.

The principal reserves of potential ore are in large dikes at the Rough & Ready mine (pl. 91), where three ore bodies are partly blocked out. A small deposit is now being prospected on the property of the Dakota Tin & Gold Co. The Spearfish claim was unsuccessfully prospected in 1934. All other properties known to contain some tin have been inactive for many years.

Localization of cassiterite

The ore deposits are found only in pegmatite; none is known in the older schist and none in the younger porphyritic intrusives. Most of the cassiterite-bearing pegmatite dikes lie along the crest of Nigger Hill or east of it, but a few dikes in the headwaters of Cummings and Roena Gulches, west of Nigger Hill, are also cassiterite-bearing.

The one general rule that appears to hold for the localization of the ore within a pegmatite body is that all the cassiterite-bearing lenses or layers have the same strike, dip, and pitch as the body. They occupy various positions relative to the walls of the dikes: the largest one in the Rough & Ready is near the hanging wall, but others are near the footwalls or in the middle parts of dikes. These potential ore bodies have irregular boundaries and grade in all directions into lean or barren pegmatite. It seems impossible, therefore, to predict the dimensions of an ore body or its probable grade in advance of exploration.

Associations of cassiterite

The dark brown cassiterite occurs in grains and clusters of grains as large as 2 inches in diameter though much is in small grains known as "pepper tin." Well-formed crystals are rare; the best-formed are among the smallest. Nearly all the grains are so crushed that they readily fall out of specimens, and many are traversed by tiny quartz-albite-muscovite veinlets. In the oldest pegmatite the cassiterite appears to accompany oligoclase rather than quartz, muscovite, or tourmaline--two of the three ore bodies at the Rough & Ready mine, for example, are in oligoclase-rich pegmatite--yet much of the oligoclase-rich rock contains little cassiterite. Although both muscovite and cassiterite are conspicuous in some coarse-textured pegmatite, suggesting that coarse muscovite is an indicator of tin ore, assays prove that the tin content is higher in fine-grained pegmatite containing inconspicuous "pepper tin" and little muscovite.

Although one ore body in the Rough & Ready mine contains abundant tourmaline, the amounts of tourmaline and cassiterite vary independently. Neither the tourmaline-bearing selvages of certain dikes nor the adjacent tourmalinized schist contain cassiterite. Tourmaline is so widespread, however, that some is present wherever cassiterite is found.

In the cassiterite-bearing bodies the most common and abundant material formed by replacement is albite-quartz pegmatite. The Rough & Ready ore contains many albite-quartz lenses, and the ore at the Dakota Tin & Gold Co. mine consists chiefly of fine-grained albite-quartz pegmatite. Other cassiterite-bearing pegmatite dikes not studied in detail contain both oligoclase and albite. The masses of replacement spodumene and amblygonite in the Giant-Volney pegmatite contain little cassiterite. Some spodumene and amblygonite, as well as columbite, tourmaline, and beryl, are associated with cassiterite in one ore body at the Rough & Ready mine.

Cassiterite and columbite are closely associated in all the Rough & Ready ore bodies and also in dikes as far distant as the Jersey claim, 1½ miles to the south, and the Yeddo claim, half a mile to the north. Thin sections of the tin ore from the Rough & Ready mine show that columbite is present not only as large grains identifiable in hand specimens but also as innumerable tiny specks within cassiterite crystals. This suggests that a little columbite formed early in the pegmatite period, along with the bulk of the cassiterite. The richest tin ore, however, contains relatively little columbite, as is shown by the following analysis of a composite sample of concentrates from the Rough & Ready mine, cited by Gardner.[15/] The Giant-

Tin oxide	66.36	Calcium oxide	1.85
Iron sulphide	7.97	Niobium and tantalum oxide	3.00
Alumina	9.49	Tungstic acid	Trace
Manganese oxide	.89	Potassium and sodium oxide	1.4
Silica	6.70		99.07
Zinc oxide	1.41		

Volney tantalum ore, moreover, contains relatively little cassiterite; the hand-sorted and milled concentrates shipped during 1936-38 averaged only 17 percent of tin.[16/] Some cassiterite had been taken out during milling,[17/] but this may be approximately offset by cassiterite that fell in from the cassiterite-bearing oligoclase pegmatite which forms the hanging wall of the Giant-Volney glory hole. As no thin sections of the Giant-Volney

15/ Gardner, E. D., op. cit., p. 51.
16/ Beatty, R. J., personal communication.
17/ Gardner, E. D., op. cit., p. 59.

tantalum ore have been made, the genetic relations of the minerals therein are unknown. It is thus uncertain whether any cassiterite was formed as late as the period of maximum columbite deposition.

