Tin Deposits of Durango Mexico

GEOLOGICAL SURVEY BULLETIN 962-D

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By WARD C. SMITH, KENNETH SEGERSTROM, *and* REINALDO GUIZA, JR.

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Prepared in cooperation with the Universidad Nacional Autonóma de México, Instituto de Geología, and the Comité Directivo para la Investigación de los Recursos Minerales de México under the auspices of the Interdepartmental Committee on Scientific and Cultural Cooperation, Department of State

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1950

UNITED STATES DEPARTMENT OF THE INTERIOR

Oscar L. Chapman, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C.

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ABSTRACT

This report summarizes the economic possibilities of the tin deposits of the Estado de Durango, Mexico. It describes in detail many deposits in the leading districts, which were examined in 1944, and briefly reviews some reports on undeveloped occurrences in the southern and western parts of the State.

The general conclusion is that tin will continue to be produced by hand methods for many years, but probably at a decreasing rate, because the placer grounds which have always produced the greater part of the tin are faced with gradual exhaustion. Future production cannot be estimated closely because there is no complete record of past production which, however, has certainly averaged over 150 tons a year and perhaps over 300 tons.

The most interesting activity in the tin districts of Durango during 1943 and 1944 consisted of attempts to mill the ores. A 100-ton mill built at Ochoa was shut down after a test run, but a 10-ton mill might be operated there intermittently. More development work is needed to insure an ore supply. Tin mills at Cerro de los Remedios and at Canatlán have little chance of successful operation, for little ore has been developed at Cerro de los Remedios and almost none at Canatlán. In the América-Sapioris district and the area near Río Verde many deposits have been opened up in small mines, but in neither place is there any single mine or group of mines with sufficient ore in sight to justify building a mill. The small size and uneven grade of the deposits in those areas makes hand mining and washing more suitable than mechanized methods. A concentrating plant, to be successful, would have to operate profitably on ores that contained 0.1 to 0.2 percent of tin, since that seems to be the general range in tin content of the mineralized fault breccias that form the most extensive bedrock deposits.

INTRODUCTION

This report, dealing with the economic value of the tin deposits of the Estado de Durango, Mexico, is based upon examination of the outstanding districts in the State during the period June to November 1944. The time was opportune for such an economic review, because four plants for concentrating tin ore were built in the State late in 1943 and early in 1944, marking the first strong effort in 50 years to introduce large-scale machine methods in a region where mining and milling has been carried on almost entirely by simple hand methods.

The results of the milling ventures and of the writers' examination of the deposits all point to the same conclusion, namely, that the

bodies of tin ore are too small and pockety and too low in average grade for profitable mining and milling by large-scale methods at the present price of tin. By November 1944, all the new mills had shut down. One ran intermittently for several months, two made only short trial runs, and the fourth was never completed.

This report contains only a very condensed account of the general geology and mineralogy of the tin deposits. The report on the tin deposits of Mexico made by Foshag and Fries in 1941 [1] is concise yet accurate, and substantially complete as to all major features. The present report gives many additional details regarding certain individual mines or districts, but it makes no significant addition to the general scientific deductions made by those authors, and does not modify their economic conclusions.

The report deals chiefly with the vein deposits and mentions the placers only incidentally. The general distribution of the placer grounds and their approximate grades are known, and to make detailed surveys or to sample them adequately would require expenditures that were not provided for in alloting funds for this investigation. It should be borne in mind, however, that placers produce about three-fourths of the tin concentrates recovered in Durango.

FIELD WORK

The work in Durango began in mid-June and was completed in mid-November, 1944. As this period extended through the rainy season, the work was interrupted occasionally by unfavorable weather, but this disadvantage was partly offset by the opportunity to observe seasonal changes in activity at the tin-mining camps.

The index maps and the topographic and planimetric maps, showing the distribution of known and reported deposits of tin in Durango and within the various districts, were all prepared by Segerstrom. Most of these maps are based on his plane-table surveys, but some include data compiled from published and unpublished maps; the sources are indicated on each map. The taking of systematic channel samples at the Cerro de los Remedios and other deposits, and the laboratory preparation of the samples prior to assaying, was under the direction of Guiza. The mine maps are based on tape-and-compass surveys by Guiza and Smith, who also collaborated in mapping the geology and preparing the reports.

ACKNOWLEDGMENTS

The field work was done by members of the Geological Survey, United States Department of the Interior, and the Comité Directivo

[1] Foshag, W. F., and Fries, Carl Jr., Tin deposits of the Republic of Mexico: U. S. Geol. Surv. Bull. 935–C, pp. 99–176, 1942.

para la Investigación de los Recursos Minerales de México. It was part of a cooperative program sponsored by the Interdepartmental Committee on Scientific and Cultural Cooperation, under the auspices of the United States Department of State.

Courtesy and assistance were received from many residents of Durango, and the gratitude of the writers is only partly indicated by naming a few of the persons who were especially helpful. These included Thomas E. Allison, T. M. Edwards, Carlos Freymann, Thomas Frothingham, Manuel Garay, General M. González Peña, Ricardo Rosas, Gregorio Rivera, Jośe Miguel Salcido, M. D. Stackpole and Thomas E. Wilson.

The Director and members of the Instituto de Geología de México showed the writers every courtesy, and arranged to have the chemical laboratory of the institution determine the tin content of more than a hundred samples of tin ore. Members of the Geological Survey, particularly T. P. Thayer and F. C. Calkins, have contributed helpful criticism during preparation of the report.

GEOLOGIC FEATURES

The tin deposits of Durango (pl. 32) consist of cassiterite-bearing veins in rhyolitic volcanic rocks, and the placers derived from them. They are found at many places in the part of the State that is occupied by rhyolitic rocks. No tin deposits are known to occur in northeastern Durango, where the rhyolitic rocks have been eroded away and older rocks are exposed.

The great majority of the bedrock deposits are short thin veins, occupying simple narrow fissures, cracks, or joints that commonly show no evidence of fault movement. Some typical veins are isolated; others are in groups, with parallel or branching arrangement, extending along breccia zones; still others lie en échelon, or form criss-cross patterns. Radial patterns are uncommon. Most of the veins are vertical or nearly so, dips as low as 45° being exceptional. Some of the deposits that consist of a single vein grade into those consisting of a zone or mass of jointed, slightly brecciated rhyolite, in which the cassiterite coats the faces of joint blocks that lie in haphazard arrangement. Other veins grade into zones of breccia along faults; parts of these zones combine the features of the fissure veins and the deposits in jointed rhyolite, but the greater part of each breccia zone is barren.

The individual veins are small. The thickness of cassiterite-rich material ranges from thin coating or film to about 25 centimeters. The maximum thickness generally holds for only a few meters, and abrupt changes from valuable ore to tight joints in barren rock are typical. In about 80 percent of the occurrences, the ore is exhausted

in workings that are less than 10 meters long and 10 meters deep. A vein that has minable ore for a length or depth greater than 50 meters is exceptional, and in such a vein the ore is not uniform. The longest deposits are those in breccia zones along faults, but in such deposits the ore is not likely to be either as rich or as continuous as that in the veins.

An uneven or pockety distribution of the cassiterite is characteristic. Thin veins may consist of nearly pure cassiterite for a short distance, then change to nearly pure specularite or to clayey material; all three substances are commonly mixed in various proportions. The amount of cassiterite disseminated in the wall rock along fissures or in the breccia along faults is insignificant.

The cassiterite is intimately associated and intergrown with specularite, which in most deposits is the more abundant mineral. The intergrown particles are often so fine that it is impossible to effect a complete separation of these minerals mechanically, either in a commercial concentrating plant or in the laboratory, even if the material is ground finer than 200 mesh. The other minerals found in the tin deposits are easily separated in milling. They include quartz, tridymite, cristobalite, chalcedony, opal, fluorite, topaz, mimetite, montmorillonite, clays, zeolites, sanidine, and durangite.

MINING AND CONCENTRATING

A comparison of the prevailing mining and concentrating practice with large-scale machine methods raises a strong doubt whether new methods would lower the cost of mining tin from the veins, though it might lower milling costs.

Most of the tin concentrates are produced entirely by hand methods by independent workers called gambusinos, who have the scantiest possible equipment. The narrow irregular workings show that the usual practice is to follow the veins with a minimum of excavation, digging out the vein material with picks, and removing as little as possible of the barren wall rock. When a gambusino gets to the end of the ore, he abandons the opening, which may, however, be worked later by others.

The material mined is hoisted with a simple hand windlass or carried out on a man's back, sorted and crushed by hand, and washed on a "planilla," a gently sloping platform of earth or flat rocks built at the mine portal. If the cassiterite is in small grains, nearly half of it may be lost in washing, but usually the recovery is better than half. Very little valuable ore is left in sight in an abandoned mine, and little goes into the dumps.

The basic features of the industry are the large amount of hand labor it entails and the low cost of that labor. For most of the miners a modest return makes the work profitable. Many of them work in the tin fields for only part of the year at times when they are not claimed by farming or other necessary work. When the rains have opened up new pockets of stream gravel and when water, an essential in that dry region, has gathered in pools that facilitate washing the gravel, mining takes precedence over other work. A miner counts that day successful in which he has recovered concentrates worth the average daily wage of the region (about 4 pesos or 80 cents in United States money in 1944), and he is not too discouraged if he has a poor day now and then.

In considering the changes that would be involved in an attempt to work the ores by large-scale machine methods, it must be assumed that a central mill would treat ore from scattered small veins, for in no district is there a single vein deposit that is large enough to support a mill. The demand for tonnage would result in large workings, partly pushed through barren ground, with the result that more waste would be handled for each kilogram of concentrate. Working as company employees, the miners would have to be paid a full day's wages every day, and their output probably would be less than it is when they are working for themselves. The ore would also have to be moved, in the required tonnage, from the mines to the central mill instead of merely to the portal of each mine. Milling would entail, not only a considerable investment in the mill and other equipment, but an increase in costs owing to the need of operating in moderately remote places. The high cost of these items might offset economy resulting from the efficiency of a large concentrating plant. Ore buyers in the city of Durango estimate that ore averaging about 1 percent could be handled at a profit; but ore as rich as this is rarely found except in lenses that contain only a few tons apiece.

