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TUNGSTEN DEPOSITS ISLA DE PINOS, CUBA

BY

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TUNGSTEN DEPOSITS, ISLA DE PINOS, CUBA

By Lincoln R. Page and James F. McAllister

ABSTRACT

The tungsten deposits of the Isla de Pinos, Cuba, occur in the southwestern part of the island, near the Lomas de Siguanea. They are about 30 miles (50 km.)1/ by dirt road south of Nueva Gerona, the main port of the island. The Pan-American Tungsten Corporation (Corporacion Pan-Americana de Tungsteno, S. A.), which owns the Lela or Mina Lela claim, is the only operator in the Siguanea district. Nine other claims have been staked in the district, but development has been limited to small prospect trenches and pits.

The dominant rocks of the district are isoclinally folded fissile biotite and muscovite schists, which in places grade imperceptibly into quartz-mica schists and quartzites. These rocks vary in strike and, in general, dip 20° to 30°. They have been cut by small faults and in places are strongly brecciated. One of the most common structures in the schists and quartzites is a well-developed system of joints (sheeting) that strike N. 10°-25° E. and dip 75° to 90°.

Igneous rocks of three ages have been intruded into the metamorphic rocks of the district. The oldest are thin pegmatite dikes, which are associated with large barren quartz masses. The most abundant igneous rock is feldspar-quartz porphyry, which occurs in dikes that strike from a few degrees west of north to about N. 30° E. and dip as much as 75° to 90°. It is older than the tungsten veins, and the veins are cut by dikes of rhyolite porphyry, which were intruded along the veins and along fractures that strike N. 45°-55° W. The rhyolite is rarely well exposed, being easily weathered.

The chief ore mineral, ferberite, occurs in quartz-tourmaline veins and in tourmalinized and silicified breccia, feldspar-quartz porphyry, schist, and quartzite. A little scheelite has been formed by alteration of ferberite. Some alluvial, residual, and marine sedimentary deposits may contain appreciable amounts of detrital ferberite.

The tungsten deposits are found in an area about 12,000 feet (3.7 km.) long and 5,000 feet (1.5 km.) wide, but most occurrences of possible economic importance are localized in an area approximately 6,000 feet (1.8 km.) long and 2,800 feet (0.85 km.) wide. Northeast of this area the mineral deposits are of the sulfide type and are indicated on the surface as gossan. Many veins are exposed in the district, and 37 of the most promising, all on the Lela claim, have been described in

1/ Where the English measures represent rough estimates, their metric equivalents are given only approximately and usually in round numbers.

detail. The veins strike from a few degrees west of north to N. 40° E., but most of them strike between N. 10° E. and N. 25° E. and form a fanlike pattern diverging to the northeast. In general the veins dip 50° or more toward the central part of the mineralized area, but there are many exceptions. Most of the veins are less than 5 feet (1.5 m.) thick, but some are about 12 feet (3.6 m.) thick. The individual veins differ greatly in length, but some can be traced as much as 1,500 feet (460 m.) along the strike.

In the Lela mine at least six tungsten-bearing quartz bodies have been prospected by more than a mile of underground workings at the 125- and 225-foot levels. The only other development work of importance is on the Pruneda vein, about 1,400 feet (425 m.) west of the Lela mine. Here a shaft has been sunk to the 200-foot level and is being connected with the Lela workings. The property is equipped with a 200- to 250-ton mill, which has not yet begun production.

The tungsten reserves of the Siguanea district appear to be fairly large, but at the time of the examination not enough work had been done to serve as a basis for satisfactory estimation of potential tonnages and grade. At that time the reserve of tungsten ore was roughly estimated, without benefit of sampling data, at 55,000 tons containing about 750 tons of WO_3. On the basis of recent developments, however, it appears probable that the reserve of ore is larger than this, and with continued development even larger reserves may be proved.

INTRODUCTION

Isla de Pinos, with an area of 1,214 square miles, is about 60 miles (100 km.) south of the main island of Cuba, between 21° and 22° north latitude and 82° and 83° 15' west longitude. Tungsten deposits occur on the southwestern part of the island, near Lomas de Siguanea, which is at the head of the Ensenada de la Siguanea (pl. 32).

Tungsten is being developed only at the Lela mine, operated by the Pan-American Tungsten Corporation (Corporacion Pan-Americana de Tungsteno, S. A.). The settlement of Siguanea is connected by 30 miles (50 km.) of dirt road with Nueva Gerona, the main port, which is at the north end of the island. All equipment and supplies used on the island are shipped from Habana or other ports on the island of Cuba by railroad to Batabano, where they are reshipped by boat. The mining supplies used by the Pan-American Tungsten Corporation are now transported by truck from Nueva Gerona, although some of the heavier machinery was brought on small fishing schooners to a dock within 3 kilometers of the mine.

Unconfirmed reports indicate that tungsten minerals were first recognized on the Lela claim as early as 1900, but the first known discovery of these minerals was made by George Tower, Laurence Litchfield, and T. C. Denton while they were prospecting the island in the summer of 1927 for the company operating the Field gold mine, in the western part of the island. In the summer of 1928 a claim was staked by Litchfield and Denton, who optioned the property to the Vanadium Corporation of America. In 1929, after a few prospect trenches and pits had been dug, the claim was allowed to lapse. In 1938, Engineer Antonio Calvache, of Habana, Cuba, recognized tungsten minerals in samples from this area submitted by Jesus A. Estrella, Guido Calvache, and Rafael Rivis, and advised them of its economic possibilities. Estrella immediately located the claim now known as the Mina Lela or Lela claim. The Molybdenum Corporation of America did a little prospecting on the claim in the fall of 1938. In February 1939, the property was acquired from the Cuban interests by S. C. E. Melkman, and the Pan-American Tungsten Corporation (Corporacion Pan-Americana de Tungsteno, S. A.) was then formed. Underground development was started immediately and a mill was erected, which in 1939 produced about 2 tons of concentrates. In 1940 the control of the company passed to Mr. W. M. Archibald, who is at present directing mining operations. The mill, which has been shut down since the initial period of operation, was redesigned in 1941 and 1942 to handle as much as 200 to 250 tons of crude ore per day.

After the discovery of the Lela property, Jesus A. Estrella staked the claims known as the Genaro, Rolando, Ancash, and Fer-Mi on recommendation of Engineer Calvache, and on his own initiative restaked the Guido and Cancio claims. At about the same time, Eduardo Escribano staked the Aguedita and Louis Pozo the Mercedes claim.

The tungsten deposits were described by Calvache [2] in 1939 and 1940, and were later mentioned by Corral.[3] The general geology of the island is incompletely known, but some phases of it have been discussed by Hayes, Vaughan, and Spencer,[4] Allen,[5] Suárez Murias,[6] Brown and O'Connell,[7] Allende,[8] Rutten,[9] and Schuchert.[10] Maps of the island were published by Fernandez de Castro and Salterain y Legarra in 1844, in the bulletin of the Commision del Mapa Geologico de España, Madrid, and also by Lewis.[11]

The tungsten deposits of the Siguanea district were examined by the Geological Survey during a four-month period extending from July to November 1941. The work formed a part of the Department of State's program of cooperation with American Republics, and was done in collaboration with the Dirección de Montes, Minas, y Aguas of the Cuban Government. A topographic and geologic map, representing an area of about one square mile (259 hectares) which included the Lela claim, was made with the telescopic alidade and plane table on a scale of 200 feet to the inch (1:2,400), and a map on a scale of 1,000

2/ Calvache, Antonio, Tungsteno en Isla de Pinos: Revista de Agricultura, no. 22, pp. 41-44, Enero 1939; Estado de la mineria en Cuba al finalizer el ano 1939, p. 9, Habana. Editora de libros y Folletos, 1940.

3/ Corral, José Isaac del, La minera Cubana: sus industrias racionales. Revista de la Soc. Cubana de Ing., no. 37, pp. 42-43, 1942.

4/ Hayes, C. W., Vaughan, T. C., and Spencer, A. C., Report on a geological reconnaissance of Cuba. Made under the direction of General Leonard Wood, in civil report of Brig.-Gen. Leonard Wood, military governor of Cuba, for the period from January 1 to December 31, 1901, vol. 1, pp. 9-10, pp. 112-117, 1901.

5/ Allen, G. M., Fossil mammals from Cuba: Harvard Coll., Mus. Comp. Zool., Bull. 62, pp. 133-148, 1918.

6/ Suárez Murias, E. R., Visita de inspeción á la Isla de Pinos, Cuba: Direc. de Montes y Minas, Bol. Minas, no. 6, pp. 24-28, 1920.

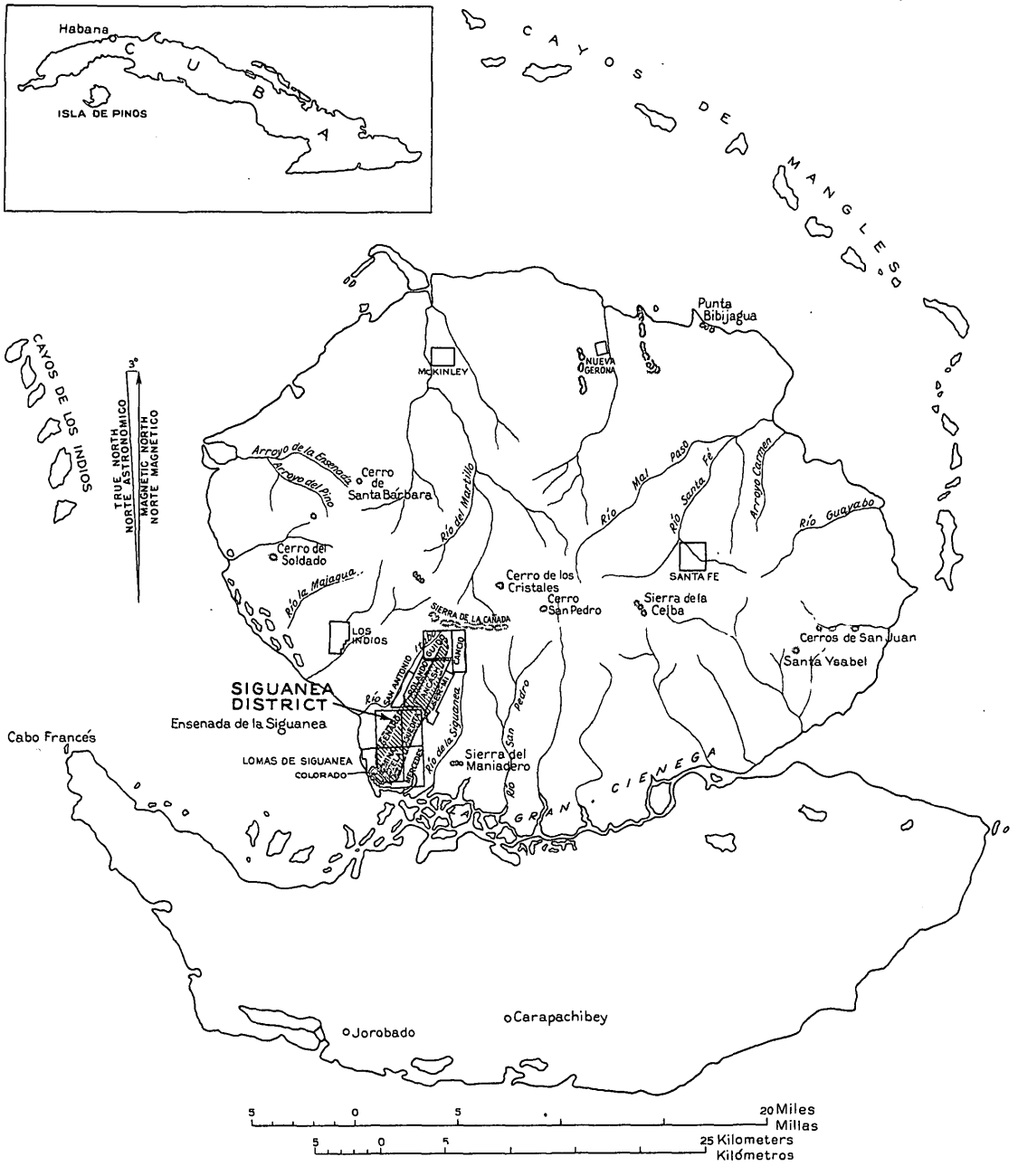
7/ Brown, Barnum, and O'Connell, Majorie, Correlation of the Jurassic formations of western Cuba: Geol. Soc. America, Bull., vol. 33, pp. 639-664, 1922.

8/ Allende, Roque, Estudio técnico de los yacimientos minerales de Isla de Pinos, Cuba: Direc. de Montes y Minas, Bol. Minas, no. 7, pp. 51-67, 1923.

9/ Rutten, L. M. R., Geology of Isla de Pinos, Cuba: K. Akad. Wetensch Amsterdam, Sec. Sci. Proc., vol. 37, no. 7, pp. 401-406, 1934.

10/ Schuchert, Charles, Historical geology of the Antillean-Caribbean region, pp. 488-489, p. 518, pp. 523-525, New York, 1935.

11/ Lewis, J. Whitney, Geology of Cuba: Am. Assoc. Petroleum Geologists Bull., vol. 16, pp. 533-553, 1932.



INDEX MAP, SIGUANEA DISTRICT, ISLA DE PINOS, CUBA

MAPA INDICE, COTO DE LA SIGUANEA, ISLA DE PINOS, CUBA

feet to the inch (1:12,000) was made of a tract ½ to 1 mile (0.8 to 1.6 km.) wide and 5 miles (8 km.) long, which forms a northeastward extension of the mineralized area. Underground maps were made on a scale of 50 feet to the inch (1:600). All reported occurrences of tungsten minerals were examined in the Genaro, Aguedita, San Antonio, Rolando, Ancash, Fer-Mi, Guido, Cancio, Mercedes, and Colorado claims, but only the more promising areas were mapped in detail.

The writers are indebted to the officials of the Pan-American Tungsten Corporation, especially Mr. W. M. Archibald and Señor Louis Pozo, president of the corporation, for their cooperation throughout the period of field work and for furnishing the party with living quarters. Information relative to the development work done on their property since completion of the field work has been made available by Mr. Archibald. Sẽnor Antonio Calvache kindly lent maps from his personal files and gave detailed information concerning the early history and development of the district, and courteously gave his assistance, as representative of the Cuban Government, in arranging necessary interviews. Transportation between Habana and Isla de Pinos was furnished by the Cuban Government. Sẽnor Eduardo Escribano, of Nueva Gerona, Mr. Nesbit S. Allen, of Habana, Señor Jesus A. Estrella, and others who owned claims in the district kindly made available information concerning their respective properties.

GEOLOGY

The metamorphic rocks that make up a large part of Isla de Pinos include a wide variety of schists interbedded with quartzites and marbles.[12/] In the district studied, the calcareous members are absent. Here the rocks are fissile biotite and muscovite schists, which in places grade imperceptibly

12/ Rutten, L. M. R., op. cit.

into quartz-mica schists and quartzites. These rocks, probably marine sediments originally, were called the Santa Fe schist and Genaro marble by Hayes.[13] More recent writers have correlated them, entirely on the basis of lithologic similarity, with the San Cayetano formation of Pinar del Rio Province, on the island of Cuba. The San Cayetano formation has been supposed to contain Middle Jurassic fossils,[14] but there has been a controversy as to whether the diagnostic fossils are from the San Cayetano formation or from the overlying Vinales limestone.[15]

The metamorphic rocks of Isla de Pinos are intruded by igneous rocks of at least three and perhaps four different ages. The oldest of these, called diorite schist by Hayes [16] and amphibolite by Rutten,[17] was intruded before the regional metamorphism, which in Pinar del Rio Province is believed to be of late Jurassic age. It has been found southeast of Santa Fe but was not observed in the Siguanea district, where the oldest igneous rocks are thin pegmatite dikes, associated with large barren quartz masses. The most abundant dike rock is feldspar-quartz porphyry. This rock is older than the tungsten veins, but the veins are cut by younger dikes of rhyolite porphyry.

The tungsten deposits, which are all characterized by ferberite, are quartz-tourmaline veins and tourmalinized and silicified breccias, schist, and quartzite. The rocks adjacent to the veins are well jointed, faulted, and partly replaced by quartz and tourmaline.

13/ Hayes, C. W., Vaughan, T. C., and Spencer, T. W., op. cit., pp. 114-115.

14/ Dickerson, R. E., and Butt, W. H., Cuban Jurassic: Am. Assoc. Petroleum Geologists Bull., vol. 19, pp. 116-118, 1935.

Imlay, R. W., Late Jurassic fossils from Cuba and their economic significance: U. S. Geol. Survey, manuscript in preparation, 1942.

15/ Brown, Barnum, and O'Connell, Marjorie, op. cit.

16/ Hayes, C. W., Vaughan, T. W., and Spencer, A. C., op. cit., p. 115.

17/ Rutten, L. M. R., op. cit., p. 403.

Erosion has reduced the greater part of the island to a gently rolling plain, 50 to 200 feet (15 to 60 m.) above sea level, but around its fringes marine deposits of sand, clay, and gravel extend to altitudes of 20 to 30 feet (6 to 9 m.). These marine deposits merge with alluvium at their upper edge and include areas of ferruginous conglomerate, thought to have formed by precipitation of iron oxide in swamps or from spring water.

Rock formations

Schist and quartzite.--Mica schists underlie the larger part of the areas mapped (see pls. 33 and 34). In general these are poorly exposed; the observed outcrops are mostly of schist that is rich in quartz or has been silicified or tourmalinized by hydrothermal solutions. The fresh rock obtained from underground workings is dark gray to black and contains biotite, muscovite, and quartz, together with less feldspar, staurolite, kyanite, zircon, titanite, and apatite. The relative abundance of these minerals differs in different beds, but by far the greatest difference between beds is in the percentage of quartz. The schists have been weathered in places to a depth of 150 feet (45 m.), and are usually stained yellowish to red with iron oxide. Near the veins, introduction to tourmaline along the bedding or foliation planes has in places produced tourmaline schists and gneisses composed almost entirely of quartz and tourmaline. Silicification along the veins has converted the schists into hard cherty rocks which in places are similar to the quartzites.