The mineral associations suggest that the cassiterite crystallized abundantly during one stage in the solidification of the earliest pegmatite but that the fine-grained borders of the dikes solidified too early and the quartz-rich parts too late to include much cassiterite. The crystallization of oligoclase began before that of cassiterite and continued later, so that oligoclase not only is present in the ore but also makes up lean or barren material that solidified in part before, in part after, all or most of the cassiterite. The fact that the ores were originally rich in oligoclase made them susceptible to replacement by albite, spodumene, amblygonite, microcline, and perhaps tourmaline and columbite.

As the replacement minerals spodumene, amblygonite, columbite, and to a less extent, albite are commercially valuable, their presence in a tin ore body would enhance its value if a milling process could be devised to concentrate each mineral separately. The advantage of saving these minerals would be greater if the dikes were mined from wall to wall than if the tin-rich parts alone were mined, for in general the pegmatite rich in tin contains only small amounts of these replacement minerals and, conversely, the concentrations of spodumene, amblygonite, and columbite contain relatively little cassiterite. The addition of albite, spodumene, and amblygonite to a cassiterite-bearing pegmatite dike is of economic importance only insofar as these minerals replace less valuable oligoclase and only if they are saved; if so much material is added that the volume of the dike is increased, the ore is of course diluted with respect to its tin content.

Reserves

The only ore bodies in the district that have been sufficiently tested to establish their grade and size are in the Rough & Ready mine. As the pegmatites have a wide range in tin content, estimates of reserves will vary, depending on the minimum grade that is included as potential ore. What is probably more important in such ores as those at Tinton is the interpretation, based on geologic data, of the possible extension of partly developed ore bodies.

The results of sampling and exploration conducted by the Bureau of Mines indicate a reserve above the 135-foot level of about 68,000 tons of tin-bearing pegmatite containing an average of 6.33 pounds of tin to the ton.[18/] Details of the assay data and other pertinent information obtained by the Bureau of Mines have not yet been published, but figure 88 shows approximately the outlines of the richest parts of the tin-bearing pegmatite in the Rough & Ready mine. None of these bodies can be mined profitably for their tin content under present economic conditions. Gardner's data [19/] on the cost of mining and milling indicate that if the Rough & Ready property was operated at the capacity of the mill, or 150 tons a day, the tin produced would cost $1.03 a pound. The average price of tin during 1939 was 50.323 cents a pound.

Work done elsewhere in the district indicates that no other deposits approach the Rough & Ready as possible sources of tin. No reserves are blocked out, but small lots of ore would probably be mined if the Rough & Ready mine was operating, and Gardner [20/] estimates that they would add about 10 percent to the reserves of the district.

18/ Calculated by W. F. Jahn.
19/ Gardner, E. D., op. cit., p. 53.
20/ Idem, p. 71.

It seems unlikely that important new ore bodies will be discovered in the district by surface prospecting, because cassiterite, which is well known and easily recognized, has been sought in the pegmatites for many years. Considering the large