The milling of the tin ores did not prove to be difficult except in respect to reducing the iron content of ores that contain a large proportion of specularite, as most of them do. Recently an outlet has been opened for iron-rich ores at the Texas City smelter, and that fact has become an important consideration in planning to concentrate the tin ores. While smelters in Mexico require that the tin content be above 50 percent, the Texas City smelter will accept concentrates containing 18 to 35 percent of tin, with no limitation on the iron content.

SAMPLING AND ASSAYING

Systematic sampling of vein deposits was undertaken at only one locality, the Cerro de los Remedios, where about a hundred samples were collected, mostly by cutting channels in the exploratory workings. Although the individual samples were not large, they were numerous enough to establish beyond reasonable doubt that the material is almost all of low grade and includes relatively little high-grade ore. The sampling also indicated the distribution of tin in the different kinds of country rock, such as breccia and altered rhyolite.

Small samples were collected also at Cerro de los Remedios from a few of the larger veins, dumps, and placers. Although these cannot be regarded as establishing the tin content of any large bodies of material, they are useful as indicators of possible grade. The assays obtained from them agree fairly well with estimates of grade based on inspection or panning tests.

Experience has shown that the low-grade tin ores cannot be fairly represented by small or isolated samples. The irregular distribution of the small quantity of cassiterite that is present in such deposits makes it necessary to take large samples and reduce them carefully if precise results are wanted. This is a costly procedure, and it was not adopted in the present investigation because nearly all the ore that was assayed was so far below the grade needed for commercial exploitation that accurate determinations of the grade of large bodies of ore seemed unnecessary. Such determinations ought perhaps to be made, however, before a final decision is reached as to whether large-scale operations are likely to be profitable.

Experience has shown, also, that low-grade tin ores present difficulties to the analyst. If the tin content is less than half of 1 percent, determinations by different laboratories ordinarily show conspicuous differences. In this investigation, determinations of tin in all the samples were made first at the chemical laboratory of the Institute de Geología, and then, by way of check, selected samples were also assayed in the laboratories of the Comisión de Fomento Minero at Tecamachalco, D. F., Mexico, and in those of Ledoux & Co., New York, N. Y. The results, which are given in the following tables, illustrate the differences that may reasonably be expected when samples of low-grade tin ore, collected with care, are analyzed by different laboratories having the high standards of the three that did this work.

Tin content of samples from Cerro de los Remedios

Sample No.[1]	Percent of tin reported [2]			Average of A, B, and C
	A	B	C	
1	0.	0. 00		
2		. 00		
3		. 18		
4		. 16		
5		. 00		
6	0. 16	trace	0. 26	0. 14
7	. 25	trace	. 35	. 20
8	. 23	trace	. 30	. 18
9	. 16	. 38	. 25	. 26
10–A		. 02		
10–B		. 18		
11–A	. 42	. 46	. 68	. 52
11–B		10. 95	12. 00	11. 48
12–A		. 12		
12–B		. 00		
13		. 26	. 28	. 27
14		. 12		
15		. 11		
16		. 14		
17		. 34	. 28	. 31
18		. 02		
19		. 48	. 62	. 55
20–A	. 0	. 06	[3] trace	. 02
20–B		. 14		
21		. 13		
22		. 02		
23	. 0	. 00	[3] trace	. 00
24	. 0	. 00	. 05	. 02
25		. 12		
26		. 04		
27		. 08		
28		. 34	[3] trace	. 17
29–A	. 01	. 04	[3] trace	. 02
29–B		. 02		
30		. 00		
31		. 02		
32		. 16		
33		. 04		
34		. 00		
35		. 00		
36		. 09		
37–A		. 08		
37–B		. 02		
37–C		. 02		
38–A		. 00		
38–B	. 005	. 14	. 03	. 06
38–C		. 74	1. 41	1. 08
38–D	5. 12	4. 36	5. 23	4. 90
39		. 00		
40		. 12		
41		. 02		
42		. 02		
43		. 00		
44		. 02		
45		. 14		
46		. 29	. 36	. 33
47		. 00		
48	. 38	. 32	. 33	. 34
49		. 16		

Tin content of samples from Cerro de los Remedios—Continued

Sample No.[1]	Percent of tin reported [2]			Average of A, B, and C
	A	B	C	
50–A		0. 12		
50–B	1. 23	1. 12	1. 36	1. 24
51–A		. 02		
51–B		. 88	1. 22	. 55
51–C		8. 58	10. 83	9. 71
52–A		1. 48	1. 63	1. 56
52–B		. 86	1. 21	1. 04
53		. 24	. 31	. 28
54	. 64	. 70	. 73	. 69
55	1. 74	1. 68	2. 13	1. 85
56		1. 46	1. 87	1. 67
57		. 34	. 64	. 49
58		. 06		
59–A		4. 58	5. 93	5. 26
59–B		. 0		
60		. 32	. 48	. 40
61		. 68	. 76	. 72
62–A	. 28	. 32	. 31	. 30
62–B		. 76	. 85	. 81
63		. 34	. 22	. 28
64		. 08		
65–A	9. 32	9. 52		9. 42
65–B	. 49	. 40	. 15	. 35
66–A		3. 84	5. 07	4. 46
66–B		. 04		
67	. 72	. 54	. 73	. 66
68–A	. 03	. 04		. 04
68–B		1. 01		
69		. 15		
70		. 74	1. 14	. 94
71–A		. 82	1. 44	1. 13
71–B	. 48	. 72	. 49	. 56
72		. 22		
73		1. 28	1. 55	1. 42
74		. 10		
76 [4]		. 09		
77	. 01	. 04	. 04	. 03

[1] The samples are located by number on the assay plan, plate 4.
[2] The determinations were made in the following laboratories: Column A, Comisión de Fomento Minero, Tecamachalco, D. F., Mexico; B, Instituto de Geología, México, D. F., Mexico; C, Ledoux & Co., New York, N. Y.
[3] "Trace—less than 0.01 percent" (Ledoux & Co.).
[4] There is no sample 75.

Tin content of samples from the América district

Property	Sample No.	Percent of tin reported [1]			Average of A, B, and C
		A	B	C	
Fierrosa	F–1	0. 25	0. 90	0. 93	0. 69
Do	F–2	6. 20	3. 96	4. 83	5. 00
Jaltomates	J–1	. 43	. 10	. 46	. 33
San Miguel	SM–1	. 24	. 26	. 40	. 30
Do	SM–2	. 67	. 36	. 64	. 56
Orozco	O–1	trace	. 06	. 09	. 05
Do	O–2	8. 66	7. 38	9. 33	8. 46
Do	O–3	trace	. 04	. 23	. 09
Do	O–4	trace	. 16	. 24	. 13
Las Barrocitas	B–1	trace	. 04	. 15	. 06
Do	B–2	. 18	. 16	. 54	. 29
Las Carpas	C–1	trace	. 20	. 24	. 15
Candelaria	Cd–1	trace	. 24	. 28	. 17
Do	Cd–2	. 0	. 0	. 12	. 04
Grant	G–1	. 0	. 02	. 07	. 03
Do	G–2	. 30	. 72	. 87	. 63
Do	G–3	. 55	. 62	. 67	. 61
Do	G–4	trace	. 18	. 20	. 13
Do	G–5	. 0	. 06	. 09	. 05

[1] The determinations were made in the following laboratories: Column A, Comisión de Fomento Minero, Tecamachalco, D. F., Mexico; B, Instituto de Geología, Mexico, D. F., Mexico; C, Ledoux & Co., New York, N. Y.

PRODUCTION STATISTICS AND ESTIMATES

Full and reliable data on past production of tin in Mexico, if they were available, would afford a valuable indication of what to expect in future years since the quick abandonment of the milling projects indicates that no radical change in mining methods is likely to develop soon. Unfortunately, the records of past production are incomplete. In trying to supplement them, reliance must be placed on the estimates of ore buyers and others familiar with the industry. The total amount of tin produced in Mexico in recent years is undoubtedly greater than is shown in official Mexican government publications (Boletín Minero and Boletín Petróleo y Minero), because the official records do not include the unknown quantity of tin that is taken by miners and ore buyers to small smelters and to exporters. Such tin never appears on the records of large smelters, tax offices, railroads, or exporters, whose records provide fairly complete statistics of the ore that they handle. The actual tin production of Mexico is thus a matter of estimate, the official figures being a minimum.

According to the official statistics, Mexico produced, on the average, 386 metric tons [2] of tin per year during the 10 years 1930–39, inclusive.[3] During that period about half of the tin came from the unusual ore

[2] Metric tons and other metric units are used throughout this report. A table of factors for converting to English units is given at the end of the report.
[3] Foshag, W. F., and Fries, Carl Jr., op. cit., pp. 104–105.

body in the San Antonio mine near Santa Eulalia, Chihuahua. Small mines and prospects produced the rest, about 180 tons per year, and in subsequent years they produced all the tin recorded. The recorded production for these years, calculated as metallic tin, is given below.

Recorded production of tin in Mexico

Year	Production (tons)
1940	351
1941	216
1942	370
1943	434
Average	343

Estimates of the actual production in Mexico, obtained from apparently competent authorities, differ widely. For example, Foshag and Fries [4] concluded that the official figures, though incomplete, are "probably of the right order of magnitude." But M. D. Stackpole [5] of Durango, a well-informed ore buyer with 40-odd years of experience in Mexico, estimated that for the 10 years prior to 1944 the actual production averaged about 1,200 tons of tin per year, more than three times the amount officially recorded. Estimates by others are not in close agreement with either of the foregoing estimates. The tin comes from so many small and widely scattered sources and is distributed by so many small handlers that no one has a comprehensive knowledge of the entire industry.