The quartzites are most prominent east of the brecciated zone shown on plate 34, in the southeastern part of the Lomas de Siguanea, and along the southern edge of the adjacent hills. Quartzite is also exposed along the boundary between the

Genaro and Aguedita claims, in the Ancash claim, and as thick beds in cliffs on the Sierra de la Cañada.

The quartzites are for the most part micaceous and grade both laterally and vertically into schists. The beds of quartzite are lenticular and it was found impracticable to map them separately, but the approximate distribution of the quartzite is shown on the map. The fresh rock is light-gray to buff; upon weathering it becomes lighter colored except where stained by iron oxide.

Pegmatite and quartz bodies.--Numerous thin quartz-feldspar pegmatite dikes and associated small barren massive quartz lenses lie parallel to the bedding and foliation of the schists in the underground workings on the Lela claim. The pegmatite rarely contains muscovite, and feldspar usually forms less than half of the rock, being in places entirely absent. The dikes, where observed, are usually less than a foot (0.3 m.) thick, and in cross section they appear as a series of connected or disconnected lenses or podlike bodies. Pegmatite was not definitely recognized on the surface, but it may be represented by similarly shaped bodies of quartz, which before weathering may have contained feldspar.

Other areas (pl. 33), particularly the Guido claim, contain many large lenticular to tabular bodies of barren milky quartz, some of which are as much as 700 feet (210 m.) long and 60 feet (18 m.) wide, although in general they are less than 25 feet (7.5 m.) wide. The smaller bodies lie parallel to the foliation of the schists, but many of the larger ones cut across the structure.

Cassiterite is said to be present in one of these quartz bodies on the Guido claim,[18] but none was observed by the writers, who found only black tourmaline, fractured and veined with quartz, rutile, and occasional muscovite as original

18/ Calvache, Antonio, oral discussion.

minerals accompanying the quartz. Iron oxides are sparingly present, and green tourmaline in thin needlelike crystals and aggregates may be seen in a few of the outcrops, being most abundant where the sulfide-tourmaline veins cross or intersect the quartz masses. In some places there are cavities containing euhedral crystals of quartz, which may be coated with these needles of tourmaline.

Feldspar-quartz porphyry.--The feldspar-quartz porphyry dikes (pl. 34) are irregular in shape, but most of them are tabular and strike from a few degrees west of north to about N. 30° E. A few strike as much as 45° west of north. Accurate dips on most of the dikes are not obtainable because of poor exposures and local irregularities of the contacts, but many of the dikes have dips as steep as 75° and some appear to be nearly vertical. On the map (pl. 34) some of them are represented as branching, but at some places it is not possible to determine whether a dike actually forks or two dikes cross one another.

The older dikes of feldspar-quartz porphyry consist mainly of conspicuous phenocrysts of orthoclase and quartz in a greenish-gray, very fine grained groundmass, but they contain smaller phenocrysts of sericitized oligoclase and partly chloritized biotite. Their groundmasses consist of very small grains (commonly 0.03 mm.) of orthoclase and quartz, with accessory garnet. In composition the older porphyry is probably in part latitic, and in part rhyolitic. It is distinguished from the younger rhyolite porphyry by its coarser texture, its more abundant and larger phenocrysts, and the predominance of feldspar phenocrysts over quartz phenocrysts.

Some of the feldspar-quartz porphyry was altered during the tungsten mineralization in such a way that tourmaline has replaced the groundmass without altering the phenocrysts; in some of it, on the other hand, the feldspar phenocrysts have

been selectively replaced by tourmaline, making them conspicuous in a white groundmass that has not been replaced (see pl. 35). Some of the well-defined quartz-tourmaline veins, where they enter the porphyry, split up into numerous tourmaline veinlets, which lose their identity in a broader mass of black mineralized porphyry.

In the silicified areas on the south side of Lomas de la Siguanea, the porphyry crops out as a greenish to white cherty rock that shows the original texture and minerals in various degrees of preservation. In the more completely silicified areas the porphyry cannot be distinguished from silicified metamorphic rock.

Rhyolite porphyry.--The rhyolite porphyry of the later dikes is the youngest igneous rock in the Siguanea district. As shown in plates 34 and 36, it cuts the feldspar-quartz porphyry and the tungsten-bearing veins. Some of these dikes follow fractures that diagonally cross the vein system, whereas others have followed the Pruneda and other veins, splitting a vein in the middle at some places instead of following either wall. One dike of this group (pl. 36) has a peculiar blocky outcrop and ends abruptly on the surface, though it apparently continues underground without a change in thickness.

The rhyolite porphyries are more regular in strike and dip than the feldspar-quartz porphyries, and their position can be predicted fairly successfully in advance of mining. The regularity is illustrated in the Lela mine (pl. 40), where a 3- to 4-foot (0.9 to 1.2 m.) dike maintains a nearly straight course of N. 55° W. and dips 80° SW. to 80° NE. across the explored area.

The rhyolite porphyry is rarely well exposed, for it is easily weathered, being completely decomposed even on the 125-foot level of the Lela mine. The weathered rock is a buff to

light-gray, fine-grained porphyry with scattered phenocrysts of quartz and kaolinized feldspar. Dark grains of iron oxide, derived from completely altered biotite or hornblende, are disseminated in a very fine grained groundmass of secondary quartz. Dark-reddish to purplish iron oxide usually stains the surface exposures. At one place on the ridge northeast of the No. 3 adit, a little tourmaline, apparently introduced, was observed in a dike of this rock.

The least altered specimen, from a dike on the 225-foot level of the Lela mine, is buff to brown and fine-grained. It contains scattered phenocrysts of quartz, rounded and corroded, in a matrix of carbonate, fine-grained quartz, iron oxide, and sericite. The lathlike shape of the original feldspar crystals is preserved by aggregates of sericite and quartz. This rock may be a hydrothermally altered latite porphyry.

Veins, breccias, silicified rocks, and tourmalinized rocks.--(See pls. 33, 34, and 43). The ferberite-bearing quartz-tourmaline veins and associated sulfide veins, ferberite-bearing breccias, and silicified and tourmalinized rocks are described in detail in the section of this report dealing with ore deposits, pages 191 to 210.

Mantle.--Surface deposits of clay, sand, gravel, bog iron, and ferruginous conglomerate cover a considerable part of the Siguanea district. On the map of the district (pl. 33) only the ferruginous conglomerate is distinguished by a special pattern, all the other surficial deposits being represented by one other pattern. Clay, sand, and gravel, at least in part marine, cover most of the surface below the 20-foot contour, above which clay and fine sand extend up shallow, nearly flat valleys to an altitude of 100 feet (30 m.) or more. The gentle slopes near the divides are paved with residual gravel, as much as 3 feet (1 m.) thick, from which the fine material has been removed by sheet wash. Some of the gravel,

irregularly distributed between 20 and 55 feet (6 and 15 m.) above sea level, is cemented by iron oxide derived from springs and perhaps bogs.

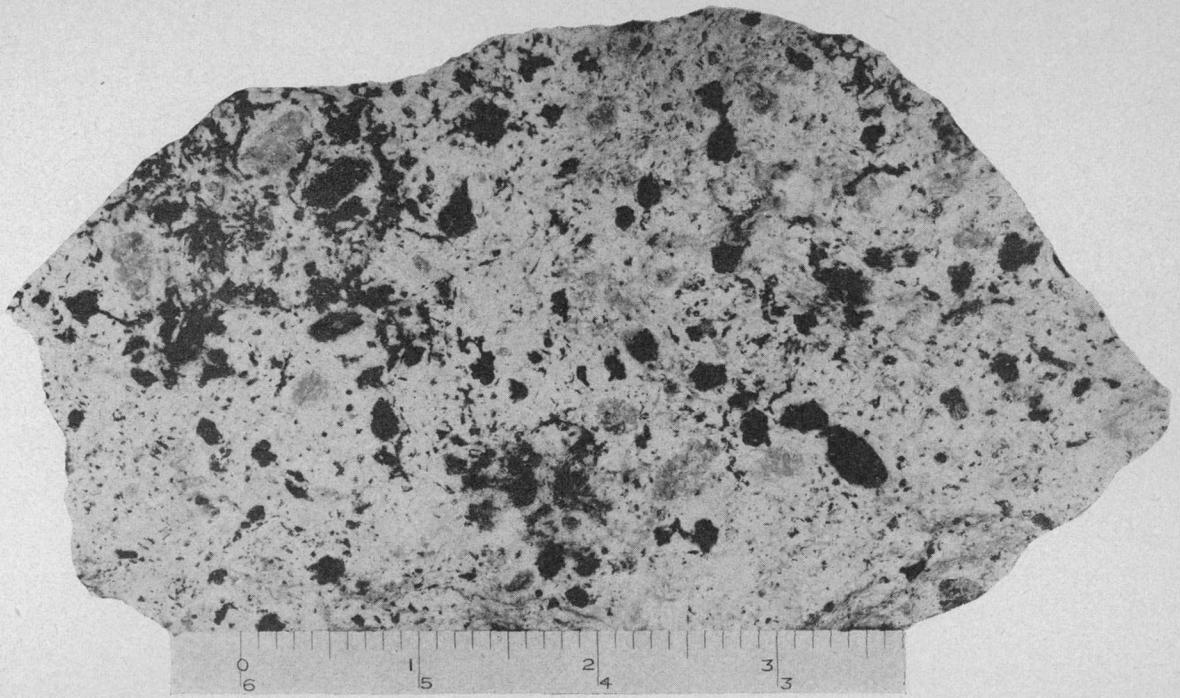
The alluvium shown on the map of the Lela claim (pl. 34) includes some marine deposits and iron-cemented conglomerate. Slope rubble and residual material cover parts of areas designated as schist and quartzite.

Structure

The isoclinally folded schists and quartzites of the Siguanea district appear to be on the eastern flank of a large anticlinal or arched structure. Poor exposures, limitations of time, and absence of good horizon markers in the metamorphic rocks made it impossible to map even the major structures in detail. These structures are complicated by at least three systems of faults and fractures and by three groups of igneous intrusions.

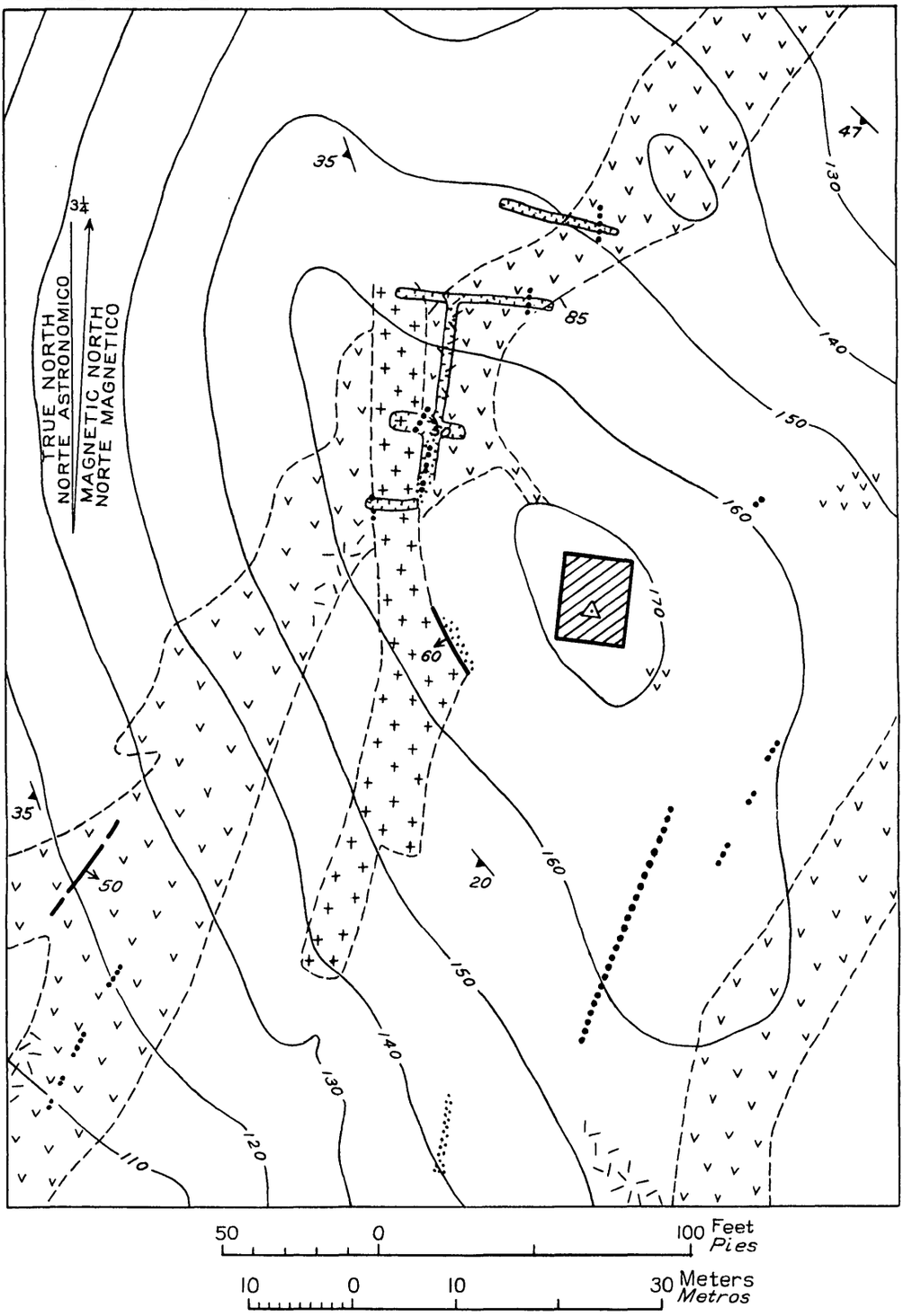
Folds.--It was probably at the end of the Jurassic period that the rocks of the Siguanea district were metamorphosed and isoclinally folded. The foliation, which is essentially parallel to the bedding, is followed by many of the pegmatite dikes and by the associated thin quartz lenses.

The structure in the Lomas de Siguanea, though complicated by many minor isoclinal folds and faults, appears to be in general anticlinal. In the western part of this area most of the schist strikes N. 10°-35° W. and dips 20°-30° SW., but eastward its attitude gradually changes, so that in the eastern part of the area it strikes N. 60°-80° E. and dips 20°-30° SE. The broad low ridge extending northeastward from Siguanea to the Sierra de la Cañada may be on the axis of this anticline, but minor folds, faults, and lack of outcrops make the structure at this locality obscure. The schists in the southeastern part of Sierra de la Cañada have, in general, a strike



TOURMALINIZED FELDSPAR-QUARTZ PORPHYRY.

Feldspar-quartz porphyry showing feldspar phenocrysts replaced by tourmaline (black); rounded and corroded quartz phenocrysts (gray); and kaolinized groundmass (white). From the 225-foot level of the Lela mine.



EXPLANATION		EXPLICACION
Schist and quartzite		*Esquistos y cuarcita*
Feldspar-quartz porphyry		*Pórfido de teldespato y cuarzo*
Rhyolite porphyry		*Pórfido riolítico*
Quartz-tourmaline veins		*Vetas de cuarzo y turmalina*
Tourmalinized rock		*Roca turmalinizada*
Silicified rock		*Roca silicificado*
Strike and dip of bedding and foliation	35	*Rumbo y buzamiento de estratificación y foliación*
Fault, showing dip	60	*Falla, indicando su buzamiento*
Pit		*Calicata*
Triangulation station	△	*Vértice de triangulación*

DETAILED MAP OF PORPHYRY DIKES NORTH OF THE NO. 2 ADIT ON THE LELA CLAIM, ISLA DE PINOS, CUBA

PLANO DETALLADO DE LOS DIQUES DE PORFIDO AL NORTE DEL SOCAVON NO. 2, CONCESION LELA, ISLA DE PINOS, CUBA

of N. 10°-20° W. and dip 20°-25° NE.; those in the northern part strike N. 60°-70° W. and dip 5°-20° NE. Minor isoclinal folds are well exposed in the underground workings on the Lela claim. The pitch of their axes, where measured, is 15°-25° SE.

Faults.--A number of faults were observed in the Siguanea district, but their exposures are discontinuous and do not in most places permit accurate determination of the attitude or amount of offset. There is evidence of at least three main periods of faulting and fracturing, which followed the metamorphism and folding of the original rocks. The earliest fracture system, probably developed shortly after the folding, localized the pegmatite and barren quartz bodies that cross the structure of the schists in the Guido and other claims. The second period of faulting started before the tungsten mineralization and continued intermittently until the last of the vein-forming minerals were deposited. The earliest stage of this deformation probably was marked by the formation of breccia bodies and of the fractures along which the feldspar-quartz porphyry dikes were intruded. Later the porphyry dikes were cut by faults with offsets of a few feet. The fan-shaped system of faults and fractures now filled with quartz-tourmaline veins was superimposed on these earlier structures. After deposition of the early quartz and ferberite of the veins, fracturing and faulting was renewed, for this early vein material is brecciated. Sheeting structures were probably developed at this time and were later mineralized with tourmaline, ferberite, and sulfides. Faulting and fracturing occurred along these same trends after the introduction of tourmaline. Strike faults extend along many of the veins, but there is little displacement on them. Some are filled by late rhyolite porphyry dikes, and sulfides have been introduced along others. The wide brecciated zone, now heavily iron-stained, east of the Lela shaft, was probably formed at this

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time. Probably at the same time, also, the fractures and faults striking N. 35°-55° W. were formed that in some places cross the veins and feldspar-quartz porphyry dikes. In the Lela mine one of these is followed by a rhyolite porphyry dike.

Joints.--One of the structures most common in the schists and quartzites is a well-developed system of joints that strike N. 10°-25° E. and dip 75°-90° SE. or NW. Where the joints are especially numerous and closely spaced—1 to 3 inches (2.5-7.5 cm.) apart—they have been called sheeting. Sheeting is especially prominent in the rocks on the 125-foot level of the Lela mine, where it makes a small angle with the veins. Here tourmaline, ferberite, sulfides, and, more rarely, silicification, have followed the sheeting. Sheeting is not as prominent on the lower level of the mine.

Less regularly spaced joints cross the sheeting but are not numerous. The porphyries are not sheeted; they are broken into large irregular blocks by unsystematic joints, which are so open that the dikes act as channelways for large quantities of water.