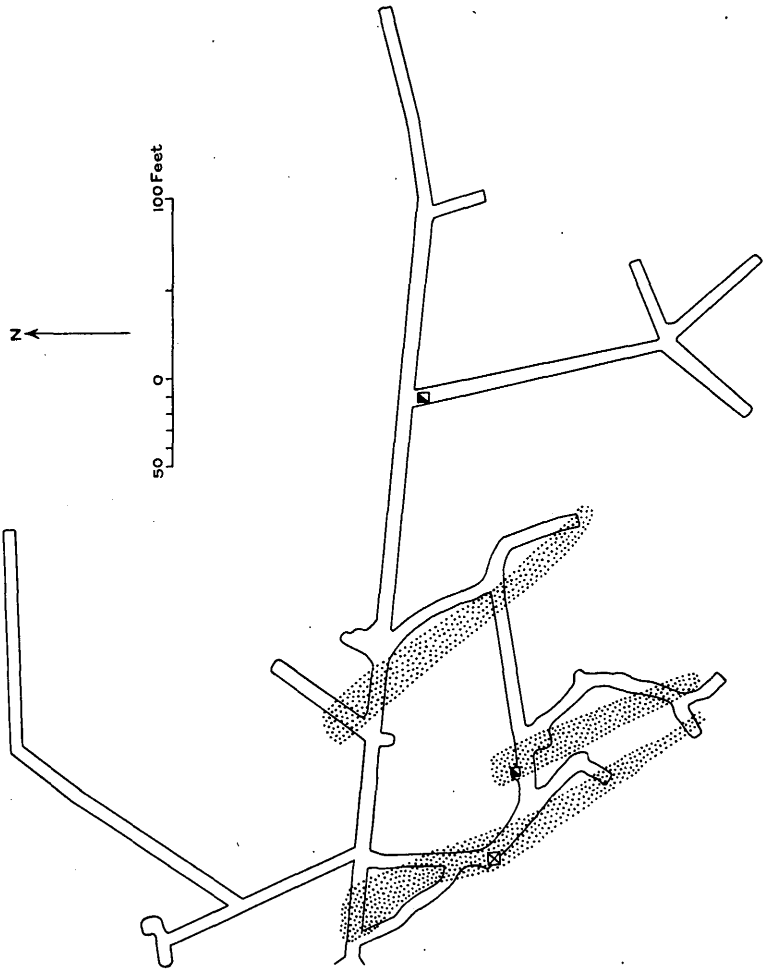


Figure 88.—Plan of the Rough & Ready mine, showing the parts of the pegmatite richest in tin.

number of the dikes exposed and prospected, the surface showings presumably indicate what the pegmatites contain at depth. Whether deeper tests of known deposits will develop any large ore bodies or reveal high-grade ore in bodies that are lean at the surface is unpredictable.

Mines and prospects

Practically all the tin-bearing pegmatites in the Tinton district are covered by patented claims. More than 100 claims, totaling about 2,700 acres, are held by the Black Hills Tin Co., which also owns the buildings at Tinton, mining equipment, and a mill equipped to treat 150 tons of ore a day. Groups of claims are held by the Dakota Tin & Gold Co., Mrs. George White, the Connors Tin Production Co., the Bear Gulch Mining Co., and A. J. Johnston and associates. Outstanding in the district are the tin deposit on the Rough & Ready claim and the tin, tantalum, and lithium deposits on the Giant-Volney claims, all of which belong to the Black Hills Tin Co. The Spearfish claim, one of the smaller prospects belonging to the Black Hills Tin Co., was prospected in 1934, and the Dakota Tin & Gold Co. claims were being developed when the writers were at Tinton in 1939 and 1940. No work of importance has been done on other claims for many years.

Rough & Ready mine

The Rough & Ready mine, of the Black Hills Tin Co., is at the center of the district, just west of Tinton. Practically all the lode tin that has been mined in the district has been taken from this property. The mine produced 14,330 tons of ore, which yielded 104,987 pounds of metallic tin, prior to 1910,[21] but only 325 pounds of tin has been mined since then.[22] The latest development work by the company was done in 1928, when a large steam-shovel cut was excavated west of the mine portal in preparation for open-cut mining. In 1939 and 1940 the Bureau of Mines sampled the mine and explored the ground below it with diamond-drill holes totaling 4,000 feet in length.

21/ Gardner, E. D., op. cit., p. 50.
22/ Hess, F. L., and Bryan, Barnabas, Jr., op. cit., p. 1.

The principal development has been on the adit level (pl. 92). The adit is 540 feet long, and from it branches 1,400 feet of crosscuts and drifts. Sixty feet below the adit level is a drift 200 feet long, known as the winze level, reached through a winze from the No. 0 South drift (fig. 86). Twenty-eight feet below the adit is the so-called intermediate level, a crosscut 130 feet long, which is connected with the No. 3 South drift and the surface through the 155-foot Allie shaft (fig. 87).

The mine workings encounter pegmatite and hornblende and quartz-mica schists, which are cut by many lamprophyre dikes and several dikes of monzonite porphyry. A steep fault that strikes N. 70° W. through the workings displaces the rocks 25 feet horizontally, and there are smaller faults and breccia zones at several places. All the rocks contain more or less pyrite, a product of hydrothermal mineralization that occurred later than the intrusion of the lamprophyres.

The tin deposits are in a group of pegmatite dikes that converge southward to form a single body on the Giant-Volney claims. As shown on the geologic map of the claims (fig. 86), none of the separate dikes on the north is more than 75 feet wide, but the southern pegmatite body attains a maximum width of 400 feet. Other noteworthy features of the pegmatites shown on the map are (1) the alternation of dikes and schist at the Rough & Ready glory holes, (2) the termination of dikes that taper north and south of the Rough & Ready mine, (3) the variations in thickness along the dikes, and (4) the abrupt termination of the wide Giant-Volney pegmatite mass on the south. For convenient reference, the dikes on the north are lettered in sequence, beginning with A on the west. To the south, the dikes merge into thick bodies that cannot be subdivided on the map.