The official records of production in Durango are probably as incomplete as those for Mexico as a whole. The records of the State, based on taxes paid on concentrates were available for the year 1943 only. They indicated a production of 150 tons of metallic tin which was more than 30 percent of the national production in so far as it was officially recorded.

Production estimates for Durango differ as widely as those for all Mexico and it is impossible to reconcile them. Garcia [6] for example, estimated in 1926 that the annual production in Durango varied between 10 and 12 tons. The official records, however, give the total production from Mexico for the nearest years, 1924–26, as 8.084, 1.023, and 2.224 tons, respectively. Estimates of Durango's recent production range from 900 tons to 30 percent of his estimate for the national production.

The production of tin from individual mines and districts is largely unrecorded. A few items of information have been gathered, however, from published accounts and personal communications, and are given in the descriptions of districts later in this report. It is

[4] Foshag, W. F., and Fries, Carl Jr., op. cit., p. 104.
[5] Personal communication.
[6] García, J. Aurelio, Monografía del estaño: Bol. minero, vol. 22, núm. 1, pp. 22, 1926.

generally agreed that the most productive area in Durango is the Sierra de San Francisco, which includes the América-Sapiorís, or Potrillos district. Its production in 1944 was estimated to be between 10 and 25 tons per month, a large share of the total for the State. The Río Verde district (also called the Sierra de Cacaría and the Otinapa district) and the Ochoa district each produced less than the Sierra de San Francisco but stand well ahead of all others; their annual production is estimated as 30 tons and 15 to 40 tons, respectively. These three districts are also regarded as having the most promise for future production, and, together with the less promising Cerro de los Remedios and the Canatlán district, they have been involved in projects for large-scale mining and milling.

DISTRICTS AND MINES EXAMINED

DEPOSITS IN THE CERRO DE LOS REMEDIOS

The tin deposits in the Cerro de los Remedios, which is a low hill at the west edge of the city of Durango (pl. 33 and 34), have been known since about 1890. Their production has not been recorded but has been estimated as more than 10 tons.[7]

Until 1940, mining at Cerro de los Remedios was intermittent, the properties being left idle for years at a stretch. The only important workings were deep, narrow open-cuts along the La Vanguardia vein, which crops out on the northwest slope of the hill. Since 1940 the hill has been prospected extensively under the leadership of Carlos Freymann of the city of Durango. His Compañía Minera de los Remedios explored the north and west sides of the hill with more than 800 meters of underground workings. In addition, the ground adjacent to the old La Vanguardia workings was explored with about 250 meters of drifts and crosscuts by Estaños del Norte, S. A., a company that leased the La Vanguardia claim from Freymann in 1942. As a result of this prospecting, the underground workings in Cerro de los Remedios have a greater total length than those at any other tin deposit in Durango.

Two concentrating plants were built on Cerro de los Remedios, one by each company, during 1943 and 1944. The plant of Estaños del Norte, S. A., which is adjacent to the La Vanguardia mine, was completed early in 1944, and was operated intermittently until November 1944, partly on material from old dumps. No information was obtainable as to the results of the milling operations. The mill of the Compañía Minera de los Remedios at the western base of the hill was not completely equipped and was never operated. The capacities of the mills were estimated as 40 and 20 tons per day.

[7] Foshag, W. F., and Fries, Carl Jr., op. cit., p. 165.

In November 1944 the outlook for the mills at Cerro de los Remedios was not promising. Exploratory work had uncovered a few small veinlets of rich ore, with a maximum tin content of 11.48 percent, but these were only about 3 centimeters thick; the larger ore bodies did not contain even the 1 percent that is regarded as the lowest percentage that will yield a profit.

An indication of the low grade of ore available for mill feed was given by samples from the 325-ton ore pile that had been accumulated at the mill of the Compañía Minera de los Remedios and was ready for treatment when the mill should be completed. This material was presumably mined from the part of the La Vanguradia vein that was opened in the Tiro Tomás workings. Four samples were collected by digging pits 1 to 2 meters into the ore pile, one pit on top and three others in the sides. These samples were found to contain, on the average, about 0.2 percent of tin.

CHARACTER OF THE VEINS

The veins in Cerro de los Remedios are breccia zones along faults. The Vanguardia vein, which has yielded most of the tin recovered from the hill, is typical: it strikes N. 30° E. and dips between 70° S. and vertical, and it cuts across layered porphyritic rhyolite which, on the average, dips 20° SE. The fault zone is thickest at the northern limit of exploration (pl. 34); southward it becomes thinner and splits into several branches. Through much of its length the average thickness is about a meter. Some of the rhyolite in the fault zone is in large blocks between branching, curving fissures, but most of it is breccia containing streaks of clay. The La Gloria vein resembles the Vanguardia but contains more clayey material, and between the two veins there are a number of similar but smaller breccia zones.

The cassiterite is partly in thin veinlets within the breccia and partly in small masses of fissured, brecciated rhyolite which form relatively small parts of the breccia zones. Although cassiterite occurs as incrustations or fillings in breccia and has penetrated a few millimeters into some fragments of rhyolite, there is no widespread dissemination of cassiterite either in the breccia or in the wall rock.

The veins could be mined in either of two ways. All the breccia in the fault zones could be taken out in order to get the cassiterite that is scattered in widely spaced veinlets and pockets, or the zones could be widely prospected and the richest parts mined selectively. The work done to date indicates that mining by either method is unlikely to be profitable at present prices for tin.

EXPLORATORY WORK, 1943–44

Exploration by Estaños del Norte, S. A., was confined to the La Vanguardia claim and consisted mainly of prospecting northward along the La Vanguardia vein and southward on it and its branches. This work is shown in plate 34, together with data on samples collected by the writers. Part of the work was done through the shaft called the Tiro Norte Viejo, which adjoins the old open stope, and part through the new shaft called the Tiro Sur.

The Compañía Minera de dos Remedios prospected the La Vanguardia vein north of the La Vanguardia claim line by way of a crosscut from the shaft called the Tiro Tomás. An injunction from the authorities of Durango, who believed that the blasting endangered the city pumping plant and water-supply lines, stopped work on the level that is shown in plate 34. Prospecting northward on a lower level was started in 1944, but this level was flooded during the writers' stay in Durango. The company also ran a crosscut 150 meters long extending southeastward from the Tiro Tomás, hoping thus to reach a vein that had yielded rich pockets of ore in the shallow workings of the Tiro Norte (pl. 34). This vein was not found, but the crosscut encountered the thick fault zone known as La Gloria vein. On the southwest side of the hill the company drove two adits, called the Socavón del Polvorín and the Socavón Nuevo, and sank a shaft called the Tiro Bolívar. This work was done in search of a southward extension of the Vanguardia vein, but only very small fissures were found.

SIZE AND GRADE OF ORE BODIES

This extensive exploratory work uncovered some small bodies of ore that could be selectively mined at a profit, though they are not valuable enough to pay for the exploration. The work also developed some large sections of veins adjacent to the old stopes that have potential value for the future, though they are of too low grade to be mined at present. A compilation given in the following table, of the size and grade of ore bodies shows, in general, that the longer and thicker the ore body, the lower its grade. Tonnage is shown only for the three bodies that, because of their size or grade, are potentially most valuable. The tonnage for the very small but moderately rich stringers is insignificant and was not computed. It seemed useless, also, to compute the tonnage of the large parts of the breccia zones that contain less than a quarter of 1 percent of tin, for material of such low grade cannot be regarded as having potential value when treated by present methods, or by any method likely to be developed in the near future. One block for which the inferred percentage of

889408—50——2

tin is given as 0.2 to 0.5 percent probably should be regarded as containing only about 0.2, for it is only half a meter in thickness, whereas in mining it is necessary to take out a thickness of at least a meter. Its tonnage therefore is not computed.

LA VANGUARDIA MINE, TIRO NORTE WORKINGS

The exploratory work from the Tiro Norte, adjacent to the old open-cut, is on a level 30 meters below the collar of the shaft.

The north drift on the La Vanguardia vein would seem, as shown in the projection (pl. 34), to have been stoped upward to a height of 4 meters, but half of this apparent height is the result of lowering the level 2 meters after one section had been completed. At the beginning of the north drift one sample (50–B) showed a tin content of 1.24 percent through a thickness of 90 centimeters, but on other sample was found to contain more than 0.35 percent, and the average was below 0.2 percent. The initial workings south of the shaft are under old open pits, and include a stope from which some ore was taken. Samples along this section showed the characteristic distribution of cassiterite in thin stringers, and they indicated that the tin content through an average thickness of a meter was probably between a half and three-fourths of 1 percent. It would be relatively easy to make mill tests of this part of the breccia, and to do so should be the first step toward determining its value. It is estimated that 2,000 tons of ore might be recovered from this part of the lode, assuming it could be stoped to the surface pits and that it maintains its thickness.

Size and grade of ore bodies, Cerro de los Remedios

Location	Length developed (meters)	Average thickness (meters)	Inferred percentage of tin [1]	Metric tons of potential mill ore
La Vanguardia mine, Tiro Norte workings:				
La Vanguardia vein, north of shaft	40	1.00	0.1–0.2	
La Vanguardia vein, first section south of shaft	50	1.00	.5– .7	2.000
La Vanguardia vein, second section south of shaft	50	.50	.2– .5	
Vein in crosscut (samples 67 and 70)	10	.65	.8	150–200
Vein in first drift (samples 71–A, 71–B, and 73)	7	.20	1.25	
Vein in second drift (samples 68–A and 68–B)	15	.10	1.00?	
La Vanguardia mine, Tiro Sur workings:				
Vein in first drift, at crosscut (sample 19)	10?	.10	.50	
Vein in first drift, southern part (sample 16, etc.)	30	1.00	.1	
Vein in second drift	45	1.00	.2	
Remedios mine, Tiro Tomas workings:				
La Vanguardia vein, in part (sample 38–D)	5	.50	5.0	25
La Vanguardia vein, all except foregoing part	25	1.70	.05	
Vein east of La Vanguardia (sample 40)	10	.60	.1	
Vein near shaft (sample 41, etc.)	40	1.00	.1	
La Gloria vein	150	1.00	.05	
Ore pile at mill			.2	325

[1] Because of possible inaccuracies in sampling and in determining the tin content of ores so low in grade, the percentages given might be in error by one-fourth their value, plus or minus.