Summary of geologic events

Although field relations observed within the Siguanea district make it possible to work out the sequence of geologic events in the district, they do not serve to date these events according to the geologic time table. All geologic dates are necessarily based on similar tentative correlation with rocks on the mainland of Cuba, where the sequence of events has been worked out by other writers. The sequence as indicated by evidence in the Siguanea and adjacent areas is as follows:

1. Deposition of a thick series of interbedded sand, clay, and sandy clay, probably in Jurassic time.

2. Intrusion of diorite.

3. Regional metamorphism and deformation of the sediments and diorite, probably at the end of Jurassic time.

4. Emplacement of massive quartz bodies and pegmatites along foliation planes, isoclinal folds, and fractures.

5. Brecciation and faulting, closely followed by intrusion of feldspar-quartz porphyry, which was probably accompanied by some silicification of breccias and other rocks. The age of the intrusions is unknown but may be late Cretaceous or early Tertiary.

6. Additional faulting and hydrothermal alteration, including the main tungsten mineralization of the area. Quartz-ferberite veins were formed and were later fractured and brecciated. The sheeting structure was developed before the final introduction of tourmaline, ferberite, quartz, arsenides, and sulfides. Fractures and faults that were formed after the deposition of most of the tourmaline were later mineralized with pyrite.

7. Intrusion of rhyolite porphyry dikes, both along the strike and diagonally across the trend of the vein system, marking the end of the main period of mineralization. The presence of carbonates in the dikes suggests some later hydrothermal alterations.

8. Subaerial erosion and the deposition of marine sands and gravels.

9. Deposition of alluvial material, formation of residual deposits, ferruginous conglomerates, and gossan caps.

ORE DEPOSITS

The most promising tungsten deposits are in the southern part of the Siguanea district. Ferberite and scheelite formed during late stages of the mineralization occur in quartz-tourmaline veins, tourmalinized breccia, silicified

breccia, silicified and tourmalinized schist, quartzite, and feldspar-quartz porphyry. Some ferberite occurs in the surficial deposits derived from these altered rocks.

Veins

Quartz-tourmaline veins.--The quartz-tourmaline veins are best exposed in the Lomas de la Siguanea (pl. 34), where surface indications of more than 50 veins were found by traversing the top of the main northwest-trending ridge. A number of other veins do not cross this ridge, so that the total number of distinct veins in the area must be very large. These veins are not all of commercial size or grade, nor were tungsten minerals observed in all of them, but they were all formed in the same period of mineralization, and it is probable that many of them intersect, as shown in section A-A' (pl. 34), along their strike or dip with veins that contain tungsten. Some of them may contain ore bodies that do not crop out. The mineralized ground appears to be limited, for the most part, by an iron-stained brecciated zone east of the Lela shaft, and it dies out to the northeast. No tungsten minerals were observed in veins north of the central part of the Genaro and Aguedita claims. It is significant that the greenish and brownish fine-grained crystalline tourmaline that characterizes the veins in the southern part of the area is present in only a few places north of the center of the area comprising these claims. Iron sulfides become increasingly abundant in the veins along the trend of the mineralized zone to the northeast, and north of the Lela claim the veins are characterized by limonite gossans.

The veins strike from a few degrees west of north to about N. 40° E., but most of them strike between N. 10° E. and N. 25° E. and form a fanlike pattern diverging northward. In general the veins dip toward the Pruneda vein in the central part of

the mineralized area, but as shown in section A-A' (pl. 34) there are many exceptions. On the edges of the vein system the dips are mostly 50° to 60°, but rarely they are as low as 30°. Subsidiary veins of steeper dip diverge from those of lower dip, and surface exposures as well as recent underground developments indicate that these subsidiary veins also diverge to the north.

The veins fill fractures in the schists, quartzite, and feldspar-quartz porphyry. In some places they have well-defined walls, in others they fill openings in narrow tabular breccia zones, and some have been formed primarily by replacement of the wall rocks. Silicification and tourmalinization of the wall rocks have made it impossible to define the exact limits of many of the veins. In general they are lenticular in section, both horizontally and vertically, and the thicker parts show an overlapping or echelon arrangement. In general the veins are less than 5 feet (1.5 m.) thick, but some are as much as 10 to 12 feet (3 to 3.6 m.) thick. The individual veins differ widely in length. Some closely related vein structures may be traced with only minor interruption for as much as 1,500 feet (460 m.) along the strike.

Tourmalinized rock.--Large irregular to tabular bodies of tourmalinized schist, quartzite, quartz-feldspar porphyry, and breccia have been mapped in the Lela claim (pl. 34). This more or less completely tourmalinized rock is partly on the strike of veins that have rather sharply defined walls, and it probably represents vein matter in which tourmalinization has been complete. Other masses less sharply defined and less regular in shape appear to cross the normal structure of the veins. Some of these have a trend of N. 30°-45° W. and show no relation to the main vein system. These bodies are all east of the iron-stained brecciated zone and south of the central part of the Genaro and Aguedita claims.

The rock is dark green to black, very fine grained, hard, and resistant to weathering. Most of it is composed of green to brown tourmaline with subordinate quartz. Where it is less completely tourmalinized, especially along the walls of the veins, the rock is massive and shows its original structure. The weathered surface is usually iron-stained and is rough, pitted, and clinkery in appearance. No tungsten minerals were observed in these large irregular masses or in the tourmaline zones that trend across the vein structures, but some were seen in similar rock within veins and masses of breccia.

Silicified rocks.--Large irregularly shaped masses of silicified rocks have been mapped in the south-central part of the Lela claim (pl. 34). These include schist, quartzite, feldspar-quartz porphyry, and breccia that has been partly or completely altered to a white, gray, or greenish fine-grained cherty rock that occasionally contains ferberite. In places the alteration is so complete that individual rock types are no longer recognizable in the field. The silicified rock is very resistant to weathering and has governed the topography in these areas. Minor silicification has occurred along the veins, and in a few places the silicified material is wide enough to be indicated by a pattern on the detailed map of the Lela claim, but in general such material has been mapped as part of the vein.

Ferberite-bearing breccia.--A pre-mineralization breccia cuts the schists and quartzites on the Lela, Genaro, Aguedita, and Ancash claims. After the intrusion of the feldspar-quartz porphyry this breccia was silicified and tourmalinized, especially on the Lela claim, by hydrothermal solutions. Irregular to veinlike bodies of this rock, in part containing coarse to fine ferberite, crop out in the south-central part of the Lela claim, northeast of the Colorado claim. The larger bodies form prominent, isolated pock-marked knobs. Minor masses

occur near the southern end of the Calvache vein, and narrow veinlike bodies, too small to show separately on the map but included with veins, occur on the eastern hills and also on the Genaro, Aguedita, and Ancash claims.

The contacts between breccia and country rock are fairly sharp, especially where the matrix has been tourmalinized, but there are no visible fault planes. Some of the contacts are sharp because of later intrusion of quartz-feldspar porphyry, which may have sealed preexisting fault planes. The finer-grained breccia in some places forms dikelike masses a few inches wide, which may end abruptly in the schists and quartzites.

The breccia, as shown in plate 37, consists of fragments of light-colored schist and quartzite, and rarely porphyry, in a matrix of darker, finer-grained particles. Commonly the fragments have been partly or completely silicified and the matrix has been tourmalinized. The matrix is dark-gray, greenish-black, or black depending on the amount of tourmaline introduced. Small needles of tourmaline cross the boundaries between the matrix and fragments, but the fragments are only in small part replaced. The rock contains cavities up to a foot in size, which are lined with quartz, tourmaline, and ferberite. Coarse crystals of ferberite may line or fill the cavities in either the tourmalinized or silicified breccia. Ferberite is rarely visible in the fine-grained matrix, but irregular masses commonly fill cavities in the matrix. Two rounded grains of ferberite were observed in breccia that appears to flow around them. It is possible that these grains were formed prior to the end of brecciation and owe their shape to rolling movements, but it seems more likely that their shape reflects the original shape of the cavities in which they formed.

The best ferberite is in completely tourmalinized rock that lines cavities, but other masses may be found in adjacent less altered parts of the breccia.

Evidence as to the age of the breccia is contradictory in that, although some of the porphyry clearly cuts the breccia, a few fragments of porphyry appear to be enclosed in it. It is possible that these fragments are irregular projections from adjacent dikes that cut the breccias, sheared off by later movement, but it may be that part of the porphyry is slightly earlier than the brecciation.

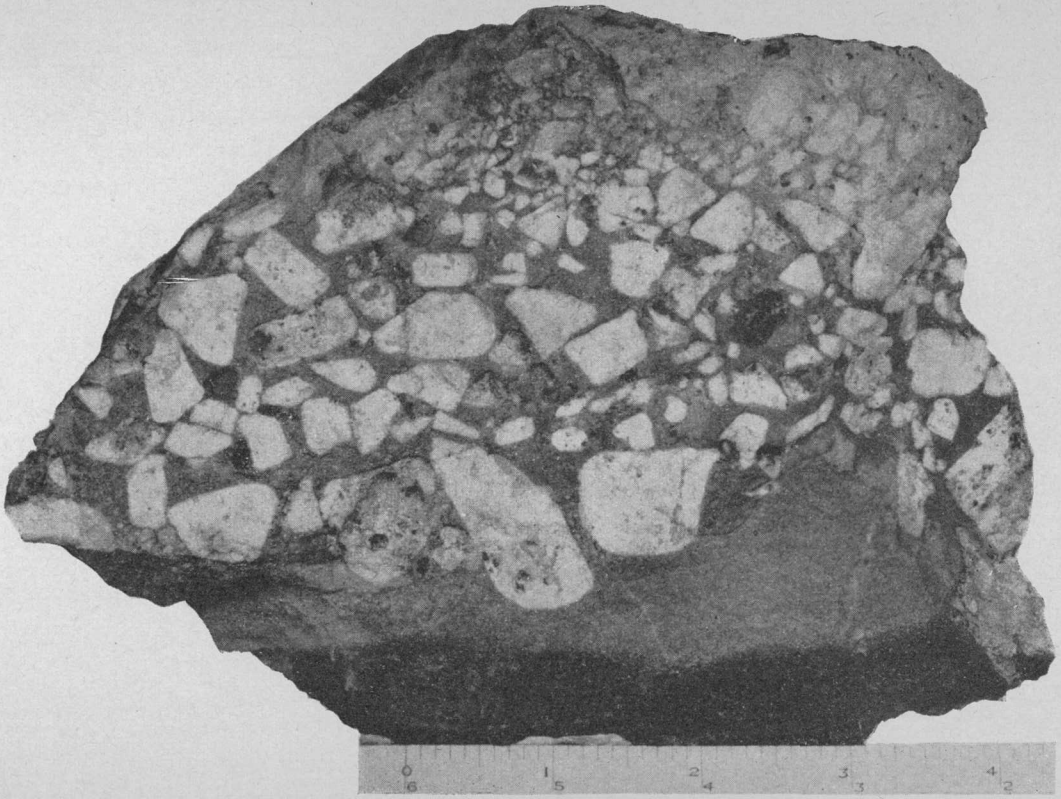
Placer deposits

There are several areas of material in the district that may be workable as placer deposits, but none of them have yet been prospected or tested. These potential placers may be divided into three groups—alluvial deposits, residual deposits near veins, and marine deposits. The most promising alluvial areas that might contain commercial detrital ferberite are as follows (see pl. 34):

1. The gulches between exposures of the No. 7 and No. 6 veins and between No. 14 and No. 15 veins contain ferberite-bearing alluvium. The northern and eastern limits of productive ground cannot be estimated without testing. The depth of the alluvium is indicated in the drainage ditch, where up to 5 feet (1.5 m.) of poorly sorted sandy and gravelly material is exposed. No bedrock and few cobbles more than 4 inches (10 cm.) in diameter were observed in the cuts.

2. The alluvium in the gulch that heads 300 feet (90 m.) southeast of the Pruneda adit might well be expected to contain ferberite at least as far north as the Pruneda shaft.

3. Ferberite float was found in preparing foundations for a house in the alluvial area 400 feet (120 m.) northwest of the Pruneda adit. The most promising part of the area appears



TOURMALINIZED BRECCIA.

The different shades of gray represent different quantities of introduced tourmaline. The dark pitted areas in the matrix and fragments may contain ferberite.

to be near the southwest edge, near the front of the Lomas de Siguanea.

4. Southeast of the Calvache shaft is a small area of alluvium derived from a slope on which the Calvache and other veins crop out. This area is promising, at least in the narrow part of the valley.

5. Alluvium in the valley east of the No. 3 adit, and in the branch that projects toward the Pruneda vein, have possibilities of producing placer ferberite.

6. A small patch of alluvium in the valley, 600 feet (180 m.) north of the southeast corner of the Colorado claim, probably contains some placer ground, for the float on the sides of the valley nearby shows coarse ferberite.

The alluvium in other valleys, especially around the southeastern part of the Lela claim, does not appear favorable, as there is no appreciable quantity of ferberite in the veins on adjacent slopes. These areas should not, however, be neglected entirely in prospecting.

On other claims in the district there are no indications of workable placer deposits, but there may be some ferberite in alluvium near veins now exposed.

The residual placer deposits are much more difficult to delimit than the alluvial placers. Probably the two intergrade and could be worked together. The residual placers must be limited to areas near veins of high ferberite content and can hardly be more than 1 to 2 feet (0.3 to 0.6 m.) thick. The best possibilities for commercial deposits of this material may be outlined as follows:

1. Residual ferberite probably occurs southwest of the Lela shaft, between the No. 1 and No. 14 veins, especially below the 140-foot contour. Narrow areas might be expected to extend south to the top of the hill on either side of vein No. 11.

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2. A strip 100 feet (30 m.) wide in the vicinity of the No. 14-A raise, along the east edge of the valley, might be expected to contain ferberite derived from the No. 14 vein.

3. On both sides of the Pruneda vein there appears to be considerable ferberite float, and commercial quantities might be proved by testing.

4. Probably some workable residual deposits would occur along the Calvache vein, especially within 500 to 600 feet (150 to 180 m.) of the shaft.

5. Along the ridge between the Calvache vein and the Pruneda vein, many small veins very rich in ferberite crop out. Certain areas on the sides of this ridge contain much float, and there may be workable deposits here.

Small residual deposits of this nature may be expected near tungsten-bearing veins in other claims in the district.

The marine sands on the south side of the hills may contain ferberite concentrations, but the overburden is probably great and there is almost no indication as to where such concentrations might be found.

In general the placers will probably be of low grade, and, as the alluvium shows little sorting of material, the chance for concentration of ferberite at any particular horizon is slight.

Mineralogy

The chief ore mineral is ferberite, the iron-rich member of the hubnerite-ferberite series (iron-manganese tungstates), though small quantities of scheelite (calcium tungstate) are found in some veins. The ferberite is called wolframite in the district, but analyses show that the percentage of iron is too high and that of manganese too low to justify that name. An analysis, made by F. S. Grimaldi in the Chemical Laboratories of the Geological Survey, of coarse ferberite from a

tourmaline vein 1,900 feet (580 m.) southeast of the Calvache shaft, on the Lela claim, gives the following result:

WO_3	76.30 percent
FeO	21.35
MnO	1.79
CaO	.20
MgO	.25
	99.89

The ferberite is widely distributed in the veins as crystals lining cavities and as irregular masses filling vugs and surrounding euhedral quartz crystals. It also forms irregular to rounded grains in breccia, irregular grains and veinlets replacing and cutting schist and quartzite, massive aggregates in quartz or tourmaline, and very fine grains widely disseminated in both the vein filling and the replaced wall rocks. The masses and grains of ferberite vary widely in size. Many masses up to 5 inches (12.5 cm.) across have been found; veinlets of nearly solid ferberite an inch (2.5 cm.) or more thick have been followed for a few feet; cavities a foot or two (0.3 or 0.6 m.) long with an inch or more of ferberite on the walls are common in one locality; and individual crystals 2 inches (5 cm.) across have been observed. The average diameter of the grains, however, is less than three-eighths of an inch (1 cm.) and in some veins much of the mineral is in grains of almost microscopic size.

The distribution of ferberite in the veins is erratic, certain parts of the veins being rich and others lean. There is no way of predicting where rich pockets will be found, but many occur where the adjacent part of the vein might be rich enough to mine even without them. In some places ferberite is confined to narrow discontinuous streaks, in others it is rather uniformly distributed throughout the vein. In some places most of the ferberite appears to be in the quartz of the vein; in other places most of it is in the tourmaline or in silicified or tourmalinized wall rock. The largest and

most abundant ferberite crystals are generally in the vuggy parts of the vein or of the mineralized breccia.

Scheelite, the calcium tungstate, occurs in small grains and aggregates that are closely associated with ferberite. On the 225-foot level of the Lela mine, the No. 11 vein contains considerable scheelite that encircles irregular grains of ferberite, and some grains of ferberite up to a quarter of an inch in diameter have been completely replaced by scheelite. Many other veins in the Siguanea district contain small quantities of this mineral.

The principal gangue minerals are quartz and tourmaline. They are accompanied by smaller quantities of arsenopyrite, pyrite, chalcopyrite, pyrrhotite, specular hematite, a bismuth mineral (probably bismuthinite), and carbonate. Sphalerite also has been reported. In oxidized vein matter limonite and other iron oxides are fairly abundant and native copper, malachite, and a yellow tungstic oxide occur in smaller amounts.

The tourmaline in the ferberite veins is colored in various shades of blue, brown, green, gray, and black, but all of it has similar optical properties. Black tourmaline also occurs in some of the pegmatites and massive quartz bodies, but this is the variety schorlite, of distinctive occurrence and optical properties. The tourmaline of the veins is partly in fine-grained dense aggregates, usually dark-colored; partly in fine, fibrous to needlelike, greenish or bluish crystals coating grains of quartz, ferberite, and arsenopyrite; and partly in brownish radial masses and aggregates several inches in length. Individual crystals are rarely so much as one-sixteenth of an inch (1.5 mm.) in diameter. The schorlite in the quartz lenses and pegmatites is in much coarser crystals and is commonly fractured and cut by veinlets of quartz.

The quartz in the veins is partly massive and partly euhedral. The veins east of the iron-stained brecciated zone

are for the most part made up of a loose mesh-work of quartz crystals from an inch to several inches long. In the tungsten-bearing veins the vuggy structure of the quartz has been obscured by fillings of tourmaline and ferberite, and in some places euhedral quartz crystals are isolated in a matrix of these minerals. Much of the quartz, especially in silicified country rock, is fine-grained and cherty.