The tin ore is concentrated in three bodies. The largest extends from the mine portal southward and is explored by the No. 0 South drift and by the drift at the winze level. It is

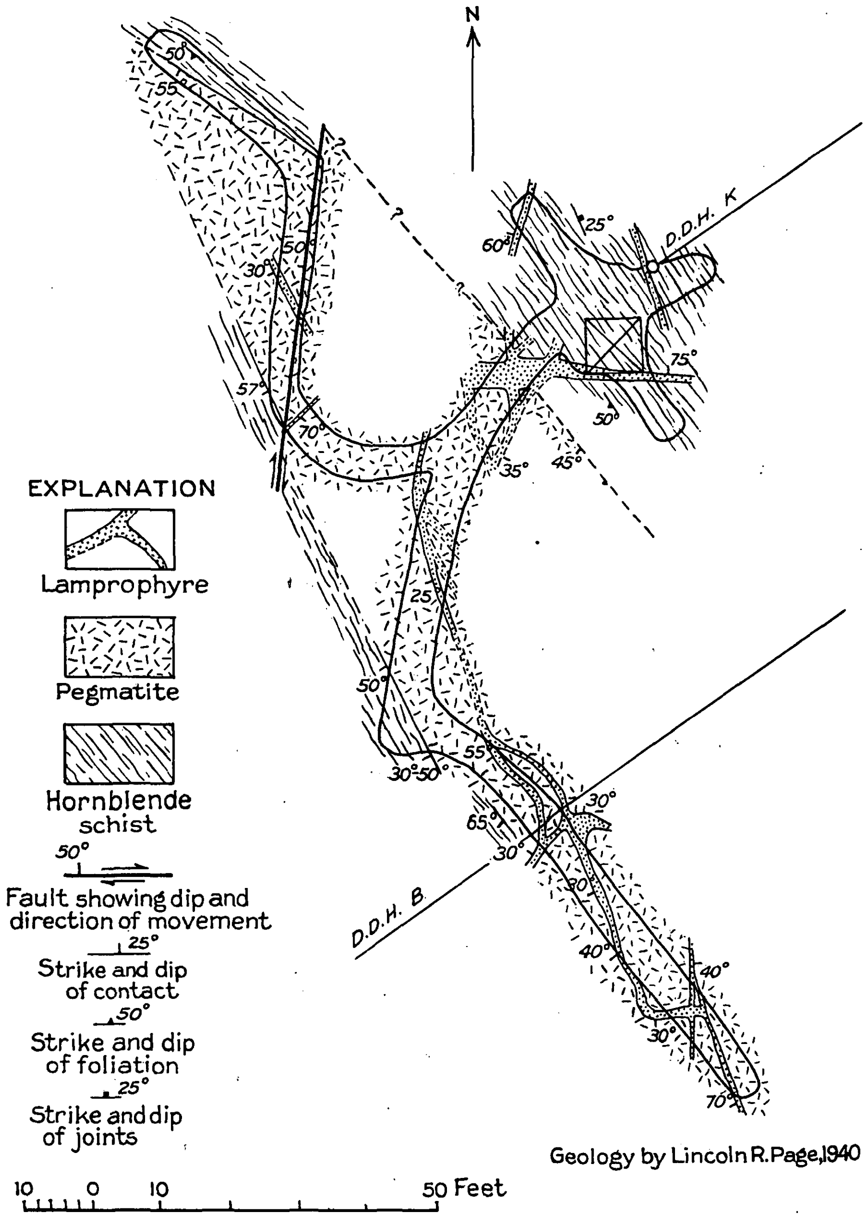
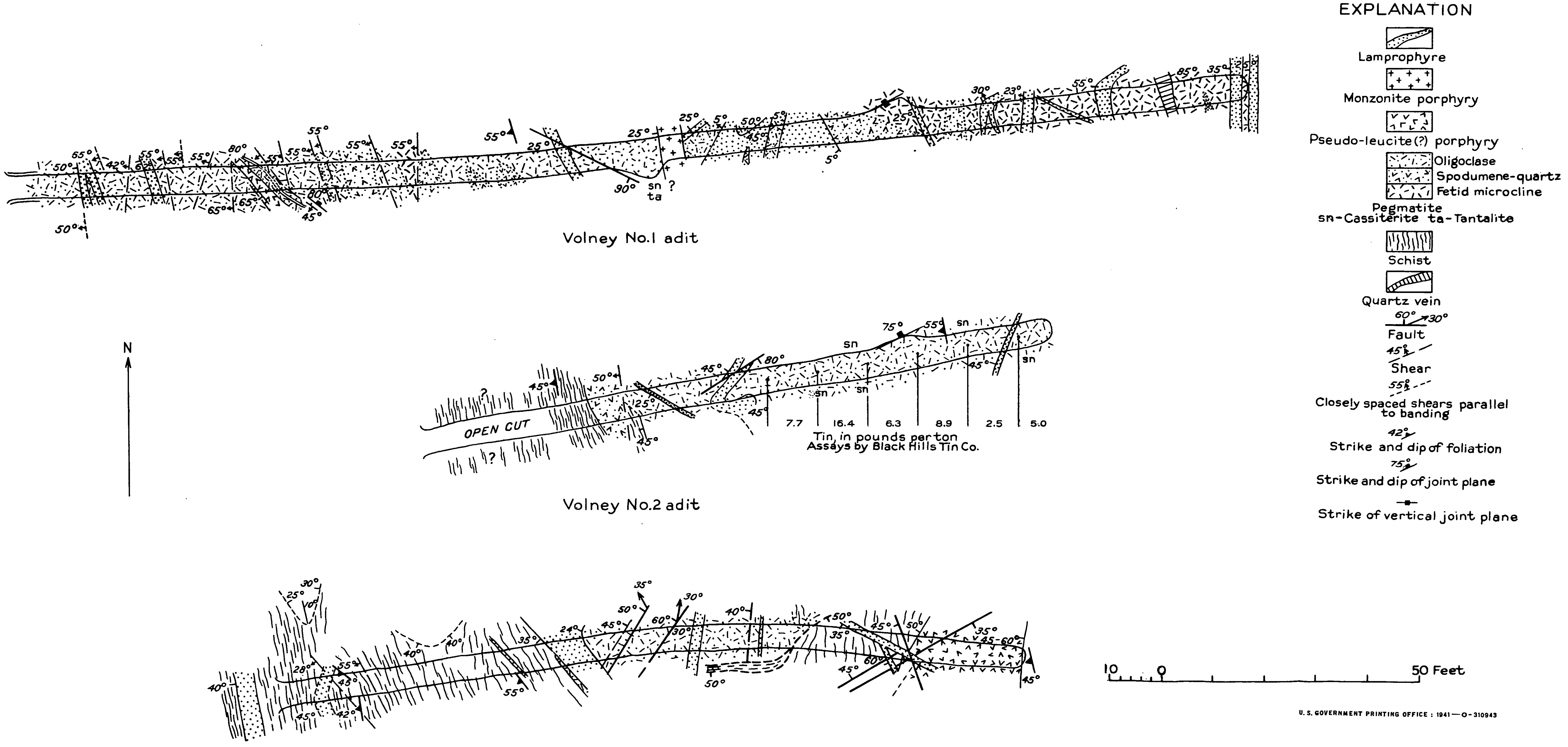