The crosscut extending eastward from the shaft crossed several small veins. The best vein, which extends from the crosscut obliquely southward and across the first drift, consists of a well-defined zone of thin stringers. The strong appearance of this vein, together with assays of 0.94 and 0.66 (samples 67 and 70), seems to justify an estimate of 150 or 200 tons, with an average tin content near 0.8 percent.

The veins in the two drifts are good examples of ore suitable for hand sorting. One vein is 20 and the other 10 centimeters thick, and if they were taken out with a mining width of the enclosing rhyolite, which is barren, the over-all tin content of the rock mined would probably be between 0.1 and 0.3 percent.

LA VANGUARDIA MINE, TIRO SUR WORKINGS

The shaft called the Tiro Sur was put down in search of southern extensions of the La Vanguardia vein near old open cuts which showed that the vein branches southward. The shaft is 35 meters deep, and the level extending from it at a depth of 20 meters is an exploratory level consisting of a crosscut and two drifts that follow fault zones. No ore suitable for milling was found, but thin veinlets within the fault zones contain streaks rich in cassiterite.

The first drift south of the shaft starts on a veinlet 10 centimeters thick that contains 0.55 percent of tin, but the southern part of the drift is along a sheared zone containing only 0.1 percent of tin according to channel samples taken at intervals of about 10 meters.

The second drift south of the shaft follows a fault zone that is probably a branch of the main La Vanguardia fault. This zone, which splits toward the south, is about a meter thick on the average. The footwall is fairly well defined and solid, but the rhyolite in the hanging wall is much brecciated and is broken into large blocks separated by branching fractures. The brecciated zone is practically barren except for one iron-stained veinlet 3 centimeters thick, which was found to contain 11.48 percent of tin. A second sample at the same place, across 90 centimeters of breccia including the veinlet, was found to contain 0.48 percent. This veinlet wedged to a narrow crack in a distance of 2 meters, and it probably has little effect on the average for the entire zone, other samples from which indicated an average of not more than 0.2 percent.

REMEDIOS MINE, TIRO TOMAS WORKINGS

A crosscut extending northward from the Tiro Tomás reached the Vanguardia vein at a distance of 65 meters from the shaft. A 25-meter drift that was developed along the vein revealed a small block of minable ore along the hanging-wall (southeastern) side of the fault

zone. This block is half a meter thick and 5 meters long, and a representative sample from it contained about 5 percent of tin. A sample cut across the adjoining breccia, in line with the cut in the rich ore, was found to contain 1.08 percent of tin, but apparently this high value is the result of having cut some of the rich ore, for most of this sample came from a block of rhyolite that looked as if it contained less than a quarter of 1 percent. The rich block was estimated to contain about 25 tons of ore, on the assumption that it continued vertically for a distance equal to its length, which is about 5 meters. Nine other channel samples were cut in the breccia where it was exposed along the drift and in the air shaft that extends to the surface. Most of these samples contained practically no tin, and the richest contained only 0.09 percent.

Between the shaft and the La Vanguardia vein, the north crosscut went through one breccia zone and several thin, iron-stained stringers. Three samples cut in the breccia zone contained practically no tin. The tin content of the only stringer sampled was 0.12 percent.

A crosscut that extends 150 meters south from the shaft cuts the major fault zone called the La Gloria vein. The drift on this vein is 105 meters long, but in this length the only indications of mineralization are a few small pockets of specularite. Samples cut across the breccia at the locations shown on the map were found to contain 0.0 to 0.17 percent of tin, indicating an average tin content of less than 0.10 percent.

TIRO BOLIVAR WORKINGS

The shaft known as the Tiro Bolívar is high on Cerro de los Remedios, southwest of the church that crowns the hill. The shaft is 35 meters deep, but the workings from it are at a level only 20 meters below the collar. Drifts were driven in three directions (pl. 34), in search of downward continuations of thin veinlets that are exposed in surface trenches north of the shaft. No veinlets were cut by the workings; the veinlets may have pinched out downward because of a change in the character of the rhyolite, for the surface trenches are in hard, solid lava, while the workings are almost entirely in fine-grained to medium-grained tuff and breccia. It is possible either that fissures formed more readily in the lava than in the tuff, or that the lava localized the tin mineralization in some other way. Two small veins, 4 and 2 centimeters thick, that were found in the underground workings contained specularite, but their tin content was small—0.09 and 0.10 percent in two samples. The miners made no attempt to follow them.

SOCAVON DEL POLVORIN AND SOCAVÓN NUEVO

The exploratory adit at the southwest end of the hill, called the Socavón del Polvorín, is 175 meters long and has about 30 meters of lateral workings and a winze 12 meters deep. A block of fault breccia that contains an abundance of specularite was explored along the winze. The lateral workings follow thin fractures containing specularite and iron-stained gouge. None of the material encountered in the workings appears to contain much cassiterite, but of four samples across part of the block of faulted breccia, two contained a little less than 0.2 percent of tin.

In November 1944 the Socavón Nuevo was 75 meters long, and had encountered nothing that looked like a vein or other tin-bearing material.

DEPOSITS OF THE AMERICA-SAPIORIS DISTRICT

GENERAL FEATURES

LODES

The América-Sapiorís district, as the name is used in this report, includes an irregular area approximately 15 kilometers long and 5 kilometers wide in the Sierra de San Francisco (pl. 35). At various times the district has been called the Potrillos district, after the first mining camp, or merely the América district or the Sapiorís district, after whichever camp was most active. At the time of the authors' visits, Sapiorís was much more active than América, and Potrillos was nearly abandoned.

The principal rocks in the América-Sapiorís district are the tin-bearing rhyolitic lavas and the tuffs and breccias interbedded with them, but the area examined also includes exposures of andesite that is older than the rhyolitic rocks and of conglomerate that is younger. The distribution of these rocks, and of the larger placers as well, is shown in plate 35.

The rhyolitic rocks and the andesite are both generally regarded as Tertiary,[8] but the age of the conglomerate is unknown. The placers are Recent.

The structure of the range has not been mapped in detail but is known in a general way. Andesite such as that exposed in the area mapped is the predominant rock in the lowland along the east side of the range, and it undoubtedly extends under the range, below the capping of rhyolitic rocks. The thickness of the rhyolitic rocks is unknown because their stratigraphy and structure have not been

[8] Ordóñez, Ezequiel, Las rhyolitas de México: Inst. Geol. México Bol., Núm. 14, pp. 66–67, 1900.

worked out, but they are probably at least a thousand meters thick near América where the topographic map shows a relief of 700 meters. Their thickness may be less near Sapiorís, which is at almost the same altitude as the top of the andesite exposed 5 kilometers to the east.

The structure of the rhyolitic rocks was examined in most detail in the vicinity of América (pl. 36), with a view to establishing if possible the relation between the attitude of the rhyolite layering and the location and attitude of the tin veins. It was found that the rhyolite layering ranges in dip from horizontal to vertical, and strikes in various directions; this diversity of attitude is the result of original flowage and not of deformation. The tin-bearing veins range in dip from vertical to 60° S., and the majority strike between N. 60° E. and N 60° W. Scarcely two cut the layers that enclose them in the same way; the primary structure of the rhyolitic flows evidently exerted no control on the alinement or position of the tin veins.

The conglomerate extends from near América northwestward beyond the boundary of the area mapped. Some features of it seem to indicate that substantial changes in the geomorphology, and perhaps in the structure, of the Sierra de San Francisco have occurred since the conglomerate was deposited. In the lower layers of the conglomerate, which are exposed in the tributaries to Arroyo de América, the pebbles and cobbles are chiefly of andesite. Some, however, are of rhyolite and upward in the stratigraphic section the proportion of rhyolite greatly increases; but andesite is present in all the layers. Since no andesite is known to crop out in the drainage basin as developed at present, the abundant pebbles of andesite indicate that some geomorphic change has taken place. The conglomerate owes its present position at least in part to faulting. It will be seen from the map (pl. 36) that the topographic relation of the conglomerate to the rhyolite east of it, in the area northwest of Las Carpas, seems to be a result of faulting. The contact on the west edge of the conglomerate also may be faulted, for its trace does not follow the pattern it should have if the conglomerate capped the ridges. Benches or terraces are indeed well developed on both sides of Arroyo de América, between the incised stream channel and the higher, rugged country farther away, but these benches are cut across the layering of the bedrock, which is rhyolite on the east and rhyolite and conglomerate on the west. The conglomerate near América, however, where its base is well exposed, rests uncomformably upon rhyolite. The conglomerate apparently accumulated during a period when the drainage basin was larger and included exposures of andesite, and some of the conglomerate has been preserved because it was faulted down relatively to the adjoining rhyolite.

No cassiterite has ever been found in the conglomerate, or in the stream channels that cross it, but there may be a little in the upper part, where the rhyolitic rocks predominate. The predominance of andesite in the lowest layers indicates that there is probably no concentration of cassiterite at the base of the conglomerate, which is ordinarily the best place to look for placer values in such material.

PLACERS

The placers in the América-Sapioris district include deposits of gravel along the stream channels and patches of residual material close to the outcrops of veins. The residual placers are generally richer than the stream gravels and contain larger fragments of cassiterite, but the gravel deposits are much larger, and being better supplied with water they are more easily worked. During each rainy season, moreover, the gravels are partly rewashed by the streams, so that new workable pockets accumulate each year. The stream gravels have always yielded the greater part of the concentrates produced in the district.