The arsenopyrite forms euhedral crystals in quartz and cavity fillings around euhedral crystals. Specular hematite occurs in thin plates at the edges of quartz crystals. Pyrite, chalcopyrite, pyrrhotite, and carbonate usually occur as veinlets crossing the vein quartz, but they also fill cavities that are lined with other minerals.

The relative quantity of each mineral differs from vein to vein and also from place to place in individual veins. Some veins consist mainly of quartz, in part milky, in part massive or vuggy, with ferberite filling spaces between the quartz crystals. Others consist of fine-grained, dense, massive quartz and silicified schist, with ferberite disseminated throughout the entire width; still others consist of dense, black, fine-grained tourmalinized rock with disseminated ferberite. Especially common are quartz veins that grade along the strike into tourmaline veins and grade laterally into either silicified or tourmalinized rock.

The sequence of minerals, in the ferberite-bearing veins, as determined by textural relations, is similar to that deduced from the broader field relations. Mineralization began with the introduction of silica, which continued to be deposited until the end of hydrothermal activity in the district. Much of the massive and vuggy quartz in the ferberite-bearing veins, and the larger areas of silicified rock, probably formed before the deposition of ferberite. Both massive quartz and silicified wall rock have been replaced and veined

by ferberite, which also filled cavities around euhedral quartz crystals. A later generation of quartz cuts the ferberite of some veins (pl. 38). The silicification of the wall rocks is believed in part to have preceded tourmalinization and in part to have followed it. In silicified feldspar-quartz porphyry, veinlets of cherty silica are cut by tourmalinized breccia; in other places tourmalinized rock is silicified and crossed by veinlets of quartz.

Ferberite, the second mineral to be introduced, started to crystallize soon after the quartz and was closely followed by arsenopyrite and specular hematite. The veins were fractured and brecciated after much of the quartz and ferberite had formed, but before the tourmaline and more ferberite were introduced. Thus a brecciated ore was formed, in which quartz and ferberite fragments were cemented by tourmaline and a second generation of ferberite.

The widespread tourmalinization of the district began after this period of fracturing and brecciation and continued until the sulfides started to form. Ferberite continued to be deposited during the earlier part of this period, but its deposition had ceased before the sulfides were introduced.

A second fracturing and faulting, which occurred near the end of the tourmalinization, followed earlier lines of weakness. Along the fractures thus formed, pyrite, chalcopyrite, pyrrhotite, spalerite, and carbonate form separate veinlets and replace the earlier vein material. Much of the high-sulfide ore in the Calvache and other veins and in the iron-stained brecciated zone east of the Lela shaft belongs to this part of the mineralization. The alteration of ferberite to scheelite in some of the veins may be related to this last stage of mineralization.

In the upper parts of the veins the primary minerals have been oxidized by meteoric waters to limonite and other iron

oxides, malachite, native copper, and yellow tungstic oxides.

Origin

The ferberite ores were deposited by hydrothermal solutions, which were probably derived from the parent magma of the quartz-feldspar and rhyolite porphyry dikes. It appears likely that the solutions came from a moderately deep source below the southern part of the district, and that they migrated upward and northeastward along a complicated fan-shaped system of fractures and open breccia masses. The large outcrops of silicified and tourmalinized rocks in the south-central part of the Lela claim suggest that the source of the solutions that formed most of the veins was underneath this area. The Calvache and associated veins may have been derived from another buried center of hydrothermal activity. The character of the veins east of the iron-stained brecciated zone suggests that they either were derived from still another center or were formed at a different time than the ferberite-bearing veins.

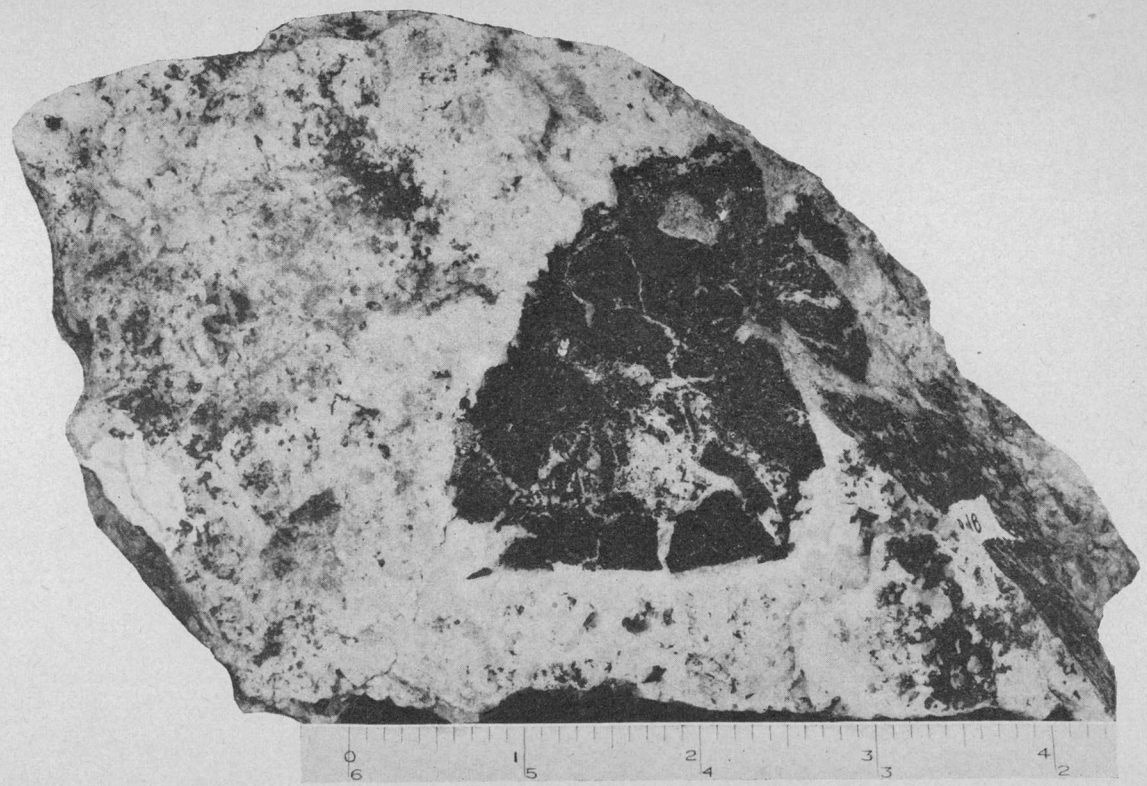
The divergence of the veins from the large area of silicified rock on the Lela claim suggests that this area was also the center of the deformation that produced the mineralized fracture system. A fracture system of this type might have developed as a result of faulting or folding, or it might perhaps have been formed above the top of an igneous mass forcibly intruded below this area. The intense alteration in this area, as well as the presence of coarse ferberite in cavities in tourmalinized rock, indicate that solutions were more abundant, and the temperature at which the ferberite formed was longer maintained here than in the veins farther to the north. In the district as a whole, there is a general decrease northeastward in the quantity of ferberite and tourmaline along the trend of any single group of veins. No ferberite and little

tourmaline was found 12,000 feet (3.7 km.) beyond the strongly silicified area. At the edges of the mineralized area, the maximum distance of known tungsten mineralization from the supposed source is only 8,000 feet (2.4 km.). The northern extension of the tungsten vein system is represented by sulfide veins and by sulfides disseminated in schist and quartzite. It is supposed from these field relations that the sulfides crystallized at lower temperature than the ferberite. As the sulfide veinlets cut across the ferberite-bearing veins near the silicified area, they must have been formed late in the period of mineralization.

One reasonable explanation of the facts would seem to be that the solutions emanated from the southern part of the district and moved northeastward, depositing ferberite in favorable places near the source and sulfides at greater distances. Yet it is also possible that the change in the character of the veins is related not to the horizontal distance from a small area in the southern part of the district but to the vertical distance down to an igneous mass that underlies the entire vein zone and that is farther below the surface at the northern than it is at the southern end. The former view would imply a horizontal zoning, whereas the latter view would imply a vertical zoning of minerals. There is no evidence to eliminate either possibility, and both conditions may well coexist.

Localization

Ferberite has been observed throughout an area 12,000 feet (3.7 km.) long and 5,000 feet (1.5 km.) wide, but most occurrences having possible economic importance are localized in an area approximately 2,800 feet (0.8 km.) wide and 6,000 feet (1.8 km.) long. This area appears to be limited on the west by the Calvache vein and on the east by the iron-stained



COARSE FERBERITE ORE (BLACK) VEINED WITH QUARTZ.

brecciated zone. Most of the veins found to the east of this zone are composed of a mesh-work of euhedral quartz and contain little tourmaline or ferberite. Most of the tourmaline is in the matrix of narrow breccia bands, along fault planes, and in narrow veins near the iron-stained brecciated zone. A few grains of ferberite were observed in one of these veins.

Ferberite was observed in a vein west of the Calvache vein, on the Genaro claim. Other veins west of the Calvache vein system appear to be of favorable structure and composition, so that they may well contain ferberite.

No mineralogic type of vein can be definitely eliminated as a possible source of ferberite, but it seems likely, from examination in the field and development work to date (November 1941) that the veins east of the iron-stained brecciated zone, which are composed almost entirely of euhedral quartz, are barren of ferberite. Some of the streaks of hard, dense, tourmalinized rock that trends across the structure of the veins may perhaps be eliminated as possible sources of ore bodies, but ferberite is difficult to observe in such rocks, especially on weathered outcrops. Tourmalinized breccias and veins appear to offer more promise of containing ore bodies. Silicified rocks adjacent to veins, especially silicified breccia, may be expected to contain ore bodies, but the larger areas of silicified rock are probably barren.

The distribution of small high-grade ore bodies in tourmalinized or silicified breccia is controlled by the open spaces that existed prior to introduction of hydrothermal solutions. Many of the breccias observed in the area had a very fine grained, dense matrix of rock grains and fragments before alteration, and these breccias do not contain visible ferberite. The breccias that contained cavities before the addition of silica and tourmaline, or in which solution cavities developed during alteration, may contain small ore bodies. The

ferberite in these ore bodies will be limited to the breccia except for minor quantities formed by the replacement of adjacent wall rock.

Development work up to November 1941 had not been sufficient to reveal the shape and localization of the mineralized bodies in the quartz-tourmaline veins. The bodies are lenticular, and in places they appear to pitch southward. Ore is exposed on the No. 1 adit level 100 feet (30 m.) north of the Lela shaft, but is not exposed north of the shaft on the 125-foot level though cut by the shaft at 96 feet (29 m.). Likewise, other bodies cut on the 125-level were not cut by the No. 201 crosscut W. on the 225-foot level. There is evidence also that some of the bodies may pitch north, or that one edge of a body may pitch south and the other north. These mineralized bodies may be either in the quartz-rich or in the tourmaline-rich parts of the vein. Within any particular shoot there will be both high-grade pockets and barren masses. The shoots in general appear to be in the thicker parts of the veins, although in the No. 11 vein, north of the No. 4 crosscut W., the ore contains closely spaced stringers of ferberite and quartz.

Size and grade

No ore body in the Siguanea district has been completely delimited, but from surface indications and present development it seems likely that some may be as much as 1,000 feet (300 m.) long, and for short distances some are as much as 10 or 12 feet (3 or 3.6 m.) wide. The longest continuous vertical exposure at present in the underground workings is 170 feet (52 m.), but some of the veins may well extend vertically more than 250 feet (75 m.). Table 7, page 207, shows the dimensions of possible ore bodies indicated by development work in the Lela mine. It will be noted that in vein No. 11

Table 7.--Dimensions of mineralized bodies, Lela mine

Vein	Length on 125-foot level			Width (inches)			Average vertical distance to surface (feet)	Remarks
	Vein (feet)	Ore shoots		Minimum	Maximum	Average		
		Number	Total length (feet)					
No. 1	340 (400)*	2	190 (250)	12	48	24	140	Southern limit unknown.
No. 2	445	1	300	12	36	24	100	100 feet on 225-foot level. 1-5 feet thick.
No. 6	110 (250)	1	(100)	8	15	12	120	.....
No. 6A	(75)	1	(50)	10	12	10	100	Limits of ore body unknown.
No. 7	360 (500)	2	290 (350)	12	66	18, 30	160	Southern limit of ore body unknown.
No. 7A	(115)	1	(115)	12	36	24	80	Limits of ore body unknown.
No. 7B	(35)	1	(35)	10	10	10	80	Limits of ore body unknown.
No. 11	515 (675)	1	300 (400)	6	60	18	160	Southern limit unknown. Some ore in closely spaced stringers and on 225-foot level.
No. 14	75 (350)	1	(70)	24	24	24	100	High-sulfide ore 5 feet thick where cut on 225-foot level. Also parallel vein 40 feet west with 48 inches of ore.

* The figures in parentheses give totals including work reported by W. M. Archibald after examination by the Geological Survey.

the largest mineralized body developed is 400 feet (122 m.) long, 160 feet (49 m.) in vertical dimension, and 5 feet (1.5 m.) in greatest thickness. Not enough development work has been done on veins beyond the limits of the Lela claim to give any adequate idea as to the size of possible ore bodies.

Prior to November 1941, at least four and possibly six ore bodies were partly developed on the 125-foot level of the Lela mine in veins Nos. 1, 2, 7, and 11. Veins Nos. 6 and 14 were expected to show ore on further development. Only the No. 2 vein showed promise of ore on the 225-foot level. It is reported that additional work has proved extensions of these known ore bodies. Possible ore shoots are said to have been discovered in veins Nos. 6 and 14, and also in veins Nos. 6A, 7A, and 7B on the 125-foot level and in Nos. 2, 11, and 14 on the lower level.

The Pruneda vein, from surface exposures and a small amount of underground work, appears to contain larger and richer ore shoots than those explored in the Lela mine. Many other veins, including the Calvache, contain ore bodies that are less well developed. These veins are described elsewhere in this report.

One small deposit of ferberite in tourmalinized breccia is exposed on the top of the ridge in the south-central part of the Lela claim, 2,140 feet (650 m.) southeast of the Calvache shaft. The ore body is 10 feet (3 m.) wide and crops out in a cliff about 20 feet (6 m.) high and 25 feet (7.5 m.) long. The coarseness and irregular distribution of the ferberite make any visual estimate of its quantity hazardous, although the body appears to be high-grade.

The grade of ore varies considerably from vein to vein, and from place to place along individual veins. No accurate estimate of grade can be made without much sampling, preferably bulk samples put through a mill, because of the apparently

spotty nature of the ore. It is hoped that heads containing at least 1 percent WO_3 can be maintained.

The grade of the possible placer deposits is unknown, but it is believed that much of the alluvial material in the district is worth testing. Small amounts of residual debris near some of the vein outcrop might be expected to produce ferberite.

Reserves

Not enough development work had been done at the time the writers made their examination (1941) to permit satisfactory estimation of potential tonnage and grade. At that time the probable reserve of tungsten ore was estimated as about 55,000 tons containing approximately 750 tons of WO_3. These figures were based on visual estimates of grade plus a very few assays, made available by W. M. Archibald, and calculations from the grade of the few tons of ore mined and milled in 1939. Additional development work at the Lela mine is reported to have disclosed ore in at least seven veins, most of which do not appear on the surface above the workings. The bodies observed have been extended by drifts, and ore has been blocked out by raising. From these reports it appears likely that the tonnage of probable ore is greater than estimated, and that with continued development even larger reserves will be proved.

The tonnage of possible ore present in the district is fairly large, for, in addition to the 37 veins described in this report, there are other veins in which further underground exploration might be expected to reveal ore bodies. Past experience shows that in this district even the smallest of veins may widen to commercial size along either its strike or dip.

The placer deposits on the Lela property might yield a fairly large quantity of ferberite concentrates. There is nearly 400,000 square yards of surface underlain by alluvium that might possibly yield alluvial tungsten.

MINING AND PROSPECTING

The Lela claim is by far the most thoroughly prospected portion of the Siguanea district and includes the only active mine. Development work on the other claims of the district has been limited to shallow, unsystematic surface trenching.

Lela claim

The main workings on the Lela claim are the Lela mine and Pruneda shaft. Two other prospect shafts, three adits, and a number of pits and trenches prospect other parts of the property.

Lela mine.--The Lela mine (pl. 40) consists of a 240-foot (73 m.) three-compartment shaft, from which lateral workings extend on the 125- and 225-foot levels. At the time of the writers' examination, in November 1941, the workings included 995 feet (303 m.) of crosscuts and 1,920 feet (585 m.) of drifts on the 125-foot level; 550 feet (168 m.) of crosscuts and 25 feet (7.5 m.) of drift on the 225-foot level; and three raises, totaling 330 feet (100 m.) between the 125-foot level and the surface. Additional development work done since that time includes 415 feet (127 m.) of crosscuts and 1,050 feet (320 m.) of drifts on the 125-foot level, and three raises from that level to the surface; on the 225-foot level, 60 feet (18 m.) of crosscuts, 175 feet (53 m.) of drifts, and two raises to the 125-foot level have been made.

Two small stopes were made in 1939 in the No. 2 drift N. and the No. 1 drift S., from which about 100 tons of rock was taken. The stope on the No. 2 vein is 15 to 18 feet (4.5 to

5.5 m.) high, about 80 feet (24 m.) long, and 6 to 8 feet (1.8 to 2.4 m.) wide; that on the No. 1 vein is 40 feet (12 m.) long, 6 to 8 feet high, and 6 to 8 feet wide. It is said that chutes have been prepared for stoping operations in the No. 1 drift N., No. 2 drift N., No. 6 drift S., No. 7 drift N. and S., No. 11 drift N. and S., and No. 14 drift S.

The country rocks are strongly jointed and sheeted mica schist, quartz-mica schist, and quartzite, intruded by dikes of feldspar-quartz porphyry. The rocks are thoroughly weathered on the 125-foot level, but are fresh on the lower level except for minor weathered zones along fractures and veins. The schists and quartzites in the upper levels, especially near the veins, are so strongly jointed that the rock breaks into small pieces, and in places the veins themselves are similarly jointed. This condition will be a material handicap in stoping.