Figure 86.--Geologic map of the Rough & Ready mine, winze level.



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Geology by Lincoln R. Page 1940

GEOLOGIC MAPS OF VOLNEY No.1, VOLNEY No.2, AND GIANT ADITS, TINTON, S. DAK.

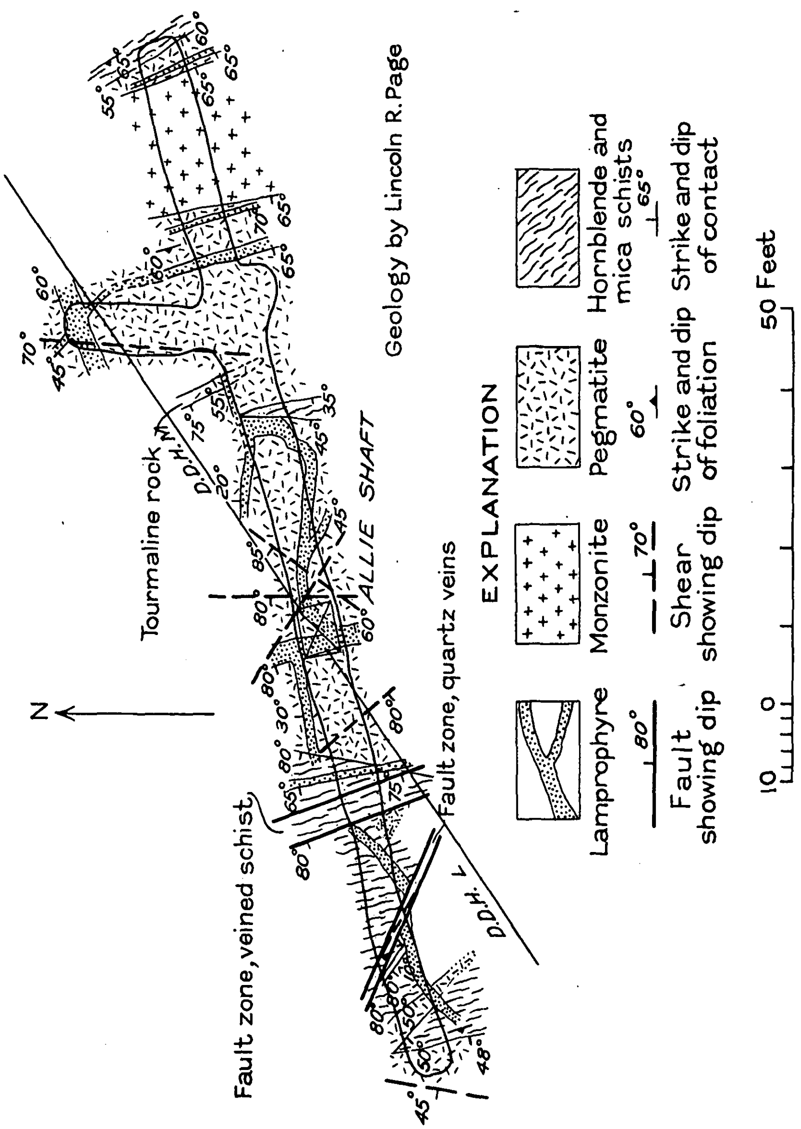

Figure 87.--Geologic map of the Rough & Ready mine, intermediate level.

near the hanging wall of the most westerly pegmatite body (dike A), which is distinctly a dike on the winze level and where it is crossed by drill holes, but merges into others on the adit level to form a thick mass. This largest ore body is 240 feet long, averages about 25 feet in thickness, and extends downward at least 60 feet to the winze level. The ore consists of "pepper tin" in fine-grained oligoclase pegmatite lenses, which are thickly spaced in coarser, more quartzose pegmatite.

A second ore body extends along No. 5 South drift from the No. 1 South crosscut, and it may extend southward beyond the present workings, and also northward into a timbered section of the adit. Its average thickness is 15 feet and its length at least 70 feet. Inasmuch as it was not encountered by diamond-drill holes below the drift, its vertical extent may not be more than 50 feet. This ore body is near the junction of dikes B and C and may be either in the footwall of dike B or the hanging wall of dike C. The ore is similar to that of the first body.

The third ore body extends from the face of No. 2 South drift northward at least as far as No. 1 South crosscut. It probably continues northward, for what appears to be the same body crosses the adit west of its junction with No. 2 South drift. If it reaches the N. 70° W. fault beyond the adit, it is offset by the fault 25 feet westward. The ore is in the middle of a wide pegmatite mass that divides northward and downward into dikes D and E. The maximum length of the ore body is 150 feet and its average width about 10 feet. Here also, an estimate of 50 feet for the vertical dimension would be liberal, for the ore was not identified in drill holes that extend below the drift. The ore contains much tourmaline and a little columbite, spodumene, and amblygonite.

The pegmatites east and south of the No. 2 South drift contain small amounts of unevenly distributed cassiterite, but no ore body has been developed in them. The best showing is in the No. 3 South crosscut, west of the No. 3 South drift. Further prospecting in this part of the mine might determine valuable ore, but it seems advisable to first test the northward and downward continuation of the three ore bodies already known.

Further details of the shapes and attitudes of the pegmatite bodies, particularly their tendency to coalesce southward and to pitch northward, are revealed in the underground workings (see pls. 92-93 and figs. 86-87). South of the adit, where the dikes coalesce, the workings are almost wholly in pegmatite. The adit cuts through pegmatite, hornblende schist, and quartz-mica schist at an angle of 60° to their strike, which is about N. 30° W. The schists dip 40°-65° W., and all the pegmatites dip in the same direction except one above the portal, which dips 60° E. In the adit, dikes F and G are distinctly separate bodies, but others merge and their limits are uncertain. Two pegmatite dikes cut by the adit pitch northward and pass below the No. 1 North crosscut, which is in schist for half its length.

The variations in thickness and the splitting of the pegmatite bodies are also shown by the drill holes represented in the sections (pl. 94). In section A-A[1], pegmatite dikes that are narrow at their surface exposures swell to a maximum thickness along the line of diamond drill hole A-1 and pinch to a very small thickness in drill hole A-2. Along section B-B[1], schist and pegmatite alternate in the Rough & Ready glory holes, pegmatite is nearly continuous on the adit level beneath, and schist again predominates in drill hole K, below the adit level. In section C-C[1], the pegmatite is continuous at the adit level, where normal to the dip it is 150 feet thick, but drill hole B, below the adit and normal to the dikes, passed through four separate pegmatite bodies, whose aggregate thickness is only 60 feet. In section D-D[1], through the Allie shaft, the complex shapes of the pegmatite bodies are most impressively demonstrated. Section E-E[1] shows the thick monzonite porphyry dikes that intersect in the middle of the area.