The extent of the placer grounds in the district is fairly well represented on the planimetric map (pl. 35), although many small placers on minor streams and near veins are not shown. In the stream gravels, the thickness of a deposit is roughly proportional to its areal extent. The maximum thickness in Arroyo de Sapioris is about 8 meters. In Arroyo de Liendres it is about 5 meters, and in Arroyo de América it is about 3 meters. The average thicknesses are less than half the maxima; in most of the gravel deposits it is less than a meter.

The volume of gravel in the three largest placers was roughly estimated by Foshag and Fries [9] as follows:

	Cubic meters
Arroyo de América, 100,000 cubic yards	76,000
Arroyo de Sapioris, 200,000 cubic yards	152,000
Arroyo de Liendres, 200,000 cubic yards	152,000

These figures probably should be regarded as minima, for the approximate survey made by the writers of this report indicates that the volumes may be two or three times as large as those listed above.

In estimating the chances of profitably exploring the placer deposits by machinery, grade is a much more critical factor than volume. Foshag and Fries [10] estimated that the gravels had an average tin content of about 0.02 percent (about half a kilogram per cubic meter). This is a careful estimate based on their own panning tests as well as inspection and to improve upon it would require large expenditures

[9] Foshag, W. F., and Fries, Carl Jr., op. cit., pp. 174–175.
[10] Foshag, W. F., and Fries, Carl Jr., op. cit., pp. 174–176.

for test pits and samples. It is probable that testing would develop only a small volume of gravel containing a kilogram per metric ton (0.1 percent), the minimum grade found workable under the favorable conditions prevailing in the Malay tin fields. Thorough tests of similar placers in the Black Range, N. Mex., showed that the tin content of large bodies of gravels was unworkably low,[11] and that is probably true of these large placers in the América-Sapiorís district.

MINES NEAR AMERICA

GRANT

The Grant mine lies 1,450 meters N. 70° E. of América at an altitude of 2,145 meters. The mine workings are the most extensive in the district; indeed, among all the tin mines that the authors visited in Durango only the exploratory workings at Cerro de los Remedios are larger. Most of the workings (pls. 37, 39) look as if they were opened in the course of fairly systematic mining, and probably date from the early 1890's. Although the mine has been practically abandoned ever since that period, some later work is indicated by irregular workings and haphazard backfills.

The Grant deposit is notable for consisting of several well-defined veins that intersect, and for having some unusually large stopes at the intersections. The veins are nearly parallel in strike (N. 60°–75° E.) and intersect because they have different dips: the largest vein dips 60° S., and the smaller ones, which lie below it, are steeper.

The veins are short, as can be seen both on the surface and in the underground workings. In the accessible workings they are exposed for a horizontal distance of about 90 meters and for a total vertical distance of at least 45 meters. The deeper workings (including whatever may extend from an 86-meter shaft south of the main workings) were not accessible, but according to Thomas Frothingham[12] no veins were found in them. At the ends of the workings on all the accessible levels, the fractures in the rhyolite are thin and contain only streaks of barren gouge. It is evident that the early operators and the gambusinos who followed them carried their search for additional ore to reasonable distances, but without success.

The size of the stopes suggests that some of the Grant ore bodies may have been remarkably wide, as ore bodies in such mines go. One stope is more than 5 meters wide and others are 2 to 3 meters wide. The width of some stopes was obviously determined by the distance between the two veins or fractures that served as convenient walls, and both may have contained cassiterite. Other stopes appear to have

[11] Fries, Carl, Jr., Tin deposits of the Black Range, Catron and Sierra Counties, N. Mex., a preliminary report: U. S. Geol. Survey Bull. 922–M, pp. 366–367, 1940.
[12] Personal communication.

been widened by caving, for they are in rhyolite softened by alteration. But after allowing for these conditions and keeping in mind that all the fissures now exposed at the ends of the workings are only a few centimeters thick, it still remains probable that some of the ore bodies in the Grant mine attained a width of a meter or more. Of all the mines in the América district, the Grant and the Candelaria are the two that appear most likely to have contained the wide ore bodies that Ingalls[13] described as follows: "The ore that has been mined, however, has generally shown from 3 to 10 percent of metal, and as thus obtained, has been broken from breasts 3 or 4 feet wide" (1 or 1.3 meters wide).

The cassiterite in such wide ore bodies was probably in stringers or veinlets, rather than disseminated, according to all observations made by the writers. Most of Ingalls' descriptions[14] refer to ore in veinlets; only the following statement suggests the presence of disseminated ore: "These ore-bodies are exceedingly ill-defined, passing into the barren country-rock by insensible gradations."

The tin content of the ore now in sight is certainly not up to that which Ingalls reported, at least not through such widths of ore. What seemed to be the richest material exposed in the mine was in pillars, and the following assays of samples taken from three pillars showed little tin.

Sample	Width represented (meters)	Percent of tin (average of 3 determinations)
G–3	1. 5	0. 61
G–4	1. 3	. 31
G–5	1. 15	. 05

The dumps appear to be very lean, showing so little cassiterite that, in the writers' estimation, the average tin content is probably less than half of 1 percent. A small grab sample taken from the surface of the dump was found to contain 0.63 percent of tin, which is more than was found in the richest pillar, but this sample is certainly not representative. The dump contains 6,000 or 7,000 tons of material.

A placer lies on the gently sloping surface west of the Grant mine, but it cannot be regarded as a promising source of tin because most of the ground in it has been worked one or more times. Some parts of this placer were originally as much as three-quarters of a meter thick, but the average thickness was not more than a quarter of a meter. All the material seems to be residual and was perhaps formed by erosion of western extensions of the Grant veins; none of it appears to have been transported for any considerable distance. None of it was sam-

[13] Ingalls, W. R., The tin deposits of Durango, Mexico: Am. Inst. Min. Eng. Trans., vol. 25, p. 154, 1896.
[14] Ingalls, W. R., op. cit., vol. 25, p. 155.

pled, for none of the remaining placer material seemed worth sampling. A sample (G–1) taken from a similar placer that was being worked north of the Grant mine, in the drainage of Arroyo del Negrito, contained about 0.03 percent of tin. Although the gambusinos have some very modest success in recovering concentrates from streaks that are richer than average in such deposits, the low average grade and small size of the deposits obviously make it unprofitable to work such placers by mechanized methods.

LAS BARROCITAS

Las Barrocitas mines lie 2 kilometers N. 40° E. of América, at altitudes near 2,200 meters. They are evidently the same as the Mina Barrosa shown on the map made by Patoni [15] in 1891, and the same as the mine described in 1941 by Foshag and Fries [16] under the name Varocitos.

The deposits are in rhyolitic lava, which is altered in many places to a white porous material containing considerable clay (hence the name Barrocitas, or "Little Muddy" mines). In some places the rock is altered only along the course of the veins, but much of the rhyolite along the veins is unaltered, and in the area of most intense alteration there are no veins. Well-defined layering in the rhyolite dips 20° to 35° in some places (pl. 38); these are probably initial dips rather than the result of folding. Apparently the attitude of the layering had no effect on the attitude of the veins, which strike N. 70° E. and dip between 70° S. and vertical having the attitudes most common in the district.

Although the deposits were known as early as the nineties and have been worked as recently as 1943, the mines are small because the ore is pockety. Most of the workings (pl. 38) are on a group of six veins, the longest of which has been traced about 70 meters. Two less productive veins that lie 150 meters east of the main group are slightly longer, but other veins in the area are much smaller. The ore shoots did not exceed 35 meters in maximum length, and none was followed downward more than 15 meters. The remaining traces of ore indicate that it consisted of cassiterite-rich shoots in fissure veins a few centimeters thick. The largest shoot might have been 30 meters long and equally deep, but it averaged no more than 10 centimeters in thickness. Such an ore shoot might yield valuable high-grade ore to the hand miner, but it could not provide many tons of ore suitable for milling. Furthermore, the shoots are too far apart, as well as too small, for systematic mining.

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[15] Patoni, Carlos, Región minera de Potrillos, Estado de Durango: Boletín Minero, tomo 3, núm. 2, p. 72, 1917 (although published in 1917, the report and map are dated 1891).

[16] Foshag, W. F., and Fries, Carl Jr., op. cit., p. 172.

A grab sample from the dumps was found to contain about a quarter of 1 percent of tin (sample B–2; average of three determinations 0.29 percent). The dumps look as barren as this result indicates. It is evident that little of the rock taken from the workings, which are mostly a meter or more in width, would be worth milling.

OROZCO

The Orozco mine is at the southwest edge of Mesa de Orozco, at the headwaters of a small tributary of Arroyo de las Culebras. The mine is 3 kilometers N. 11° E. of América, at altitudes of 2,110 to 2,140 meters.

Although the deposits have been known for many years, they have been worked only intermittently, by gambusinos. Their production is unrecorded, but Foshag and Fries [17] have stated that the miners whom they met at the mine early in 1941 had been obtaining 100 kilograms of concentrates a week for 3 weeks.

The placer ground near the mine is likewise attractive only to gambusinos. Placer workings west of the mines cover an irregular area 50 by 150 meters in extent, about 80 percent of which has been worked. The maximum thickness appears to have been about 30 centimeters. A sample taken from unworked material was found to contain practically no tin (sample B–1; average of three determinations 0.06 percent).