The porphyry dikes, though somewhat irregular, have a more easterly trend than the veins. A vein, after paralleling the dikes for a short distance, may pass through the porphyry, where it breaks down into thin stringers and ill-defined masses of tourmalinized rock, then resumes its usual character on re-entering the schist. The porphyries act as channelways for considerable quantities of water. One rhyolite porphyry dike, 3 to 4 feet (0.9 to 1.2 m.) wide, crosses the veins exposed in the No. 1, No. 6, No. 7, and No. 11 drifts with a straight course of N. 55° W. This dike was also identified in the lower level.

Six veins containing ore bodies were observed on the 125-foot level and two on the 225-foot level. Development work in the No. 3 crosscut W., completed after the examination, found either extensions of these or three entirely new veins. A 5-foot (1.5 m.) vein was also reported in the No. 9 crosscut E. The No. 4 crosscut W. crosses four other veins, 6 to 12 inches

(15 to 30 cm.) thick, which might be expected to become stronger along the strike or dip. In addition to all these, more than 38 veins 1 to 6 inches (2.5 to 15 cm.) thick are crossed by the workings. Only the important veins need be described individually.

The No. 1 vein (pls. 34, 39, and 40) can be traced for 420 feet (128 m.) on the surface, for 230 feet (70 m.) on the No. 1 adit level, and for 400 feet (122 m.) in the No. 1 drift S. It is followed by the No. 1-A raise, and it is also intersected by the shaft at 96 feet (29 m.), but it feathers out northward and appears in the No. 3 crosscut as a group of narrow stringers. This vein was not recognized on the 225-foot level.

On the surface, where the vein is locally as much as 5 feet (1.5 m.) thick, it is composed of silicified and tourmalinized schist with a center of massive to crystalline quartz. North of the No. 1-A raise it consists of silicified breccia 3 to 4 feet (0.9 to 1.2 m.) thick. It appears to intersect the vein designated as No. 1-A near the water tank. The No. 1-A vein, though poorly exposed, probably persists under the flat northeast of the old Vanadium Corporation trenches to the silicified and brecciated vein zone in the Mercedes claim. To the south, scattered outcrops of vein quartz, tourmalinized and silicified porphyry, and schist suggest that this vein extends across the hills. It may represent one of the main channelways followed by the ore solution. It also marks the western edge of the iron-stained brecciated zone. Outcrops suggest that there are other subsidiary veins.

On the adit level the No. 1 vein is composed of vuggy quartz, which is 40 inches (1 m.) thick in places, and of brecciated quartz in a tourmaline matrix. Ferberite was observed in both the quartzose and the tourmaline-rich

material. Similar material is found on the 125-foot level, but here the vein rarely exceeds 30 inches (76 cm.) in thickness.

In the No. 1 adit (pl. 39) this vein strikes N. 5° E. except at the north end, where it strikes N. 25° E., and dips 55° to 60° NW. At the south end of the adit it splits; the main vein south of the fork strikes N. 15° W. and dips 55° SW. and the lesser branch strikes N. 35° E. and dips 75° SE. On the 125-foot level the vein strikes N. 10° E. and dips 55° to 60° NW. in the northern end of the No. 1 drift S., and strikes N. 20° E. and dips 60° to 90° NW. in the southern part of the same drift.

Where it is crossed by prominent sheeting zones, the vein is brecciated and consists largely of tourmaline. In these places the rocks adjacent to the vein are impregnated with quartz and tourmaline. The less brecciated ~~vein matter~~ is mainly quartz, but ferberite and a little sulfide are visible in most of the exposed portion. The vein is in part weathered, and near the No. 4 crosscut W. it carries large quantities of iron oxide, in which wires of native copper occur. On the 125-foot level the ore body is at least 250 feet (76 m.) long and 12 to 48 inches (30 to 122 cm.) thick, averaging 24 inches (60 cm.).

The vein called the No. 2 on the 125-foot level cannot be definitely identified on the surface, and the vein thus designated in plate 34 may be the subsidiary vein No. 2-A, which is also exposed on the 125-foot level. It can be traced on the surface for 160 feet (50 m.) and contains 6 to 10 inches (15 to 25 cm.) of quartz with ferberite.

On the 125-foot level (pl. 40) the No. 2 vein is exposed for 445 feet (135 m.) in the No. 2 drifts N. and S. and is also exposed in the No. 2-A raise. The ore body is about 300

feet (91 m.) long. The middle 150 feet (46 m.) of the ore body is mainly quartz and 30 to 36 inches (76 to 91 cm.) thick; the ends are largely brecciated quartz and tourmaline. The vein pinches out in both directions and is represented in the No. 4 crosscut W. by 1- to 2-inch (2.5 to 5 cm.) stringers. The vein strikes about N. 20° E. and dips 50° to 60° NW., though there are local dips as high as 70°. Ferberite is present throughout the length of the vein, but the deposit will probably suffer some dilution in stoping because of the highly fractured nature of the wall rock. A composite sample of ore mined from this vein in 1939 is said to have assayed slightly over 1 percent of WO_3, and calculations of concentrates recovered and losses in milling checked this figure.

In the No. 201 crosscut (pl. 40) this vein, where it was cut 142 feet (43 m.) west of the shaft, was 12 inches (30 cm.) wide and contained coarse ferberite, sulfides, quartz, and tourmaline. It is reported that on drifting 35 feet (10.6 m.) north the vein was found to widen to 5 feet (1.5 m.), but it narrowed at 100 feet (30 m.), where a raise was started. The wide part of the vein and the drift south are reported to be in ore.

The No. 6 vein, 150 feet (45 m.) west of the No. 1 vein, is poorly exposed on the surface, but it can be seen to be a quartz vein, containing ferberite where its walls are schist, and a tourmalinized zone where it crosses feldspar-quartz porphyry. On the 125-foot level (pl. 40) it strikes about N. 10° E. and dips 80° NW., and is exposed for about 250 feet (76 m.) as an 8- to 15-inch (20 to 38 cm.), highly fractured and sheared quartz vein containing sulfides and ferberite. Recent development is reported to have disclosed a mineralized shoot 150 feet (45 m.) long. This vein may intersect the No. 1 vein down dip and along the strike to the south; to the north it may connect down dip with the No. 2 vein. The No. 2-A vein is

probably an offshoot of the No. 6. Although narrow, it contains considerable ferberite.

In the No. 3 crosscut W., a vein along the west side of a porphyry dike, designated as the No. 6-A vein, is reported to contain 10 inches (25 cm.) of quartz with WO_3. This is said to die out southward against porphyry and to widen northward. It strikes about N. 10°-15° E. and dips 80° NW., probably connecting with vein No. 2 at depth.

The No. 7 vein is exposed on the surface at the east end of the long east-west trench 450 feet (137 m.) southwest of the Lela shaft. There are two small offshoots on the hanging-wall side, 20 feet (6 m.) north and 100 feet (30 m.) south of the trench, which may be traced toward the No. 11 vein for 50 feet (15 m.). The main No. 7 vein can be traced 140 feet (42 m.) northward to its intersection with porphyry, where it is covered with alluvium, and 180 feet (55 m.) southward to the No. 7-A raise, where it is almost on the porphyry contact. South of the raise it cannot be definitely traced, but it probably is represented by vein outcrops 100 feet south, which intersect the No. 11 vein near the top of the hill.

Underground the No. 7 vein (pl. 40) is exposed for approximately 500 feet (152 m.) in the No. 7 drift, but possible ore is limited to 350 feet (106 m.). There are two separate mineralized bodies, one of which begins 80 feet (25 m.) north of the No. 4 crosscut W. and extends 70 feet (21 m.) along the No. 7 drift S. A body of schist 40 feet (12 m.) long and up to 5 feet (1.5 m.) wide is enclosed in ore 30 to 36 inches (75 to 90 cm.) thick. South of this schist the vein is 20 to 36 inches (50 to 90 cm.) thick; just to the north it is 48 inches (120 cm.) thick, but it thins rapidly northward and splits north of the rhyolite dike. South of the No. 4 crosscut W. the vein dips 70° NW., but to the north it is nearly vertical.

At the north end of the drift the vein is represented by stringers that dip 70° to 75° SE.

The second mineralized body starts 40 feet (12 m.) south of the one described above and is at least 200 feet (60 m.) long. It has been followed to the surface by the No. 7-A raise. In the drift the vein is 12 to 36 inches (30 to 90 cm.) wide, averaging 18 inches (45 cm.), but in the raise it is reported to average 24 inches (60 cm.) and to be, in places, as much as 5 feet (1.5 m.) thick. The ore shoot dips 70° to 75° NW., and it may be connected, above the 125-foot level, with the other ore shoot, as the vein between appears to have been thinned by postmineral faulting. Iron sulfides are abundant on these faults.

In the No. 9 crosscut E. there is said to be a 5-foot (1.5 m.) vein that may be an offshoot of the No. 7. Two other promising veins, No. 7-A and No. 7-B, are said to be exposed in the No. 3 crosscut W. The No. 7-A vein is 1 to 3 feet (0.3 to 1 m.) thick and has been exposed for 115 feet (35 m.) in the drift. The No. 7-B is 10 inches (25 cm.) wide and has been drifted on for 35 feet (10 m.). Both dip 80° NW. and both contain ferberite. These are represented on the 225-foot level by narrow stringers.

The map suggests that the No. 7 vein may be expected to join the No. 11 vein about 350 feet (107 m.) south of the present workings, almost directly beneath the intersection of these veins on the surface. This vein is similar in mineral composition to the others in the Lela mine, but in its wider parts it contains a larger proportion of silicified and tourmalinized wall rock. Assays are said to show that this mineralized wall rock contains as high a percentage of tungsten as the parts of the veins that appear to be fracture fillings. The postmineral fault fissures are occupied by pyrite veins, but these do not contain ferberite.

The No. 11 vein, 120 feet (36 m.) west of the No. 7, can be traced almost continuously on the surface for at least 1,400 (425 m.) and possibly 1,700 feet (520 m.). Through a vertical range of 180 feet (55 m.) the vein, which contains as much as 24 inches (60 cm.) of quartz, is in the middle of a tourmalinized, silicified, and brecciated zone 15 feet (4.5 m.) in maximum width. In places the wall rocks have been altered to tourmaline schist or gneiss. Ferberite was observed only on the north side of the hill; none was seen in the veins, east of the No. 11 vein and roughly parallel to it, that are well exposed on the south side of the hill.

The No. 11 vein has been explored by drifting on both the 125- and 225-foot levels. Throughout most of the No. 11 drift the vein consists of a single quartz-tourmaline vein whose wall rocks are more or less replaced, but in the northern part of the drift the vein splits or "horsetails out" into a number of thin stringers, many of them rich in ferberite. Between these stringers the schist is strongly silicified. The thickness of the vein ranges from 6 to 60 inches (15 to 150 cm.), averaging 18 inches (45 cm.) between the face and a point 80 feet (24 m.) north of the No. 4 crosscut W. North of this point one to four stringers, up to 6 inches (15 cm.) thick, occur in a silicified zone 6 to 12 feet (1.8 to 3.6 m.) wide. Small parts of this section may be rich enough to stope, for some of these narrow veins contain as much as 50 percent ferberite. A small mass of schist included in the vein just north of the No. 4 crosscut W. splits the 60-inch (1.5 m.) vein into two parts. South of the schist the thickness of the vein is from 12 to 30 inches (30 to 76 cm.) except for a 25-foot (7.5 m.) section that is thinned to 6 or 8 inches (15 or 20 cm.) by faulting. The vein dips 70° to 80° NW. except on the footwall split north of the schist inclusion, where the dip is 80° to 90° NW.

The No. 11-A raise, 200 feet (61 m.) south of the No. 4 crosscut W., followed the vein to the surface. Here the vein averaged 18 inches (45 cm.) in thickness but in places it was 4 to 5 feet (1.2 to 1.5 m.) thick. It is said that a 35-foot (10.6 m.) section just below the surface contained high-grade ferberite, although the average ore in the vein was not high-grade.

On the 225-foot level the No. 11 vein is exposed in the No. 202 drift S. In the No. 201 crosscut W. it is 2 to 5 inches (5 to 13 cm.) thick and contains ferberite, in part altered to scheelite. Here it strikes N. 35° E. and dips 55° SE., but in the drift to the south it becomes stronger and has the same attitude as on the 125-foot level. A raise on this vein shows ore.

The No. 14 vein has been traced continuously on the surface for 1,000 feet (305 m.) south of the No. 14-A raise. It does not crop out strongly for the first 300 feet (91 m.), but it is prominent farther south, where it consists of 8 to 24 inches (20 to 60 cm.) of quartz in an altered zone up to 5 feet (1.5 m.) thick. The No. 14 vein has been exposed for 350 feet (107 m.) on the 125-foot level and is said to be exposed in the No. 201 crosscut W. on the 225-foot level. In the No. 4 crosscut W. it is a zone of dark, dense, tourmalinized and silicified schist 4 feet (1.2 m.) wide. South of the No. 14-A raise the vein averages 24 inches (60 cm.) thick and contains from 10 to 18 inches (25 to 45 cm.) of quartz. One ore shoot, 165 feet (50 m.) south of the crosscut, continues to the south for 70 feet (21 m.). Specimens reported to come from this ore shoot indicate that the 10-inch (25 cm.) quartz center may contain considerable WO_3. There is some fine-grained ferberite in the tourmalinized walls. On the 225-foot level, this vein is up to 4 feet (1.2 m.) wide and contains very fine grained ferberite and considerable iron and copper sulfide.

The No. 14-A vein, 40 feet (12 m.) west of the No. 14, is 4 feet (1.2 m.) thick, and has good possibilities of ore.

On the surface, about 90 feet (27 m.) east of the No. 14-A raise, a 12-inch (30 cm.) quartz vein, the No. 12, strikes N. 10° E. and dips 60° to 65° NW. toward the No. 14 vein. Ferberite is present in the float of the No. 12 vein for a distance of 240 feet (73 m.), and this vein would seem to be one of the more promising from its surface exposures, although it is not of commercial size on the 125-foot level.

The No. 4 shaft, 1,080 feet (330 m.) N. 6° W. of the Lela shaft, is probably on either the No. 15 or a subsidiary vein of the same group. This is a 10- by 6-foot (3 by 1.8 m.) prospect shaft about 20 feet (6 m.) deep, inclined 70° to the southeast. It was sunk on a mineralized zone 6 feet (1.8 m.) wide which strikes N. 38° E. The hanging wall of the vein is porphyry and the footwall gray quartz schist. Ferberite was observed at the point where the shaft started but did not continue with depth.

The No. 15 vein crops out 300 feet (91 m.) west of the No. 14-A raise as a well-defined rib of ferberite-bearing quartz and silicified schist. It strikes N. 30° E. and dips 75° SE. Where cut by the No. 4 crosscut W. on the 125-foot level, it is 10 to 12 feet (3 to 3.6 m.) wide but is split by rhyolite porphyry. Its western part contains some ferberite. This vein appears to be in a major fracture, from which at least four strong ferberite-bearing veins split off, as indicated in structure section A-A' in plate 34. The No. 15 vein probably intersects the No. 14 vein about 500 feet (152 m.) below the surface. The No. 16 and No. 15 veins may intersect south of the exposures of the No. 15 vein.

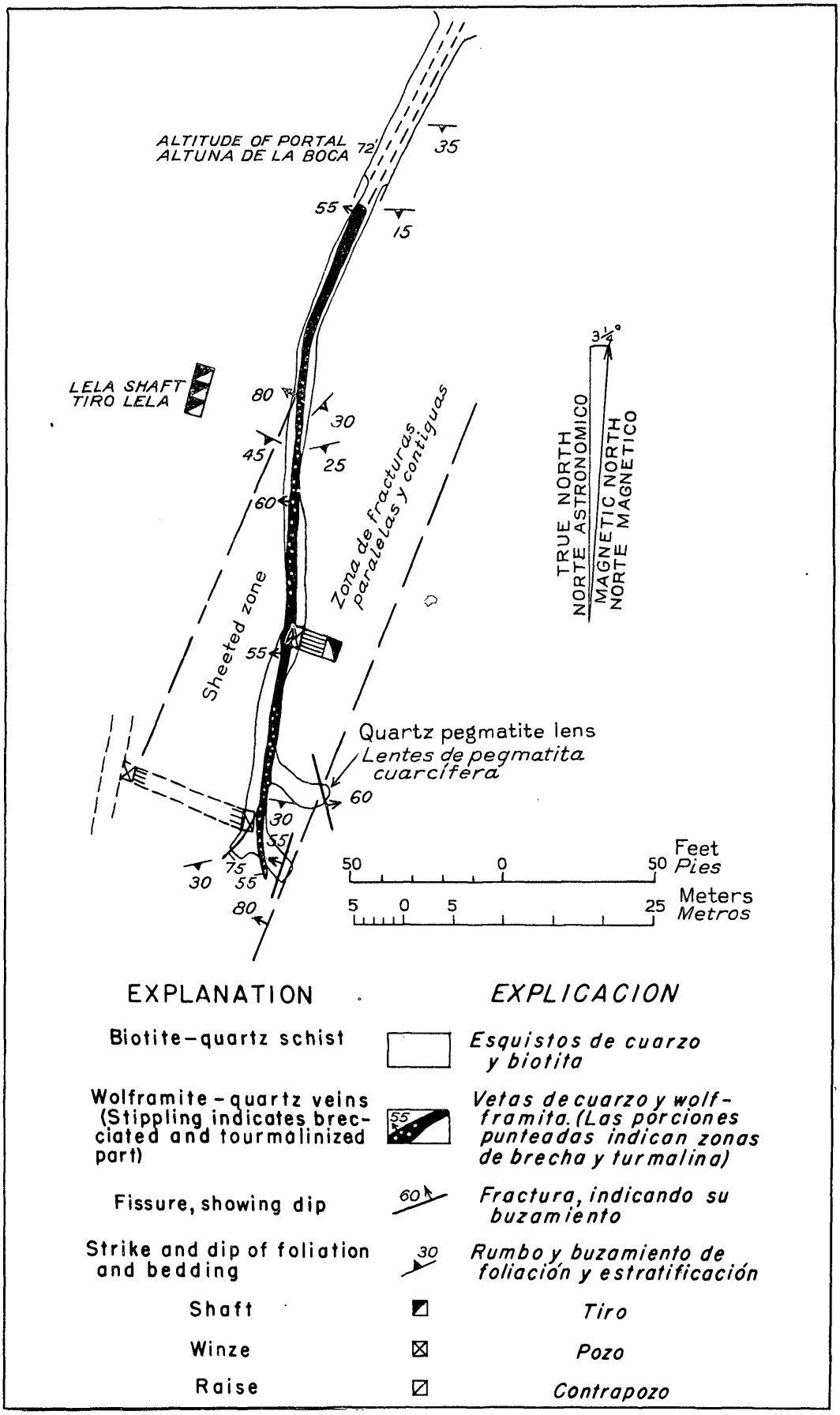
The No. 16 vein is exposed for 400 feet (122 m.) about 80 feet (24 m.) west of vein No. 15, along the north side of the hill. The northern part of the outcrop shows a strike of

N. 18° E.; in the southern part the strike is N. 23° E. and the dip 80° SE. About 150 feet (45 m.) of the vein is in schist and the remainder in porphyry. This vein has not been cut by underground workings.