Giant-Volney prospects

The Giant-Volney property of the Black Hills Tin Co. lies south of the Rough & Ready mine and west of Tinton. The large pegmatite body covered by the Giant claim on the east and the Volney claim on the west is the southern extension of the dikes that merge south of the Rough & Ready mine. It is variously known as the Giant, the Giant-Volney, and the Tantalum Hill pegmatite. Tantalum and lithium were mined from it in 1935 and 1936, but no tin has been produced, although all the early work was in search of tin. In 1939 and 1940 the Bureau of Mines drilled three diamond-drill holes (E, G, and I), with a total length of 1,122 feet, to explore the downward extension of the pegmatite.

The tin prospects on the property include many surface cuts and three adits--the Volney No. 1 adit is 230 feet long; the Volney No. 2 is 77 feet long; and the Giant is 140 feet long (pl. 93). The Tantalum mine consists of a large glory hole, an inclined shaft 60 feet deep, and 200 feet of drifts and crosscuts. The mine was flooded while the writers were at Tinton so could not be examined.

The Giant-Volney pegmatite dike includes every variety of pegmatite that has been described in this paper. Oligoclase-quartz-muscovite pegmatite forms a large mass along the west margin of the dike and extends across the south end; and scattered exposures indicate that it may also form the east and north margins. The middle part of the dike consists of albite-quartz, spodumene-quartz, and microcline-quartz pegmatites, formed by replacement, and it contains small bodies of columbite ore and amblygonite. The pegmatite dips 35°-55° W. and pitches about 20° N., as is shown by diamond-drill holes G and I, which passed below the pegmatite and cut through schist for most of their lengths (pl. 94, sections G-G^1, H-H^1).

The three adits are all crosscuts, driven eastward from the west margin of the pegmatite. The Giant adit, at the south end of the dike, cuts two masses of pegmatite and for most of its length is in schist, which dips 45°-55° W. One mass of pegmatite, 30 feet from the portal, pitches south, but the larger body, at the inner end of the adit, pitches north. Both appear to be irregular apophyses from the main body. Dikes of lamprophyre and one dike of pseudoleucite (?) porphyry cut the schists and the pegmatite.

The Volney No. 2 adit, 30 feet north of the Giant, starts in schist that dips 45° W., passes through about 5 feet of spodumene-quartz pegmatite, and for the remaining distance is in coarse-grained oligoclase-quartz-muscovite pegmatite cut by two lamprophyre dikes. Grains of cassiterite as much as an inch in diameter are plentiful in the pegmatite.

The Volney No. 1 adit is entirely in pegmatite. The first 140 feet of the adit is in layered oligoclase-quartz-muscovite pegmatite, which contains both cassiterite and columbite and in which there are lenses of spodumene-quartz pegmatite and a lens of microcline. The adit then passes through an irregular body of spodumene-quartz pegmatite 10 feet thick, and finally through microcline-quartz pegmatite to the face. About a dozen lamprophyre dikes and one of monzonite cut the pegmatite.

Cassiterite is nowhere abundant in the Giant-Volney pegmatite mass except in the oligoclase pegmatite cut by the Volney adits. The richest ore is in the Volney No. 2 adit. Assays indicate that one 10-foot section of the adit, 40 to 50 feet from the hanging wall, contains 16.4 pounds of tin to the ton and that the average for a 57-foot section beginning 30 feet from the hanging wall is 8.2 pounds to the ton (see pl. 93).[23/] These figures suggest that a fairly good ore body may continue northward along the foliation of the pegmatite, but there is no other evidence regarding the continuation of the ore unless it is the fact that the first 9 feet of pegmatite at the portal of

23/ Gardner, E. D., op. cit., p. 60.

the Volney No. 1 adit averages 10.0 pounds of tin to the ton.[24] Here also the cassiterite is in oligoclase-quartz-muscovite pegmatite near the hanging wall of the Giant-Volney body. As the adits are 450 feet apart, it cannot safely be assumed that ore extends continuously from one to the other. If further explorations for tin are undertaken, however, they should be in this hanging-wall portion.