A second placer area extends from Las Barrocitas mines southwestward as far as Arroyo del Negrito (pl. 36). It is only a narrow strip, and the diggings in it are spotty and shallow. Apparently the material was washed down from the vicinity of Las Barrocitas. The single gambusino who was working in this placer at the time of examination said that on an average day he recovered about a kilogram of concentrates (value 4 pesos or about 80 cents in 1944). This figure, it was plain, applied only to days worked in the best spots, for if the average for working all the ground had been so high, many gambusinos would have been busy on the ground. The concentrate the gambusino had accumulated that day was said to be typical, and it was made up as follows: about two-thirds of it by weight was in nuggets half a centimeter to 3 centimeters in diameter, and most of the remainder was in grains more than half a millimeter in diameter. About a third of the finer grains (less than a millimeter in diameter) were of topaz. Specularite was present in small grains and was intergrown with cassiterite in some of the nuggets, but the total amount was small. Because of its low iron content such a concentrate is easy to sell locally. The gambusino fails, of course, to save the finer par-

[17] Foshag, W. F., and Fries, Carl Jr., op. cit., p. 173.

ticles of cassiterite. There is no way of telling what percent of the original cassiterite is thus left in the gravel, but it is probably too little to pay for elaborate methods of recovery.

The rhyolite at the Orozco mine (pl. 39) is part of a devitrified and locally much altered flow. Most of it is gray, hard and moderately well layered, but along the veins and between them the rock is white, soft, and porous. The rhyolite has a layering whose attitude is not the same in any two outcrops, but the flow as a whole seems to dip between 10° and 25°E. Conspicuous vertical joints that strike N. 30° E. cut the flow layers.

The productive veins, which are parallel to these joints, are in a zone about 10 meters wide and 150 meters long; a single fissure containing little cassiterite extends southwestward along the same course for 200 meters more. The workings are open-cuts and narrow shafts, most of them less than 12 meters deep and the deepest only 18 meters. As the projections (pl. 39) show, the longest cut extends along the vein for about 40 meters. Although the veins are unusually long they are pockety and disappointingly narrow. A miner who had worked at the deposit in 1943 confirmed the impression of narrowness, saying that the vein he had followed was only 2 centimeters thick in most places, and nowhere more than about 10 centimeters thick. He regarded as exceptionally rich the only ore the writers were able to discover in the workings; this ore, which was exposed in a pillar, formed a lens 10 centimeters thick and 3 meters long. Samples taken from the pillar containing the rich ore were analyzed, and the results give striking evidence of the concentration of tin within the vein and its scarcity in the wall rock.

Tin content of a vein and of the rhyolite in the Orozco mine

Sample No.	Description of sample	Percent of tin (average of 3 determinations)
O–2	10 centimeters across clayey vein containing cassiterite in stringers and clusters of nuggets.	8. 46
O–3	65 centimeters of rhyolite forming west wall of the vein.	. 09

A sample taken from a part of one vein where breccia had developed to a thickness of 40 centimeters was found to contain only 0.05 percent of tin (average of three determinations). A grab sample of the dumps contained 0.13 percent of tin. These assays support the conclusion reached by inspection of the deposit, namely, that the wall rocks are not impregnated with tin. A few cross joints and oblique joints contain cassiterite, but not in significant quantity.

OBSIDIANA MINE OF HERMAN WEST

What is known as the Obsidiana mine of Herman West lies 300 meters S. 40° E. of the Orozco mine. The only workings are two pits on a fracture zone that dips 45° N. The larger pit, which extends about 8 meters down dip, has uncovered some tiny veinlets and small vugs containing cassiterite.

The most unusual feature of the Obsidiana mine is the one indicated by its name—the presence of glassy, unaltered obsidian. The cassiterite is enclosed in rhyolite that is devitrified but not altered to clayey material, but it occurs in close proximity to completely unchanged obsidian. This occurrence affords particularly striking evidence that extensive and thorough alteration of the rhyolite is not invariably found near the tin ores. Alteration along tin-bearing fissures, such as that seen at the Orozco and other mines, seems to have been the local effect of a rather widespread process that was not coextensive with the tin mineralization.

CANDELARIA

The Candelaria mine (pl. 40) is about 900 meters N. 35° E. of América. The principal opening accessible in 1944 was a partly caved stope that opens into the bottom of Arroyo de la Candelaria at an altitude of 2,000 meters. This stope is probably part of the old workings depicted in a sketch by Ingalls,[18] which shows them as being 50 meters deep in 1892. The accessible part of the stope was only 12 meters deep by 25 meters long, the remainder being partly caved and partly filled with washed-in stream gravel. Sixty meters west of the open stope is a deep vertical shaft 3 meters in diameter which was open in 1944 but could not safely be entered. This shaft was sunk in the nineties by the Pittsburgh & Mexico Tin Mining Co. The exploratory work done by this company, and later work done by Manuel Enríquez in 1905, extended the workings to a depth of 100 meters.[19] These operations were unprofitable, and the mine has been idle since about 1906. The production is unrecorded except for two items: the Pittsburgh & Mexico Tin Mining Co. shipped one carload of ore, and Manuel Enríque shipped 4 metric tons of concentrates in 1905.[20]

The geologic setting is unusally well shown by exposures on the north side of Arroyo de la Candelaria. The rhyolite is a well-layered devitrified lava. Most of the layers dip 70° NW. to vertical and curve in strike as if forming the nose of an anticline that pitches very steeply northwestward. Fissures exposed in the workings strike N.

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[18] Ingalls, W. K., op. cit., vol. 25, p. 153 fig. 3.
[19] García, J. Aurelio, Monografía del estaño: Bol. Minero, tomo 22, núm. 1, pp. 21–22, 1926.
Foshag, W. F., and Fries, Carl Jr., op. cit., pp. 171–172.
[20] Statistical report for 1905 of the State of Durango (unpublished).

65°–75° W. and dip 65°–75° S. cutting obliquely across the rhyolite layers. Alteration of the rhyolite near the veins has left the rock soft, bleached, and easily caved. Consequently the stope is 3 or 4 meters wide, although the individual veins were evidently small. The fissures are sheared and clayey and are less than 10 centimeters wide. No cassiterite was seen in them, but Ingalls [21] described similar fissures as containing lenses or pockets of cassiterite strung out like "a long bean-pod" that pitched 45° west.

The outlook for the Candelaria mine is not promising. Whatever may be left of the veins is now inaccessible, and they were found unprofitable in the nineties. Here as elsewhere the rhyolite alongside the vein zone has no significant content of tin; a sample taken by Foshag and Fries [22] was found to contain about 0.005 percent. The dumps appear barren. The placers in the bottom of the arroyo yield only a little concentrate each year from newly accumulated pockets of gravel. The old alluvium in terraces along the banks offers even less promise; samples taken by the writers from a pit showed only 0.17 percent of tin for the bottom 8 centimeters, and only 0.04 percent for the bottom 1.70 meters.

JALTOMATES

The Jaltomates mine is 2,500 meters N. 85° E. of América, at an altitude of 2,262 meters. The mine appears on Patoni's map [23] of 1891, but there is no record of its production and nothing is known of its history. The workings (pl. 41), which appear to have been abandoned for many years, are small. The deepest accessible in 1944 were 25 meters deep. Narrow open cuts trace the veins on the surface for a distance of about 25 meters. The main shaft was accessible in 1944 to a depth of only 25 meters, and although it was then filled with material slumped from the walls, its total depth was probably not much greater. The underground workings were about 20 meters long.

The rhyolite in the vicinity of the mine is devitrified obsidian, which forms part of a large flow that has a roughly anticlinal structure, dipping northwest at the mine and southeast a little south of it. Locally the rhyolite layering is contorted; in the mine it is in folds in some places and generally dips northwestward more steeply than the average.

Judging from scarce remnants left on the dumps, which have been completely reworked by gambusinos, the ore contained cassiterite fairly free from specularite. A grab sample consisting of material taken at random from ten places on the surface of the dump contained 0.33 percent of tin (average of three analyses). It is probable, how-

[21] Ingalls, W. K., op. cit. vol. 25, pp. 154–155.
[22] Foshag, W. F., and Fries, Carl Jr., op. cit., p. 172.
[23] Patoni, Carlos, op. cit., p. 72.

ever, that a larger and more representative sample would have given a lower assay, for one of the rare nuggets was included in the sample. No samples were taken in the mine because the veins showed nothing of promise. For the same reason, no samples were taken from the placer ground that extends as a narrow strip northwestward from the mine.

The deposit was mostly in a steep, branching vein that strikes N. 20° to 45° W., and partly in a small vein that dips 45° NE. in the lower part of the workings. The veins end within the mine; on the north they are cut off by a steep fault, and on the south they dwindle away to nearly closed joints. Prospecting for additional ore could be done in one or more of three ways: (1) drifting south in the hope that the tight joints would open into ore; (2) crosscutting north of the fault in search of a northward continuation of the vein; and (3) sinking deeper on the veins, which, however, may have been unpromising when work stopped.

LAS CARPAS

Las Carpas mine was known many years ago as the Espesa mine, and it was erroneously named "La Escarpa," on the map that Foshag and Fries [24] used in their report of 1941 (see their pl. 31)—an error for which the authors named were not responsible. That map also showed a nearby opening incorrectly labeled "La Golondrina." This is only a new name for the Las Carpas mine, given to it by W. E. Brock of Durango when he filed a claim on the property in 1940. Las Carpas mine is 2,400 meters N. 20° W. of América, at an altitude of 2,053 meters. It is on the south side of a sharp curve in Arroyo de América, just above the trail between América and Potrillos.

Most of the rhyolite near the mine (pl. 41) is a distinctly layered, hard, devitrified obsidian, but in a zone about 20 meters wide along the vein this rock is altered to a soft, white, porous material. The layers dip 35°–60° E.; the tin-bearing veins strike N. 60°–65° W. and are nearly vertical.

The veins were narrow and pockety, according to a miner who worked intermittently at the mine, and they had a maximum thickness of about 20 centimeters. Lateral exploration from the main open cuts showed that the veins branched and thinned, and no ore was found in an inclined shaft put down from the bottom of the open cut to a depth of 25 meters measured on the incline. Two crosscuts were driven from this shaft about 10 meters and 20 meters below the collar. These workings were well planned to explore the deposit, and they show that it is of small size.