Small exposures and float on the trend of this vein, 360 feet (110 m.) east of the Pruneda shaft, contain considerable ferberite.

Pruneda shaft.--The Pruneda two-compartment shaft, 1,390 feet (423 m.) northwest of the Lela shaft, prospects the Pruneda or No. 18 vein. It was about 160 feet (50 m.) deep at the time of examination. Two short crosscuts extend west from it to the vein on the 60- and 100-foot levels. It is planned to continue the shaft to 200 feet (60 m.) and to connect it by means of lateral workings with the No. 201 crosscut W. of the Lela mine, and also to prospect the ferberite-bearing vein that crops out 200 feet west of the Pruneda vein. The Pruneda vein has been stripped for 130 feet (40 m.) south and 60 feet (18 m.) north of the shaft, and also along a stretch 260 to 440 feet (80 to 135 m.) north of the shaft. Cross trenches have been made 190, 280, 330, 420, 500, 650, and 780 feet (58, 85, 100, 128, 152, 198, and 238 m.) south of the shaft.

The Pruneda vein (pl. 34) is the most promising member of the largest vein system in the area. The system includes veins No. 18 (Pruneda), 18-A, 19, 19-A, 19-B, 19-C, and 20, as well as unnumbered vein outcrops northeast of the shaft, and it can be traced intermittently for about 4,400 feet (1,340 m.). The Pruneda vein is traceable for 1,500 feet (457 m.) between its outcrop above the Pruneda adit and the place where it feathers out northeast of the shaft. The ore bodies are probably a series of closely spaced overlapping lenses rather than a single continuous vein filling. They occur in a zone 6 to 8 feet (1.8 to 2.4 m.) wide.



GEOLOGIC MAP OF THE NO. 1 ADIT, LELA CLAIM
ISLA DE PINOS, CUBA

PLANO GEOLOGICO DEL SOCAVON NO. 1, CONCESION LELA, ISLA DE PINOS, CUBA

The most northerly trench on the vein exposes 180 feet (55 m.) of vein material from 2 to 4 feet (0.6 to 1.2 m.) thick. At the southern end of this trench a vertical quartz lens, 6 to 12 inches (15 to 30 cm.) wide and 30 feet (9 m.) long, occupies the center of a 2-foot (0.6 m.) zone of silicified and tourmalinized schist. To the north, the vein is 4 feet (1.2 m.) wide and composed of black tourmaline rock that strikes N. 13°-30° E. and dips 75° NW. Ferberite was not observed in place but was found on the dumps. Immediately north of the shaft a trench exposes two lenses of vein material separated by 3 feet (1 m.) of schist. The western lens, which strikes N. 18° E., consists of 12 to 18 inches (30 to 45 cm.) of quartz enclosing a little tourmaline. The other, which crops out only in the northern end of the trench, is 12 inches thick, consists mainly of quartz, and dips 75° NW. The long trench south of the shaft was filled with water and caved at the time of examination, but the main vein there is said to have been 5 to 6 feet (1.5 to 1.8 m.) thick. Near the shaft the vein strikes N. 27° E. and is vertical; in the southeast corner of the trench it strikes N. 23° E. Apparently the vein was irregular and had numerous stringers projecting from its eastern wall. In the crosscut on the 60-foot level the vein is about 5 feet (1.5 m.) wide and is mainly tourmaline and silicified rock, but on the 100-foot level, where the vein is 5 feet thick, it is largely quartz, with some tourmaline rock at the edges. At a point 10 feet (3 m.) west of the shaft, where the vein strikes N. 18° E. and dips 85° NW., the footwall is cut by a fracture striking N. 23° E. and dipping 65° NW., and a 12-inch rhyolite porphyry dike, dipping 70° NW., splits the vein along the middle. Ferberite is present throughout the mineralized zone in these underground exposures; large masses of it fill cavities lined with euhedral

quartz, and small grains are disseminated in the massive quartz and in the tourmalinized part of the vein. Arsenopyrite fills cavities and is enclosed in the quartz. Seams of pyrite, chalcopyrite, and greenish or brown tourmaline cut the other minerals.

Between the Pruneda adit and the shaft the vein is exposed in seven cross trenches, but these were filled with water and slumped so that no detailed examination of them was possible. There are many exposures between the trenches, but they are all small. A composite sample from vein material in the trenches is reported to have assayed about 2 percent of WO_3. The first trench, 190 feet (58 m.) south of the shaft, shows vuggy quartz and ferberite, which may be followed by float and small outcrops S. 8° W. to the second and third trenches, where 2 feet (0.6 m.) of crystalline quartz, tourmaline, and ferberite is exposed. In the fourth trench the vein is split by 2 feet of red clay, probably representing a weathered rhyolite porphyry dike that strikes N. 24° E. and dips 80° NW. The vein material east of the red clay is $2\frac{1}{2}$ feet (0.7 m.) thick and that west of it 1 foot (0.3 m.) thick. In the eastern part there is 12 inches (30 cm.) of massive quartz, enclosed in dark green to brown tourmaline containing scattered euhedral quartz crystals. Ferberite is present in both the quartz and tourmaline. South of the trench the vein is mostly tourmaline, with 25 to 30 percent of scattered euhedral quartz. It can be traced to the fifth trench, where it is also split by red clay; here the eastern part is 12 inches thick and the western part 1 to 2 feet (0.3 to 0.6 m.) thick.

On the south side of the alluvium-filled gulch a trench cuts three veins. Here again the Pruneda vein is divided into two parts by 18 to 36 inches (45 to 90 cm.) of red clay. The western part, 2 feet (0.6 m.) thick, is separated by $2\frac{1}{2}$ feet (0.7 m.) of schist from a $3\frac{1}{2}$-foot (1 m.) vein, striking

N. 13° E., which has been designated as No. 18-A. Another vein, 6 inches (15 cm.) thick, striking N. 28° E., and dipping 75° SE., is 6 feet (1.8 m.) west of the No. 18-A. Other trenches, 120 feet (36.4 m.) to the south, started just west of the Pruneda vein and cut two 3- to 4-inch (7.6 to 10 cm.) veins, separated by 6 inches of schist, that strike N. 23° E. and dip 70° SE. The Pruneda vein continues as a 2- to 4-foot (0.6 to 1.2 m.) silicified and tourmalinized zone from east of these pits to the Pruneda adit and vein No. 19.

Pruneda adit.--The Pruneda adit (pl. 41), 1,100 feet (335 m.) south of the Pruneda shaft, started on the Pruneda vein, which thins southward to a narrow stringer 125 feet (38 m.) in from the portal. About 600 feet (180 m.) of crosscuts and drifts explore three weak veins in feldspar-quartz porphyry and schist. A raise to the surface followed the most easterly of these veins, but the vein is said to have been lost where it passed out of the porphyry. On the adit level, 10 feet (3 m.) east of the Pruneda vein, this vein is 15 inches (38 cm.) wide, strikes about N. 30° E., and dips 75° SE. In places it attains a thickness of 30 inches (75 cm.), made up largely of quartz, but it thins to a narrow stringer outside the porphyry. Near the southern end of this vein and 25 feet (7.5 m.) east of it, a crosscut exposes a 4-foot (1.2 m.) zone of tourmaline veinlets in porphyry. This zone also dies out to the south on entering schist, although thin ferberite-bearing veins are exposed near the face of the drift.

The veins exposed in the adit are part of the Pruneda system. They underlie the No. 19 vein, which on the surface may be followed intermittently for about 1,200 feet (365 m.) southward from a point 100 feet (30 m.) southwest of the Pruneda adit. The No. 19 vein is represented in the large trench at the top of the hill by very thin veins of quartz and tourmaline with ferberite in a mineralized zone 5 feet (1.5 m.)

wide. North of the trench this zone consists primarily of silicified and tourmalinized schist, in which no ferberite was observed. At the trench another vein, No. 19-B, splits off in a northeasterly direction, and in outcrops 100 feet (30 m.) to the northeast it contains ferberite. The No. 19 vein crops out strongly for 175 feet (53 m.) south of the trench as a 2-foot quartz-tourmaline vein. Float may be traced for 200 feet (60 m.) to the southwest, down a spur along which there are outcrops of massive quartz. Intermittent exposures extend S. 35° W. to a strong outcrop 125 feet (38 m.) long, in porphyry. South of this outcrop the vein is obscured by debris, but it may steepen in dip and extend to the tourmalinized breccia in the bottom of the gully. The breccia merges with a strong 7-inch (18 cm.) quartz vein, which follows the northeast contact of a porphyry dike for 150 feet (45 m.). No ferberite was observed in the No. 19 vein except above 250 feet (75 m.) in altitude, though it occurs in the two subsidiary veins, Nos. 19-A and 19-B.

At the top of the hill another vein, No. 17, 25 feet (7.5 m.) east of the No. 19 vein, is exposed in two cross trenches. In the southern trench, 4 feet (1.2 m.) of fine-grained gray breccia is cut by four fluted and slickensided fault fissures striking N. 23° E. and dipping 60° SE. The quartz-mica schist strikes N. 80° E. and dips 45° SE. on the footwall and strikes N. 50° E. and dips 45° SE. on the hanging wall. A 3-inch (7.6 cm.) quartz vein that strikes N. 25° E. and dips 75° NW., cuts the schists 2 feet (0.6 m.) below the fault zone, and there is an 8-inch (20 cm.) vein, which strikes N. 30° E. and dips 90°, 4 feet (1.2 m.) east of the hanging wall. The fault probably follows the main vein, and, as the tourmaline is slickensided, the faulting must have occurred later than the mineralization. In a trench 85 feet (26 m.) to the north, a 2-foot gray breccia zone strikes N. 31° E. and dips 65° SE. On the footwall

there is in places as much as 5 feet (1.5 m.) of silicified schist with veins of tourmaline and quartz that strike N. 33° E. and dip 75° SE.; and on the hanging wall there is 2 feet (0.6 m.) of vein material. Large blocks of ferberite-bearing quartz on the dump at the eastern end of the trench suggest that a vuggy quartz vein 1 to 2 feet (0.3 to 0.6 m.) wide and rich in ferberite was cut. North of this trench the vein zone, 6 to 8 feet (1.8 to 2.4 m.) wide splits near a dike of porphyry. The No. 17 vein trends N. 45° E., and the No. 17-A may be seen to trend N. 18° E. for 50 feet (15 m.) to a point where it dies out or is covered by debris.

Calvache shaft.--The Calvache shaft, 3,000 feet (915 m.) west of the Lela shaft, started by the Molybdenum Corporation of America in 1939, is reported to have reached a depth of 60 feet (18 m.) and to have cut the Calvache, or No. 28, vein at 50 feet (15 m.). Surface exposures of this vein are prospected by trenches 120 feet (36 m.) north and also 125 feet (38 m.) and 500 feet (152 m.) south of the shaft. Eight other trenches have been made in the low area west of the settlement of Siguanea on what appears to be the Calvache vein or other members of the same vein system.

At the shaft the Calvache vein strikes N. 23° E. and dips 40° to 70° SE. Intermittent outcrops suggest that this vein may extend as much as 700 feet (213 m.) south of the shaft as a brecciated, silicified, tourmalinized zone with a discontinuous center of quartz up to 12 inches (30 cm.) thick. Ferberite is present as coarse grains in vuggy quartz and occurs also in the tourmaline rock. A number of poorly exposed veins farther east appear to be branch veins that trend northward towards the Calvache vein. Of these, vein No. 28-A appears to be the only one of possible economic value. This vein strikes N. 13° E. and dips 70° SE. It is exposed in two outcrops, each about 100 feet (30 m.) long, which are 120 feet (37 m.)

apart and connected by abundant vein float. The vein consists predominantly of silicified and tourmalinized rock and has a quartz-ferberite center up to 3 inches (7.6 cm.) thick.

In poor exposures extending 400 feet (120 m.) north of the shaft, the Calvache is a vuggy quartz vein 6 to 12 inches (15 to 30 cm.) wide that carries ferberite. Other parts of the vein, up to 3 feet (1 m.) thick, consist of tourmalinized and silicified rock, which is in part brecciated. The northern continuation of this vein is indefinite, but a number of isolated outcrops and ferberite-bearing vein float may be followed northeastward to a strong vein at the northwest end of the hills. Other scattered outcrops of vein material suggest that the main vein continues north to the northern part of the Lela and the southern part of the Genaro claim, passing through the trenches 1,600 and 1,900 feet (490 and 580 m.) N. 23° E. of the shaft.

No. 2 adit.--The No. 2 adit (pl. 42), 415 feet (125 m.) northeast of the Calvache shaft, was started on the best surface showing of ore that had been found up to 1939, when the Pan-American Tungsten Corporation acquired the property. A ton or more of high-grade ore is said to have been taken out of the open pit. It came from an ore shoot about 80 feet (24 m.) long, which is said to have ended abruptly about 30 feet (9 m.) south of the portal. The shoot was in feldspar-quartz porphyry; it is now covered with debris.

Above the portal of the adit, stringers of tourmaline and quartz, which strike N. 30° E. and dip 50° SE., are exposed in the porphyry for 30 feet (9 m.), and a silicified zone continues for another 70 feet (21 m.) to a place where well-defined quartz veins are exposed. In the trenches at the top of the ridge small lenses of ferberite-bearing vein material are truncated by rhyolite porphyry and faults. The mineralized zone is not continuous down the north slope of the ridge, but

small isolated lenses of vein matter are exposed in the trenches.

The adit, which is 235 feet (72 m.) long, was made in an attempt to find the continuation of the high-grade ore body exposed in the open cut. A tourmaline vein dipping 30° SE. was intersected 30 feet (9 m.) northeast of the portal, and one small mass of high-grade ore was found. This vein is 12 to 15 inches (30 to 38 cm.) in width and has a 2-inch (5 cm.) quartz center. It dies out to the north where the tunnel turns eastward. Two other small veins and a rhyolite porphyry dike were intersected by the tunnel. The easternmost vein was cut by a fault, striking N. 15° W. and dipping 65° SW., along which there is 12 inches of gouge.

No. 3 adit.--The No. 3 adit (pl. 42), 340 feet (104 m.) southeast of the No. 2 adit, prospects the No. 26 vein, which is reported to have contained considerable ferberite where mined in the open cut. Specimens of coarse-grained ferberite (see pl. 38) in quartz are found on the dumps, but the vein is now covered with debris. The outer part of the adit follows a fault that parallels the vein and is marked by gouge and contorted schist. Fifty feet (15 m.) from the portal the vein splits or is repeated by faulting, and the eastern segment, which is followed by the adit, pinches out within a few feet. The remainder of the adit is in schist cut by a few very thin stringers of quartz.

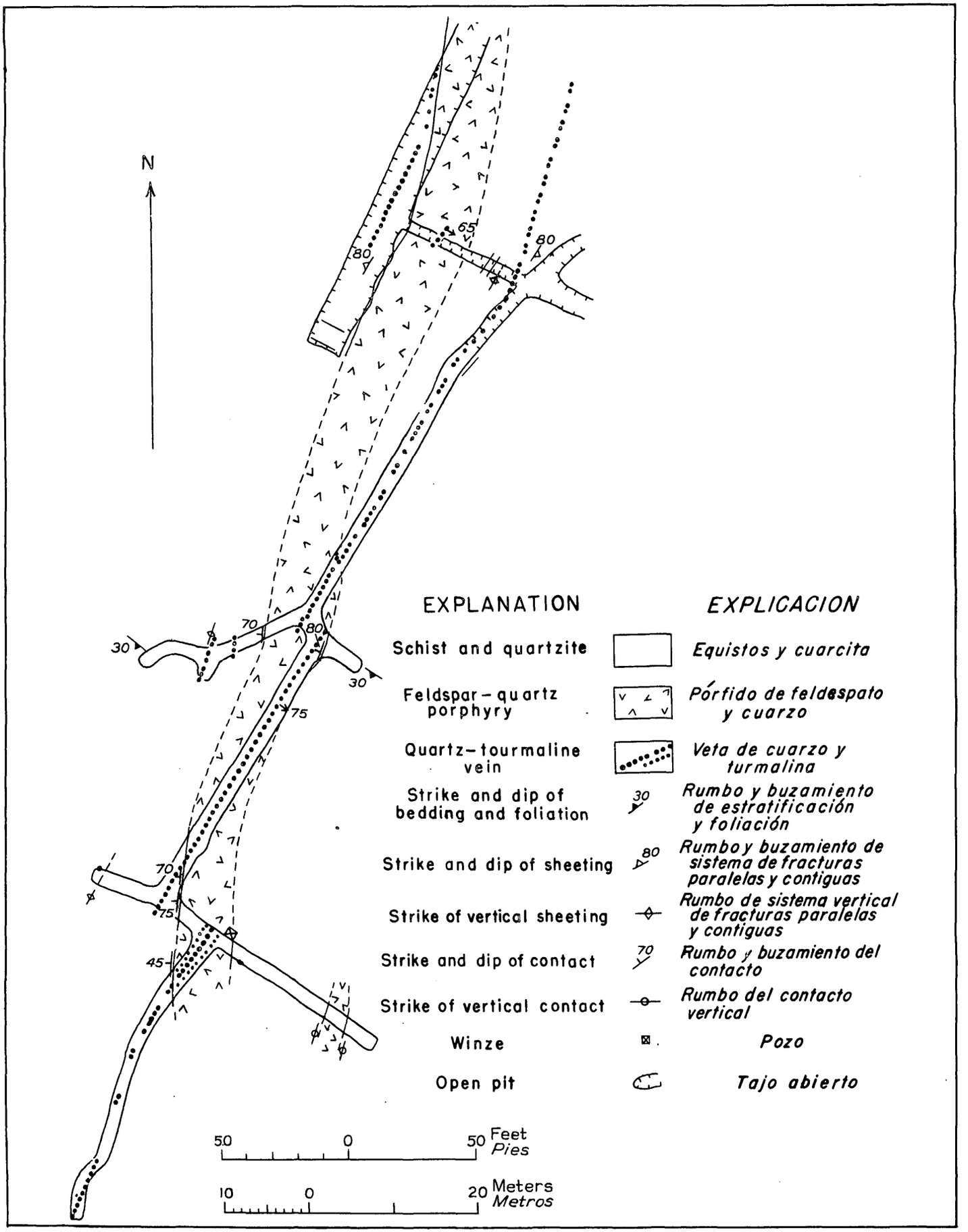
On the surface the identity of the vein followed by the adit is lost about 25 feet (7.5 m.) north of the portal in a silicified and tourmalinized zone about 30 feet (9 m.) wide, but float of coarse vein quartz with ferberite is abundant. Another vein, the No. 26-A, forms the western edge of this zone. It has been traced S. 30° W. for 175 feet (53 m.). Eight inches (20 cm.) of ferberite-bearing quartz is exposed

at the southern end of the outcrop; in some places this ferberite-bearing quartz is 12 inches (30 cm.) thick.