Other prospects

Cassiterite has been found in pegmatite as distant from Tinton as the Jersey claim, 1½ miles south, and the Boston claim, an equal distance north. The greatest number of cassiterite-bearing dikes is near Tinton, east and northeast of the Rough & Ready claim. Little is known about assay values or the extent of tin-bearing pegmatite in these dikes, but from inspection of pits and natural exposures it appears evident that none contains an ore body that approaches the Rough & Ready ore bodies in size or average grade. The prospects, indeed, show so little promise that no work has been done in recent years on any except those on the Spearfish claim and on the property of the Dakota Tin & Gold Co.

Spearfish and adjoining claims.--The Spearfish claim is 3,000 feet southeast of Tinton, and extends from the east side of Bear Creek to the Tinton-Iron Creek road. The claim, together with the Iron, Centaur, Van, and Yosemite claims to the southwest, is considered by the Black Hills Tin Co. to be the most valuable of its minor properties. Although no tin has been produced from any of the claims, they cover a group of at least 10 cassiterite-bearing pegmatite dikes, including one at the north end of the Spearfish that contains a small amount of exceptionally rich ore.

Prospect work on the claims comprises a 400-foot adit driven in 1934, a 60-foot adit and two shafts dug prior to 1910, and

[24] Gardner, E. D., op. cit., p. 60.

several open cuts. The Spearfish claim was tested with a diamond drill in 1910.

At the edge of Bear Creek, on the north end of the Spearfish claim, a 50-foot open cut leading to the portal of the 400-foot adit exposes a pegmatite mass at least 15 feet thick and 30 feet long. The pegmatite cannot be traced beyond the cut. The adit starts at the footwall of the pegmatite and is in schist and monzonite porphyry for its entire length. The pegmatite is a coarse-grained muscovite-rich rock; part of it contains cassiterite enough to assay perhaps 25 pounds to the ton, but most of it contains only scattered crystals. In a 60-foot cut south of the portal are two bodies of similar pegmatite, 10 and 20 feet wide, separated by monzonite porphyry. Here the richest part is a 3-foot layer that averages about 5 pounds of tin to the ton. Thick float covers the bedrock on the hillside beyond the cut, but the dike probably continues to a 45-foot shaft in pegmatite about 250 feet south.

Of the other claims the most extensively prospected is the Centaur. North of an old road leading from Bear Creek to the Tinton-Iron Creek road are four open cuts, the largest 40 feet long. These expose a pegmatite dike 200 feet long and as much as 15 feet thick in places, part of which strikes N. 20° E. and dips 45° W., parallel to the foliation of the enclosing schist, and part of which cuts across the schist. The dike consists mainly of coarse quartz-muscovite pegmatite but encloses lenses of massive quartz and of fine-grained albitic pegmatite. It contains scattered crystals of cassiterite and columbite, which are cut by small quartz-albite-muscovite veinlets. Its average tin content is probably less than 5 pounds to the ton. Another pegmatite body on the Centaur claim was explored with a 60-foot adit, which is now caved. Four samples taken in the adit are said to have averaged 1.6 pounds of tin to the ton.[25]

25/ Gardner, E. D., op. cit., p. 64.

The ore bodies exposed in the workings on the Spearfish group are either too small or of too low grade to be worked separately, and the pegmatites there are so widely spaced that they probably do not coalesce at shallow depth to form a single ore body that might be large enough to compensate for its low grade.

Dakota Tin & Gold Co.'s property.--The Dakota Tin & Gold Co. holds the unpatented John White claims on Potato Creek, a mile southeast of Tinton. The president and manager of the Company, W. O. Fillmore, reported shipping 500 pounds of concentrates from placer grounds, but except one lot that was cobbed and shipped to England in the early days no lode tin had been mined.

Old workings on the property, said to date from 1880, include a group of surface cuts and a 50-foot shaft connected with a 25-foot crosscut and 50 feet of drift. Recent work includes a 175-foot adit to the old shaft and a new three-compartment shaft, 130 feet deep, sunk in 1938 and 1939.

The development is on the most southeasterly cassiterite-bearing pegmatite dike. In the drift the greatest thickness of the dike is 9 feet, and it thins to 4 feet at the face. Both at the surface and in the drift it strikes north and dips 45° W. The new shaft farther west, planned to cut the downward extension of the dike, was all in schist when visited.

The pegmatite is a fine-grained, strongly foliated rock composed chiefly of quartz, albite, and muscovite, with a little apatite. The cassiterite is in small grains, which in some specimens are alined in layers. Gardner [26] estimated that the dike would average 3 or 4 pounds of tin to the ton. The block between the drift and the surface represents about 1,000 tons of pegmatite.

26/ Gardner, E. D., op. cit., p. 60.