[24] Foshag, W. F., and Fries, Carl Jr., op. cit., p. 170, and pl. 31.

No ore was seen in place in the workings, and only a few pieces of cassiterite-bearing material were found on the dumps. Specularite was conspicuous, however, both on the dump and underground. Most of it was in small fissures and cavities in brecciated rock, but some was seen to be disseminated in the altered, porous rhyolite. In spite of the abundance of specularite, the mine may contain some small pockets of tin ore nearly free from iron, for a miner said that he found one pocket containing 30 kilograms of cassiterite with almost no specularite.

No sample was taken in the mine. A grab sample from the dump was found to contain 0.15 percent of tin (average of three determinations). Evidently this low grade, together with the abundance of specularite, which the gambusinos cannot separate very well from the cassiterite, accounts for the fact that only a small part of the dump has been worked over.

A small body of placer ground, mostly surface soil at the foot of the hill below the mine, was being worked by four or five gambusinos at the time of the examination. As the material was being moved on burros to nearby Arroyo de América for washing, a rude quantitative appraisal of their work can be given. In a typical day, they said, one man would wash 15 burro-loads, amounting to something between 750 and 1,000 kilograms, and would recover 1 to 3 kilograms of concentrates. This represents quite profitable work, for a kilogram of concentrates is worth slightly more than a day's wages in the region. Estimating the original grade of the placer would require large assumptions. The miners probably worked out this placer completely within 2 or 3 weeks.

SAN MIGUEL

The San Miguel mine is a little more than 4 kilometers S. 75° W. of América, at an altitude of 2,705 meters, or about 650 meters higher than América. The mule trail to the mine crosses the most rugged ground in the district. The difficulty of access to the mine must be reckoned with in planning any large-scale development of the district—it would be rather costly, for example, to move the San Miguel ore to a central concentrating plant.

The San Miguel deposit is a fracture zone 1 to 4 meters thick, striking N. 50° W. In it, cassiterite with much specularite forms thin veinlets in crisscrossing joints in the rhyolite. The typical ore consists of joint blocks of all sizes, each block coated with these two minerals. This deposit resembles those at La Fierrosa, La Lentejuela, and La Alta mines, southeast of the San Miguel, and is quite different from the narrow fissure deposits which are so much more common in the region.

The workings at the San Miguel mine (pl. 42) are entered by way of an inclined shaft, which follows the fracture zone downward about 25 meters; the bottom of the shaft is filled with waste. Most of the ore was mined north of the shaft, from a north-pitching stope which has a maximum horizontal length of 15 meters and a maximum width of 4 meters. Short drifts southeastward show that in that direction the fracture zone pinches down to a narrow fissure in which no ore was found.

Determination of the average tin content of the material in the broken zone would require the mining of a bulk sample. Inspection of the joint-faced material gives no trustworthy impression of its tin content, and even a channel sample, or several of them, would serve only to indicate roughly the range of values. A channel sample 2.5 meters long, taken on the west wall of the stope across what seemed to be the most intensely mineralized part of the broken zone, was found to contain 0.56 percent of tin (sample SM–2, average of three determinations). This probably should be regarded as near the maximum to be expected if larger samples were taken; it is undoubtedly higher than the average for the zone through the length of 15 meters that is exposed. A sample of material collected at random from the surface of the dumps was found to contain 0.30 percent of tin (sample SM–1, average of three determinations).

LA FIERROSA, LA LENTEJUELA, AND LA ALTA

The La Fierrosa, La Lentejuela, and La Alta mines are a little more than 3 kilometers S. 45° W. of América, at altitudes near 2,700 meters. They are the largest among several workings in a row of iron-rich tin deposits that lie near the crest of the ridge extending S. 55° E. from the San Miguel mine.

These deposits have several features in common with the deposit in the San Miguel mine. Their ore contains a large proportion of specularite and occurs in crisscrossing joints in brecciated rhyolite. The more continuous joints trend N. 60° to 65° E., but the minor joints trend in many directions. All the deposits are in a zone of porous soft white altered rhyolite, which trends N. 60° W. at the La Fierrosa and adjacent deposits but curves farther northwest to a more northerly strike and passes east of the San Miguel mine. Although this zone of altered rock probably follows a fault or fissure that also localized the row of deposits, this row cannot properly be regarded as a single lode, for the ore bodies in it are small and widely spaced, and the general trend of each one is across the trend of the zone.

The largest workings are at the La Fierrosa, where there is a shaft 24 meters deep, now unused but connecting with very irregular workings, which are 15 meters long on the lowest level in the mine and

wander irregularly upward to openings in the bottom of a group of small open cuts. The workings evidently were opened by a succession of miners who were looking for cassiterite-rich pockets along mineralized joints between large blocks of rhyolite. Most of the joints have been followed only for a meter or two, but some were followed for 6 or 8 meters.

The La Lentejuela mine consists of a cut along a fracture zone that trends N. 65° E., in which the strongest fractures dip 60° S. When the mine was visited the trench was filled, partly with caved material and partly with water.

The La Alta mine is also on a brecciated zone that trends N. 65° E., but the general dip of this zone is about 45° S. The breccia is exposed in a cut 20 meters long, and shallow test pits show that it extends at least 10 meters northeast and 20 meters southwest of the cut. An open stope at the southwest end of the cut was accessible to a depth of 5 meters; the remainder of the cut was blocked largely with caved rhyolite.

The fact that some rich ore occurs in these small deposits was indicated by the tin content of two samples taken at La Fierrosa mine. A grab sample from the waste left in a small lateral working was found to contain 0.69 percent of tin (sample F–1). A channel sample cut on the southwest end of the lowest level across 65 centimeters of breccia was found to contain 5.00 percent (sample F–2). Each value is the average of three determinations. Considering the width of the cut, the channel sample was the most promising taken in the América district; unfortunately, it probably represents only a small quantity of ore. As the joints are generally short and their extent and tin content highly uncertain, there is no way of making anything but a rough guess as to how much of this rich ore is available. Mining closely along the joints and broken zones might produce between 10 and 20 tons of 3.00 percent mill heads, allowing for the fact that the smallest mining width is about 1 meter.

VEINTINUEVE DE JUNIO

The Veintinueve de Junio mine lies 3,400 meters N. 28° E. of América, in the upper part of Arroyo del Pajonal, just below the eastern edge of Mesa de Orozco. The mine (pl. 42) was adequately described by Foshag and Fries,[25] who examined it in 1941, and it is mentioned here mainly to correct their figure for the length of the adit, which is about 140 feet instead of 140 meters. No work appears to have been done since 1941, and there is no ore in sight.

[25] Foshag, W. F., and Fries, Carl Jr., op. cit., p. 174.

MINES NEAR EL PINTO AND EL PIPIAN

In 1944 the most actively worked vein mines in the América-Sapioris district were those near El Pinto and El Pipián (pl. 43). Perhaps as many as a hundred men in all were then working at six or eight places in the vicinity. Most of these men were at the mine of Julio Gutiérrez and at an unnamed group of mines south of it; several were working in and near La Morena mine, half a dozen at the mine of Theodoso Soto, and a dozen or so at small prospects elsewhere. Most of the workings in the vicinity of El Pinto and El Pipián, including scores of open pits, trenches, and shallow shafts, were abandoned years ago and have partly caved and filled with water. It was evident from brief inspection that in most of the workings the veins were narrow fissures. As there are several rows of extensive workings, the veins worked at this locality may have been as long and perhaps as valuable as some of the better-known deposits in the vicinity of América. The pits at El Pipián are the largest in the district, and they form a row that extends for a length of 150 meters. In order to examine them, however, it would be necessary to clean them out at a cost that does not appear to be justified.

The longest row of workings, which includes the mine of Theodoso Soto, has traced a mineralized fault zone of 400 meters, but Soto's mine is the only one in this row that has been worked persistently. The mine is entered by way of an inclined shaft which, at the time of the writers' visit, was caved 15 meters from the mouth; the miners said that about 20 meters of workings were blocked by the cave-in. The open part of the shaft was in sheared, clayey breccia nearly 5 meters wide. The miners could give no estimate of the quantity of concentrates that had been produced, but said that five or six men had worked intermittently at the mine for 3 years and had made a fair profit.

The scene of greatest activity in this part of the district was an area less than a hundred meters in diameter lying about 200 meters south of the mine of Julio Gutiérrez. There about 30 or 40 miners were washing surficial material, reworking dumps, and mining a group of several short veins uncovered by rows of pits or shallow shafts. No data could be obtained on the quantity of tin produced. The activity on the most recently discovered vein, which was the most westerly one, was probably typical of what takes place at a new gambusino discovery. The vein, which strikes N. 20° W. and dips 85° SW., had been traced on the surface for 15 meters and had a maximum width of 20 centimeters, but it had been found to pinch out at both ends. Within the distance of 15 meters, four independent groups of gambusinos were at work side by side, each group sinking a shaft

by hand methods. The shafts had attained depths of 3 to 5 meters. The veins previously discovered in this area had been found to pinch out at depths not exceeding 10 meters, as might have been inferred from their lengths, and this vein is not likely to go any deeper. The thickness of the veins is said to average about 10 centimeters.

At La Morena mine, the workings consist of drifts at depths of 8 to 10 meters on intersecting steep veins that strike N. 65° E., N. 20° E., and N. 20° W. Several shafts provide access to the drifts. Two men were mining a N. 20° E. vein 20 centimeters thick, and were obtaining nuggets of rather pure cassiterite, some of which were in the clayey gouge of a fissure and some of which seemed to be embedded in soft, altered rhyolite. The altered rhyolite was iron-stained, and it may have been brecciated, with the cassiterite embedded between blocks rather than in solid rock.