A weak vein, probably the southward extension of No. 26, was traced for 135 feet (41 m.) S. 15° W. from the dump. Another vein, No. 26-B, just west of the dump, trends S. 25° W. for 140 feet (43 m.); and what is perhaps the same vein, displaced 20 feet (6 m.) to the west, extends S. 28° E. for 165 feet (50 m.), then turns S. 5° W. and dies out in silicified schist. The northern segment of the vein, part of which is 2 feet (0.6 m.) thick, contains coarse ferberite in quartz. A brecciated tourmalinized schist separates this from a part of the vein in which tourmaline predominates over quartz. The southern segment, which is 2 feet (0.6 m.) thick where exposed in a trench, strikes N. 20° E. and dips 45° SE. South of the trench the vein outcrop shows irregular, discontinuous lenses of quartz.

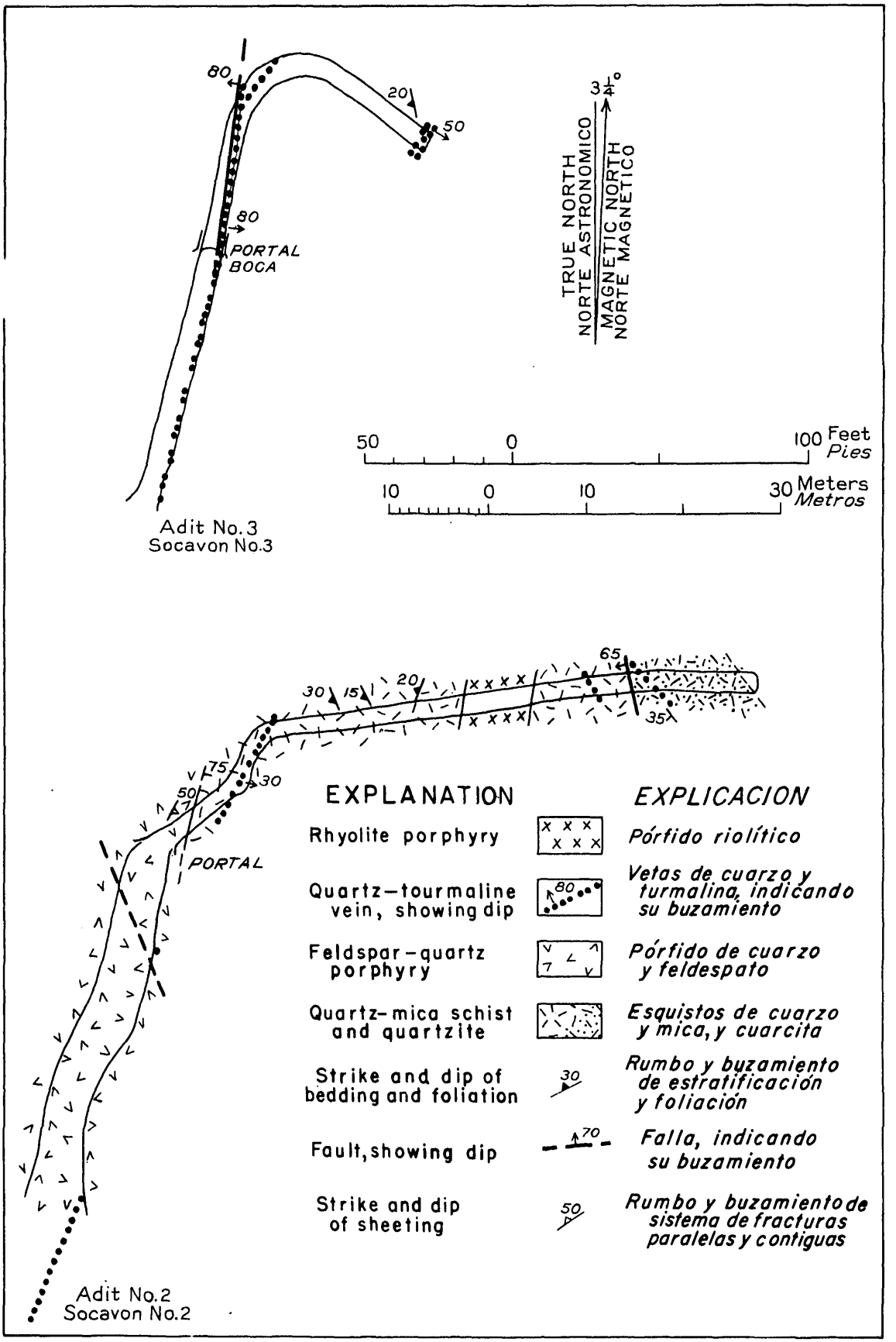
Trenches northeast of the No. 3 adit reveal four veins containing coarse ferberite. One of the strongest veins is No. 26-C, east of No. 26. Outcrops of this vein extend for 475 feet (145 m.) over the top of the hill, and the vein has been traced by float and poor outcrops down the north side of the hill. At some places on the south slope of the hill it is as much as 5 feet (1.5 m.) thick. It is 2 feet (0.6 m.) wide in the trench at the north end of its outcrop, and has 8 inches (20 cm.) of quartz in the middle. This vein consists largely of silicified rock and quartz with little tourmaline. Coarse ferberite is most abundant in the southern part where the vein is over 2 feet wide.

Between the No. 26-C and the No. 25 veins are several narrow veins that do not contain visible ferberite. The No. 25 vein is a series of discontinuous thin lenses of quartz and tourmaline containing coarse ferberite. The lenses occur in a zone 20 feet (6 m.) wide and 150 feet (45 m.) long. At the



GEOLOGIC MAP OF THE PRUNEDA ADIT, LELA CLAIM, ISLA DE PINOS, CUBA

PLANO GEOLOGICO DEL SOCAVON PRUNEDA, CONCESION LELA, ISLA DE PINOS, CUBA



GEOLOGIC MAP OF THE NO. 2 AND NO. 3 ADITS, LELA CLAIM, ISLA DE PINOS. CUBA

PLANO GEOLOGICO DE LOS SOCAVONES NO. 2, Y NO. 3, CONCESION LELA, ISLA DE PINOS, CUBA

south end of the trench the vein, which crops out for 30 feet (9 m.) and is up to 1 foot (0.3 m.) thick, strikes N. 20° E. and dips 50° SE. At the north end of the trench a segment of this vein strikes N. 28° E. and dips 80° SE. Ferberite was observed in both places.

The No. 24 vein, about 225 feet (68 m.) east of the No. 25, has been prospected near its north end by a cross trench. Here the vein strikes N. 33° E. and dips 65° SE. It is predominantly tourmaline but contains ferberite. About 75 feet (23 m.) south of the trench the vein is apparently offset 10 feet (3 m.) to the west; beyond this offset its outcrop continues for 320 feet (97 m.) farther southward. On the top of the ridge and on the south slope the vein dips as steeply as 80° SE. Here it is as much as 5 feet (1.5 m.) wide and has a quartz center 6 to 12 inches (15 to 30 cm.) thick, which is rich in ferberite. This vein gives some promise of producing ore.

Between the No. 24 vein and the No. 23 vein, which is 140 feet (43 m.) farther east, there are two parallel, rather prominent veins and a number of minor southward-trending veins, some of which contain ferberite. They are crossed by a zone of tourmalinized rock 15 feet (4.5 m.) wide that trends N. 30° W. At the south they are covered with alluvium, but south of the alluvium possible continuations of these veins, striking about N. 20° E., may be followed for a few hundred feet.

The No. 23 vein strikes N. 28° E. and dips steeply to the west. It can be followed by the aid of intermittent outcrops and float for 520 feet (160 m.). On the north slope of the ridge the vein has a 3- to 4-inch (7.5 to 10 cm.) center of coarse vuggy quartz in a silicified zone up to 5 feet (1.5 m.) in thickness. On the south slope this zone attains a thickness of 10 feet (3 m.). At the southernmost outcrop coarse

ferberite occurs in 12 inches (30 cm.) of quartz at the center of the altered zone, and ferberite was observed elsewhere in this vein.

About 135 feet (41 m.) east of the No. 23 vein, a rhyolite porphyry dike, 15 feet (4.5 m.) wide, crosses and splits a prominent vein, called the No. 22. The vein strikes about N. 25° E. and dips 85° W. The vein is 4 to 5 feet (1.2 to 1.5 m.) wide and has a central rib 2 feet (0.6 m.) thick of coarse, vuggy, euhedral to subhedral quartz coated with greenish tourmaline needles. The bordering silicified zone is in places as much as 15 feet (4.5 m.) wide. No ferberite was observed in this vein. Debris near the base of the ridge makes it impossible to trace this vein more than 500 feet (152 m.). A branch vein, 35 feet (11 m.) west, appears to be dipping southeastward near the top of the ridge but strikes N. 25° E. and dips 90° near the base of the south slope.

Between the No. 22 vein and the Pruneda system of veins at least five veins crop out along the ridge. Two of these, No. 21 and No. 20, show ferberite. The No. 21 vein, which strikes about N. 25° E. and dips 75° NW., contains ferberite in discontinuous, overlapping lenses of quartz up to 1 foot (0.3 m.) thick with minor quantities of tourmaline. A 50-foot (15 m.) segment of this vein extending from the top of the ridge northward may contain ore. A poorly exposed parallel vein 75 feet (23 m.) to the east, which dips 75° to 80° NW., contains ferberite in its southern part.

The No. 20 vein, 100 feet (30 m.) east of the No. 21, strikes about N. 30° E., dips 75° NW., and is moderately well exposed for 100 feet (30 m.) north of the ridge top. Float from this vein has been traced about 800 feet (245 m.). The vein is up to 10 feet (3 m.) wide, but on the northern slope the ferberite is concentrated in a 6- to 18-inch (15 to 45 cm.) quartz center. Some greenish tourmaline coats the quartz

crystals in vugs. A small parallel vein 20 feet (6 m.) to the east also contains coarse quartz and tourmaline along a 200-foot (60 m.) outcrop.

To summarize: The veins between No. 20 and No. 24 seem to dip westward toward the No. 24 vein, which dips eastward. This group of veins also shows a tendency to converge southward, and the strike swings from northeast to southwest toward the large silicified area at the south end of the hills.

Breccia area.--A group of four trenches (pl. 43), 1,800 feet (550 m.) S. 15° W. of the Pruneda adit, prospect a high-grade ore body exposed in a 20-foot (6 m.) cliff of tourmalinized breccia.

One trench, at an altitude of 160 feet (50 m.), is in the feldspar-quartz porphyry cut by irregular tourmaline seams, some containing ferberite. A trench at the southwest end of the outcrop appears to be close to the limit of the high-grade ore body, but the contact was not actually exposed. The two cross trenches north of the high-grade ore body indicate that the breccia body fingers out to the north, where there are four wedges of breccia that contain a little ferberite.

The high-grade ore body, exposed vertically for 20 feet (6 m.), is 10 feet (3 m.) wide and about 25 feet (7.5 m.) long. The ferberite forms subhedral crystals, and masses up to 2 inches (5 cm.) in diameter, coating or filling irregular cavities a few inches wide and up to a foot (0.3 m.) or more in length. The wall rock is a fine-grained dense greenish-black tourmalinized rock, which does not preserve the texture of the breccia. Scattered grains of ferberite were observed in the less tourmalinized material and also in the silicified breccia, but perhaps not enough to pay the cost of mining.

This high-grade ore body may be cut off by porphyry at no great distance below the present surface. Ore was deposited here because the breccia contained open spaces or easily

replaced material, and further prospecting should seek another segment of the breccia which may have been separated from the observed ore body of porphyry.

South of this high-grade ore body another breccia outcrop is exposed (see pl. 43). Feldspar-quartz porphyry apparently filled, at least in part, the open spaces between schist and quartzite fragments in the breccia. Tourmalinization and some silicification has altered the porphyry, the mixed porphyry-breccia rock, and the schist-quartzite breccia. No ferberite was observed in this outcrop.

North of the high-grade ore body, along the ridge, a number of veins extend toward those of the Pruneda system and toward the No. 15 and No. 16 veins. These veins contain a few grains of ferberite, but only the No. 30 vein shows appreciable quantities. This vein is up to 18 inches (45 cm.) thick and is composed of radiating masses of brown tourmaline in quartz. In places a yellowish secondary mineral, probably a tungstic oxide, rims the ferberite.

Two veins east of the ferberite-bearing breccia, Nos. 29 and 29-A, contain occasional coarse grains of ferberite in drusy and vuggy quartz in silicified zones that are commonly 3 to 5 feet (0.9 to 1.5 m.) wide. These are only intermittently exposed, but the No. 29-A vein may extend to a small ferberite showing 350 feet (106 m.) to the south.

On the knob 400 feet (120 m.) west of the ferberite-bearing breccia, coarse ferberite was found in float from the No. 31 vein, but none was seen in place. About 130 feet (40 m.) west of the No. 31 vein, a strong tourmaline-quartz vein, 2 to 3 feet (0.6 to 0.9 m.) thick called No. 32 crops out for 400 feet. Parts of the vein are quartz but others are almost entirely tourmaline. Ferberite was noted in a few places on the south slope of the knob.

A large pit was dug 1,050 feet (320 m.) southwest of the ferberite-bearing breccia, in an attempt to find the source of some very coarse ferberite float. A little ferberite was observed in a veinlet cutting silicified quartzite in the bottom of the trench, and 80 feet (24 m.) to the northeast there is a mass of ferberite 8 inches (20 cm.) long in silicified breccia. Grains and crystals of ferberite up to 1 inch (2.5 cm.) in diameter were seen in a tourmalinized breccia near the top of the hill, 160 feet (50 m.) northeast of this pit.

Northwestern area.--West of the camp at Siguanea a number of trenches have explored veins that are in line with those of the Calvache system. The largest, called the No. 33 vein, apparently has a number of branches that extend southwestward, and some of these have also been prospected. The No. 33 vein is exposed in trenches on either side of the road from Siguanea to the beach. These were partly filled with water at the time of examination, but ferberite was observed in place and on the dumps. In the trench north of the road, the vein strikes N. 23° E. and dips 65° SE., and is split by a sheet of buff to gray clay 4 feet (1.2 m.) thick. This clay is derived by weathering from a rhyolite porphyry dike that strikes N. 13° E. and dips 55° SE. About 1 foot (0.3 m.) of vein material lies east of the dike and 1 to 3 feet (0.3 to 1 m.) west of it. In the trench south of the road, 2 feet (0.6 m.) of vein lies east and 1 foot west, of the porphyry. Outcrops and float of vein material that consists predominantly of vuggy, crystalline quartz with silicified and tourmalinized walls may be traced for 250 feet (75 m.) southward along the strike. This section of the No. 33 vein gives considerable promise of containing commercial ore.

Three trenches, 250 feet (75 m.) further south prospect the No. 33 vein and also the intersection of two subsidiary quartz-tourmaline veins. These two veins, 12 to 20 inches (30

to 50 cm.) thick, strike N. 18° E. and N. 43° E. and dip 60° SE. There is tungsten ore on the dump. The northern trench on the No. 33 vein exposes at least 2 feet (0.6 m.) of rhyolite porphyry, with 2 to 3 feet (0.6 to 0.9 m.) of vein material dipping 70° SE., below it. In the southern trench there is 2 to 3 feet (0.6 to 0.9 m.) of vein above and 1 foot (0.3 m.) below the porphyry, which at this point is 6 feet (2 m.) thick, strikes N. 10° E. and dips 52° SE.

The central part of the No. 33 vein, opened up by another trench, shows a 5-foot (1.5 m.) zone of black tourmaline rock that strikes N. 13° E. and dips 65°-70° SE., below a porphyry dike that strikes north and dips 50° SE. Above the porphyry a second tourmaline vein 6 feet (1.8 m.) thick is exposed. This is probably a branch vein but may be a part of the No. 33 split off by the porphyry. The 5-foot (1.5 m.) vein may be traced 260 feet (80 m.) south to another trench, but beyond this trench it appears to feather out. The tourmaline-rich part of the No. 33 vein may contain ferberite, but none was observed.

The other trenches in this area are on subsidiary veins that do not appear promising. Northwest of these subsidiary veins there are other vein outcrops. No ferberite was observed at the time of the examination, but recent reports indicate that it is present.

Vanadium Corporation workings.--Several pits and trenches, the first of which are said to have been made by the Vanadium Corporation of America in 1928-29, explore some veins about 600 feet (180 m.) N. 30° E. of the Lela shaft. Seven cross trenches, from 15 to 160 feet (4.5 to 50 m.) long, and five trenches along the outcrops prospect what are believed to be the No. 2 vein and two members of the No. 1 vein system. A cross trench, 110 feet (35 m.) long, south of the brook, shows

at least 8 feet (2.4 m.) of alluvium but apparently did not cut vein material.

The westernmost vein, probably No. 2, is exposed in a 17-foot (5 m.) cross trench. It is 12 inches (30 cm.) wide, strikes N. 23° E. and dips 50° SE. It consists of ferberite-bearing quartz. The country rock is quartz-mica schist that strikes N. 62° W. and dips 35° SW. Three feet (0.9 m.) east of the vein a reverse fault, which strikes N. 12° W. and dips 60° NE., cuts the schist, which is crumpled in the hanging wall. No veins were found in the cross trench to the west, which, however, shows a 3-foot lens of barren quartz lying parallel to the foliation of the schists. Recent work is reported to have uncovered a porphyry dike between these two trenches.

A vein 100 feet (30 m.) east of the No. 2 has been stripped for about 200 feet (60 m.) and has been traced for a total distance of 380 feet (115 m.). The southern part of this vein strikes about N. 30° E. and dips steeply southeast. It is mainly tourmaline but contains in places as much as 4 feet (1.2 m.) of quartz. The vein was mined out in the large trench at the south end, where it is reported to have been a fairly high grade lenticular ore body that pinched out at both ends. The middle section of the vein strikes about N. 45° E. and the northern end N. 35° E.

Trenches 80 to 120 feet (24 to 36 m.) east of this vein explore another vein for a distance of at least 260 feet (80 m.). A triangular trench at the southern end of these outcrops is in an iron-stained tourmalinized breccia made up of schist fragments, and appears to be at the intersection of two veins striking N. 70° E. and N. 35° E. Ferberite was observed in the material taken from this pit, but none was seen in place. In the cross trench 35 feet (10 m.) to the north, 2

feet (0.6 m.) of ferberite-bearing quartz was observed. This is apparently part of the same tourmaline vein 4 to 5 feet (1.2 to 1.5 m.) thick that is exposed in the trenches to the north. The vein is somewhat arcuate in ground plan. Small outcrops of a silicified and tourmalinized vein zone 60 feet (18 m.) to the east are possibly a continuation of the No. 1-A vein.

Genaro claim

Adjoining the Lela claim on the north is the Genaro claim, 500 hectares in area, which is owned by Señor Luis Pozo and others. On this claim 13 trenches and 1 shallow prospect shaft have explored 11 veins. Ferberite is visible in two of the veins, and has recently been reported from a third. Five other veins, all barren, were mapped in the claim.

Locality 1 (pl. 33) includes three prospect trenches, caved and filled with water at the time of the examination, in which there is exposed a vein of dense, fine-grained, gray quartz containing considerable fine-grained arsenopyrite, in part altered to scorodite, and a few grains of ferberite. The vein attains a width of 12 feet (3.6 m.), strikes about N. 60° E., and dips 25°-40° SE. The wall rock is mica schist, which weathers into spheroidal boulders, each of which contains a network of seams stained with iron oxide which form a septarian pattern. A porphyry dike is exposed 25 feet (7.5 m.) northwest of the vein.

The vein appears to pinch out to the east, but offshoots of it may be picked up in pits at locality 2, where it is represented by a zone of limonitic gossan and iron-stained schist up to 5 feet (1.5 m.) wide.

The pits at localities 3 and 4 (pl. 33) are in an iron-stained gravel, 3 to 4 feet (0.9 to 1.2 m.) thick, overlying limonite-stained schist. The limonite, which pervades the

schist in veinlets, was probably formed by oxidation of sulfides disseminated in schist. At locality 5, two veins that apparently intersect have been prospected by a 30-foot (9 m.) cross trench. One vein, striking N. 15° E., is composed of brecciated schist impregnated with limonite and in part silicified; the other, striking N. 35° E., contains tourmaline. In the trench the silicified and brecciated schist is 25 feet (7.5 m.) wide, but to the north it attains a width of 65 feet (20 m.). Ferberite was observed south of the trench in the N. 15° E. vein. A small breccia outcrop 700 feet (215 m.) to the north, on the N. 15° E. trend, is believed to be part of the same vein.

A pit 600 feet (180 m.) N. 35° E. of locality 5 was filled with water. There was no vein material on the dumps.

The pit at locality 6 shows a few pieces of tourmalinized milky quartz but no vein.

The 10-foot (3 m.) shaft at locality 7 is on an 8- to 10-foot (2.4 to 3 m.) zone of tourmalinized and silicified schist. The alteration appears to be irregular and no ferberite was observed.

At locality 8 light-colored, cherty, silicified schist, 11 feet (3.3 m.) thick is criss-crossed by seams of greenish to brown tourmaline. Arsenopyrite, scorodite, and pyrite occur here, but no ferberite was observed. This locality may be on an extension of one of the tourmaline veins exposed in the northeast corner of the Lela claim.

A trench at locality 9 exposes a gray, cherty, quartz-pyrite vein, 12 feet (3.6 m.) wide and 190 feet (58 m.) long, in schist and quartzite. This vein strikes due north and dips 60° E. It weathers white to gray, but the adjacent rocks are heavily iron stained. The pyrite is evenly disseminated throughout the vein. No tungsten minerals were observed.

The most promising vein in the claim is in the east-central portion and is crossed by a trench at locality 10. Here a narrow veinlet parallel to a feldspar-quartz porphyry dike strikes N. 30° E. and dips 75° SE. Only 50 feet (15 m.) to the south, in the schist, its width has increased to 15 feet (4.5 m.). The outcrops are heavily oxidized and stained with limonite. The vein zone appears originally to have contained considerable pyrite, which was disseminated in the schist and also formed thin veinlets that cut the porphyry. It has been traced along the east side of the porphyry dike for more than 1,700 feet (520 m.) and is displaced by small east-west faults. Ferberite was not observed, but the oxidized material showed stains that suggested tungsten mineralization. After the completion of the field work, specimens reported to have come from this vein were examined and found to contain considerable ferberite. This vein may be part of the Calvache system but the exposures are too widely spaced to serve as proof.

Another vein, 3 to 10 feet (0.9 to 3 m.) thick, lying 350 feet (106 m.) west of locality 10, has been traced for 550 feet (170 m.). This vein is mineralogically similar to the longer one described above, and it likewise extends along the west side of a porphyry dike. No ferberite was observed, but some might be found by additional prospecting. Neither of these veins adjacent to porphyry dikes is a clear-cut fracture filling; each is made up of many thin ramifying veinlets.

Aguedita claim

The Aguedita claim (pl. 33), comprising 375 hectares, is controlled by Edwardo Escribano of Nueva Gerona. It adjoins the Genaro claim on the west and the Mercedes on the south. Much of its eastern part is covered with sand and ferruginous conglomerate.

At locality 2, thirteen pits and trenches explore five quartz-tourmaline-sulfide veins and one barren mass of quartz. Ferberite was observed only at locality 1, in the southwest corner of the claim, where seven cross trenches prospect a vein for 200 feet (60 m.). Most of the pits were caved and full of water at the time of examination but in the largest trench a mineralized zone 6 feet (2 m.) wide strikes N. 23° E. The ferberite was limited to a 2-foot streak that trends about N. 38° E. Pyrite, now altered to limonite, was abundant in disseminated crystals and in thin ramifying veinlets of quartz up to 3 inches (7.5 cm.) thick. Some high-grade ore specimens have been taken from this locality, but not enough prospecting has been done to show whether or not the property contains an ore body.

Two small trenches, 70 feet (21 m.) apart, at locality 3 reveal two parallel veins that strike N. 23° E. The eastern vein, 12 to 18 inches (30 to 45 cm.) wide, consists of dark bluish-gray breccia similar to that at locality 3 on the Ancash claim (p. 242). The western vein, at least 12 inches (30 cm.) and possibly 36 inches (90 cm.) thick, is primarily silicified schist cut by veinlets of tourmaline and of pyrite, which has altered to limonite. The weathered portions contain yellow alteration minerals that are probably tungstic oxides.

At locality 4, about 350 feet (105 m.) northwest of this pit, a zone of mineralized schist 10 to 15 feet (3 to 4.5 m.) wide, striking N. 28° E. and dipping 70° SE., is exposed for more than 500 feet (150 m.). Pyrite is disseminated in partially silicified schist, which is also cut by a few dense tourmaline veins up to 3 inches (7.5 cm.) thick. The weathered portion is a sintery, siliceous, limonitic gossan. No tungsten minerals were observed. What is probably the same zone crops out 2,500 feet (760 m.) to the northeast, at locality 6, from where it can be traced N. 28° E. for 2,700 feet

(820 m.). The mineralized zone here is silicified, partly tourmalinized schist breccia, 2 to 5 feet (0.6 to 1.5 m.) wide in most exposures. Most of the breccia fragments are less than 1 inch in diameter. Very fine grained quartz impregnates the rock but does not form veins. The lighter-colored silicified fragments of the breccia are surrounded with iron oxides. No tungsten minerals were found. A few feet north of the Aguedita claim this iron-stained breccia, where exposed in a trench, is divided into two zones by 5 feet (1.5 m.) of schist; the western segment is 4 feet (1.2 m.) thick and the eastern one 5 feet thick.

The mineralized zone noted at locality 5 is at least 2 feet (0.6 m.) wide. Sporadic patches of pyrite are here disseminated in quartzite on either side of a heavily pyritized zone.

Several other veins crop out in the claim, but they are poorly exposed. Prospecting of this claim, especially the southwestern part, might reveal other tungsten-bearing veins, but it would be expensive because of the almost universal cover of sand, gravel, or ferruginous conglomerate.

Mercedes claim

The Mercedes claim (pl. 33), owned by the Pan-American Tungsten Corporation, covers 700 hectares adjoining the Aguedita on the north and the Lela claim on the east, south, and west. Most of the claim is covered with marine sand and gravel or with alluvium and ferruginous conglomerates; only a small corner of the claim, therefore, was mapped in detail.

In the northwestern part, adjoining the Lela, Genaro, and Aguedita claims, a vein that may be an extension of the No. 1 system of the Lela claim has been prospected by three shallow workings near the old San Pedro-Siguanea road. A shaft was started in the central trench but was abandoned at 10 feet

(3 m.). The shaft, now filled with water, is on a 2- to 4-foot (0.6 to 1.2 m.) silicified, brecciated vein, strongly stained with limonite derived from disseminated sulfides. The vein was traced at least 300 feet (90 m.) northeastward from the shaft, mostly along the southeast side of a quartz-feldspar porphyry dike 10 to 20 feet (3 to 6 m.) thick, which the vein locally crosses. South of the shaft the same zone can be followed for about 200 feet (60 m.) to the southernmost pit. Here the iron-stained brecciated zone, which in general strikes N. 38° E., is 15 to 20 feet (4.5 to 6 m.) wide, but within it are narrower silicified zones that trend N. 23° E. Ferruginous conglomerate has been deposited along the vein zone. No ferberite was observed, nor was any reported from this vein.

Ancash claim

The Ancash claim (pl. 33), of 373 hectares, is owned by Jesus A. Estrella, Nesbit S. Allen, and others. It extends N. 30° E. from the northeast corner of the Aguedita to the southeast corner of the Guido claim. Twelve pits and trenches have been dug in gossans derived from sulfide veins and from layers of sulfide-bearing schist. There are few outcrops in the claim except those of gossan, barren quartz, and ferruginous conglomerate, but a few small areas of schist and quartzite are exposed. Most of the surface is covered with residual gravels and fine sand. No tungsten minerals were observed on the claim.

In the southwestern part of the claim five trenches prospect a zone of brecciated schist 2,500 feet (760 m.) long and 10 to 15 feet (3 to 4.5 m.) wide, which trends northward across the southwest corner of the claim. The breccia marks a fault zone, perhaps of considerable magnitude. In the trench at locality 4 there are two breccia zones 10 to 12 feet (3 to

3.6 m.) wide, and striking N. 13° E., separated by 15 feet (4.5 m.) of schist. The breccia consists of fragments of silicified schist and quartzite up to 8 inches (20 cm.) long, in a loose matrix of limonite and other iron oxides. South of this pit the breccia zones join, and at locality 3 they are 6 to 8 feet (1.8 to 2.9 m.) thick. Here the white silicified schist and quartz fragments are embedded in a matrix of black to dark-gray fine-grained material that contains a little sulfide.

The other excavations on the claim have been located on gossans most of which extend only a few feet below the surface. At locality 7 two trenches explore the same gossan zones. The northern trench shows two zones separated by 10 feet (3 m.) of crumpled and drag-folded schist, with thin quartz veins paralleling the schistosity. In general the schists dip 35° to 45° SE. and the gossans 70° SE. to vertical. The absence of any visible quartz-sulfide veins suggests that these zones are the result of deposition of iron oxides in fractures or fault zones in the schist.

A pit at locality 8 exposes about 5 feet (1.5 m.) of gossan that strikes N. 15° W. and dips 35° NE., which is also the attitude of the replaced schists. The schist along the gossan zone is highly crumpled and folded, and the gossan follows, in general, the contorted structure but in places it passes into less contorted rock. To the southeast, six other isolated gossan outcrops, 50 to 165 feet (15 to 50 m.) long, strike N. 30° E. to N. 65° W. and are arranged in such a way as to suggest the partial replacement of two folded beds of schist about 5 feet (1.5 m.) thick. No quartz veins are visible in them.

The gossan at locality 9 caps a 15- to 18-inch (38 to 45 cm.) quartz-pyrite-chalcopyrite vein which is exposed in the pits. The vein strikes N. 8° W. and dips 45° NE. It crops

out for 100 feet (30 m.) to the northwest, and it may extend southeastward to a gossan zone that appears to dip 20° NE. The other two gossan zones mapped to the south and northeast appear to be iron oxide derived from pyrite in schist.

At locality 10 there is a limonite zone 15 feet (4.5 m.) wide, striking N. 25° E., and dipping 40° SE., that appears to have formed by replacement of schists. North of the trench one part trends N. 20° W. and the other N. 25° E. For 550 feet (170 m.) south of the trench, discontinuous outcrops 5 to 10 feet (1.5 to 3 m.) wide appear to follow a folded or faulted band of schist. A similar gossan 100 feet long (30 m.) crops out at locality 11.

Schist and quartz breccia heavily stained with iron oxide crop out as a zone 1 foot (0.3 m.) wide and 200 feet (60 m.) long, trending N. 20° E., at locality 6. This zone dies out in a quartzite schist cut by numerous veinlets of quartz. It may be part of the zone that crops out at locality 6 on the Aguedita claim.

Fer-Mi claim

The Fer-Mi claim (pl. 33), comprising 255 hectares, is controlled by Jesus A. Estrella, Nesbit S. Allen, and others. It adjoins the Ancash claim on the southeast. The workings include 12 trenches and pits in gossan deposits, which are most conspicuous along the Siguanea-Nueva Gerona road, near the southeastern edge of the Ancash claim. Two zones in an area 700 feet (210 m.) long and 300 feet (90 m.) wide contain the largest gossan deposits in the district. These zones are prospected by 10 trenches. The eastern zone is a limonite band 3 to 5 feet (0.9 to 1.5 m.) wide that dips from 75° NW. to 80° SE. except at the surface, where a thin veneer several feet wide has formed along a fracture striking N. 35°-45° E. Narrower concentrations occur on fractures to the east of

this, and the highly crumpled schists are impregnated for a few feet down from the surface. The limonite grades downward from the surface and laterally into partially altered schists. The western zone, prospected by 5 cross trenches, contains similar material and in places is as much as 40 feet (12 m.) wide. Two other pits, 2,200 feet (670 m.) to the southwest, prospect limonite caps and impregnated schist.

These deposits are too limited in extent to be of value as a source of iron ore, and no other mineral is abundant enough in them to be of economic importance. No ferberite or other tungsten minerals were observed.

Guido claim

The Guido claim (pl. 33), 400 hectares in extent, is owned by Sēnor Miguel Tarafa and others. It is at the north end of the Ancash and Rolando claims. Five trenches and pits were observed in the area mapped. Large bodies of milky white quartz, barren of tungsten minerals, characterize the mapped area, and they are apparently as numerous in the unmapped area to the east, west, and north. Sulfide mineralization occurs in the southern part of the claim but is very weak. No ferberite was observed and the veins do not look promising. In two places veins of this type cut barren quartz masses, and here the quartz is associated with fine-grained greenish tourmaline similar to that in the veins at Lomas de Siguanea. This type of tourmaline also forms coatings on euhedral quartz in barren quartz masses at localities 1, 3, and 4. A black tourmaline, usually fibrous to prismatic, and crossed by quartz veinlets, also occurs in the quartz but this is different in composition from the other and is older, being an original mineral in these quartz bodies. At locality 5 a little muscovite was noted in the barren quartz. A single crystal of

cassiterite was found by Antonio Calvache [19] at locality 4, but none was observed by the writers.

Gossan zones were mapped at localities 2, 6, and 7. The largest one, at locality 7, is an irregular limonite zone in the schist that underlies a somewhat isolated knob on a side road, 1,200 feet (365 m.) west of the Siguanea-Nueva Gerona road. It is about 200 feet (60 m.) wide at the southern end, and 300 feet (90 m.) north its width has narrowed to about 50 feet (15 m.). A similar deposit at locality 7, 600 feet (180 m.) farther north, consists of brecciated massive quartz and schist. This deposit is 20 to 30 feet (6 to 9 m.) wide and is exposed for 400 feet (120 m.) along its trend of N. 70° E. About 100 feet (30 m.) from the southern end it broadens to about 50 feet (15 m.) and a branch extends westward for another 100 feet.

San Antonio and Rolando claims

The San Antonio and Rolando claims (pl. 33), owned by Jesus A. Estrella, Nesbit S. Allen, and others, contain 150 and 388 hectares respectively.

The Rolando claim is adjoined on the east by the Ancash claim and on the west by the San Antonio claim. Time did not permit detailed examination of these claims except for small areas in their southeastern parts. On the Rolando claim two pits, both exploring ferruginous conglomerate, were mapped. Two small limonite veins cut the schist in the southern part of the claim, but there is no indication that these contain valuable minerals.

Colorado claim

The Colorado claim, said to be owned by S. C. E. Melkman, lies southwest of the Lela claim (pl. 33). The entire claim

19/ Personal discussion.

is covered with marine and alluvial deposits and consequently was not mapped in detail. A number of trenches have been made but none of these reached bedrock. It is possible that the Calvache and some of the other veins, which have been mapped on the Lela claim, may extend as far south as the Colorado claim, but there are no surface indications to prove that it does so.