The mine of Julio Gutiérrez was on a small but rich vein, which was discovered in August 1944, about a week before the writers examined it. This deposit was, according to the miners, "bonanza" ore. The discovery pit, which had reached a depth of 4 meters and was 5 meters long, exposed a vertical vein striking N. 55° W. Smaller pits to the northwest and southeast were being opened along the vein by gambusinos who were independent of the discoverer. The first pit to the northwest was nearly as deep and as long as the discovery pit, and the first to the southeast was about half as large; others farther away were much smaller and showed no ore.

The thickness of the vein as seen in the ends and bottom of the discovery pit ranged from 10 to 15 centimeters, but the maxium was said to have been about 25 centimeters. In the adjoining pits the thickness of the vein decreased northwestward from 15 centimeters to 2 centimeters in a distance of 5 meters, and 3 meters southeast of the discovery pit a single vein, 10 to 20 centimeters thick, divided into two branches, 1 to 4 centimeters thick and 30 centimeters apart. The vein was curved in vertical section, its dip changing downward from 90° to 70° S. The miners said that the upper part of the vein had been thicker than the lower, and full of clay, but that the vein everywhere contained some cassiterite. The vein consisted of layered clayey material in which were embedded clusters, thin layers, and irregular masses of cassiterite nuggets, the largest of which were at least 15 centimeters in diameter. Although the nuggets contained much fine-grained quartz, the tin content of the richer pieces was probably at least 60 percent, and the average for the concentrates may have been as high as 50 percent.

The average grade of the material mined from the discovery pit can be roughly computed as follows: the volume of rock and vein

was nearly 20 cubic meters, or about 50 tons, and the miners reported that they recovered 2 tons of concentrates. As the material was coarse and was washed in small planillas, the loss of cassiterite may be considered unimportant. Assuming that the concentrates averaged about 50 percent tin, the average tin content of all the material excavated from the pit was about 2 percent. Generous allowances for various uncertainties might raise this figure, but not above 3 percent. It seems doubtful whether many tin deposits in rhyolite would yield assays of 2 or 3 percent in samples representing a width of 1 meter.

DEPOSITS NEAR OCHOA

According to local tin buyers, the production of tin concentrates from the vicinity of Ochoa attains a rate of more than a ton a week during part of the year, and the total production in a good year may amount to some quantity between 15 and 40 tons. Most of the concentrates come from placers, but veins are said to contribute a substantial part. The best group of veins lies southeast of Ochoa in the area shown on plate 44. With the expectation of getting an adequate supply of ore by mining this group of veins and purchasing ore from other nearby properties, the Mill-Tex Co. in 1943 built a large mill 1.4 kilometers south of Ochoa. The site is also conveniently located for obtaining water from the Río Caliente. However, after trial runs during two months of 1943, the mill was shut down. No data on the results of the mill test were obtainable, but inspection of the deposits indicates that the ore was of too low grade for profitable operation. Since the deposits are small as well as lean, it is not likely that the mill will be operated again, at least on the large scale originally projected.

The mill was well built, and consists of a good frame building with well arranged equipment on concrete floors at several levels. The main items of equipment include a jaw crusher, a belt elevator, a vibrating screen, two pairs of rolls, an Akins classifier, a cone classifier, two large jigs, five tables, and some drying tables. No motor was seen. Not all this equipment was installed, but nevertheless the mill capacity was said to have been, at the time the test runs were made, about 100 tons per day.

There is a good possibility, in the writers' opinion, that the mines in this group might yield as much as 10 tons of satisfactory mill ore per day; but further exploration is needed to block out ore, and sampling is needed to determine whether the grade is high enough for profitable mining. At the time the mines were visited, the mill-feed in sight, including surficial placers, dumps, and ore in the workings, would have provided as much as 50 tons a day for at least a month, or possibly for

2 months. After cleaning up this material, however, the 50-ton rate could not be maintained without taking ore greatly diluted with barren rhyolite.

The mines that appeared to be most promising are the Los Arrieros and the Cerro Grande. Others in the district are on such thin veins that they would produce mill ore only as a byproduct of gambusino work.

LOS ARRIEROS

Los Arrieros mine, which was owned in 1944 by Dr. Harry Gray of Durango, lies 4 kilometers by road southeast of the Mill-Tex concentrating plant. No record of its production has been kept. Its principal workings (pl. 45) are under the central part of a surficial placer about 80 meters in diameter. Most of the ore evidently was taken from an open cut 15 meters long by 5 deep, and from an inclined stope 16 meters long by 10 meters down the dip of a vein that dips southwest. A shaft 18 meters deep passes through the stope to an exploratory drift 65 meters long, mostly parallel to the stope and in the footwall. The drift encountered no ore unless some was found below the open cut, in a part blocked by caved ground.

The vein in the stope strikes N. 45° W. and dips 25°–60° SW., curving strongly. Veins of the same strike but of steeper dip are exposed in the open cut, but there the most productive veins strike N. 45° E. and dip 70° S. Small pits nearby show other steep veinlets striking northeast, but none has been worked very extensively. Apparently both the stope and the open-cut were opened to widths of 1 to 5 meters in following numerous thin stringers of rich ore, which lie parallel in the stope but crisscross in the open cut. The large number of closely spaced veinlets is the most noteworthy feature of the deposit.

The average tin content of the ore in the stope, according to samples taken by Dr. Gray,[26] was 1.8 percent, but it was evident on inspection that the values were unevenly distributed, most faces being nearly barren.

Although no reserves were in sight in the mine at the time of inspection, there seemed to be a fair chance that a moderate amount of exploration under the open cut and the stope might block out about 1,000 tons of ore.

CERRO GRANDE

The Cerro Grande mine is only 3 kilometers by airline from the mill, but the road to it follows a roundabout course and is partly blocked. The property was worked about 1935 by M. D. Stackpole,[27]

[26] Personal communication.
[27] Personal communication.

who reported that he recovered more than 30 tons of concentrate averaging 30 percent tin by hand mining and washing. The ore was taken from a group of pits, trenches, and open-cuts, the dimensions of which are shown on the plan of the mine (pl. 45). The largest pit was 12 meters long by 3 wide and 7 deep. Later, probably in 1943, a shaft was sunk to a depth of 16 meters and cross-cuts were extended from it that had a total length of 35 meters. The south crosscut, according to J. M. Salcido,[28] encountered a vein containing a little cassiterite. The shaft could not be entered in 1944.

The principal veins strike N. 50°–60° E. and are nearly vertical; they form an en échelon group, as shown on the map. Minor veins, oblique to the main ones, make the south end of the main pit a mosaic of joint blocks too small to be shown individually on the scale of the map. Each block is coated, rather thinly as a rule, with specularite accompanied by minor quantities of cassiterite. Some thicker lenses probably occurred in the ore, as indicated by the presence of a lens of specularite 20 centimeters thick and 2 meters long exposed in a main vein that adjoins those in the biggest pit.

East of the veins that lie en échelon is a group of minor veins that strike northwest. These were tin-bearing but not as rich as the others. The two groups of veins are probably separated by a fault, for the rhyolite enclosing the en échelon group is more altered and brecciated than that enclosing the other.

Although the Cerro Grande, like the Los Arrieros, has no reserves of ore blocked out, it has so many veins within reach of a moderate amount of exploration that it seems to offer at least a fair promise of ore for milling. It seems reasonable to hope that the mine may yield several hundred tons of ore; the grade, however, is extremely uncertain.

OTHER MINES AND PROSPECTS

The other deposits that are shown on the map of the Ochoa district are all less promising than Los Arrieros and Cerro Grande; their workings expose only very thin single veins, or small bodies of jointed, mineralized rhyolite, or no ore at all. The largest workings are on El Bueno property, where veins are exposed in two rows of pits and trenches, about 15 meters apart and 80 meters long. It is improbable that the veins extend from one pit to the next, for the pits are far apart. On the El Encino property, trenches that are approximately in line and similar in direction cover a total length of 180 meters, but there, also, the stretches between pits are long, and there is no assurance that the veins are continuous. The La Buena Suerte workings consist of pits on four or five approximately parallel veins, all

[28] Personal communication.

of which are short. The one that has been most extensively explored has been followed downward by means of an inclined stope, which is 35 meters long and has attained a depth of 8 meters. La Vaca, La Soledad, and La Manga properties each contain only one or two small prospect pits.

The deposit called La Avena is on a flat-topped mesa 5 kilometers S. 40° E. of the tin mill. Most of the work was done in three areas, two about 50 meters by 100 meters, one about 25 meters in diameter. The deposit apparently was worked as a surficial placer; the diggings go into bedrock in many places, but they expose no veins that seem worth mining. The deepest pit, which is 4 meters deep, exposes a zone of brecciated rhyolite nearly a meter wide in which the only mark of mineralization is a few coatings of specularite.

DEPOSITS NEAR CANATLAN

In 1943 a 20-ton mill for concentrating tin ores was built by the Mae-Tex Mining Co. at a site 9.6 kilometers by road northeast of Canatlán. The properties that were expected to supply most of the ore are the nearby El Porvenir and El Lucero, which were leased by the company and explored while the mill was being constructed. Brief tests showed that the ore was too low in grade for profitable milling; operations consequently stopped in September 1943 and are not expected to start again. Not only is the average tin content of ore recoverable from the nearby deposits very low, but, in the writers' opinion, the quantity of ore possibly available from all those deposits is far too small to support a mill, even if the price of tin were several times the 1943 market price. It seems doubtful whether the deposits examined (pl. 46), if worked as a group, could be mined continuously at a profit by any method, although persistent prospecting might uncover pockets that would yield a few kilograms of concentrates from time to time.

Failure of the operation cannot be charged to deficiency in the mill operation or equipment; the work, though largely in the hands of inexperienced men, was done intelligently, and the mill was well equipped. Equipment included a jaw crusher, a vibrating screen, a hammer mill, a screw-type classifier, a 2-cell jig, a cone-type classifier, and two tables. A 100-horsepower diesel motor provided power for the mill and for an electric generator. A small pump was installed for raising water from a spring below the mill-site.

The area containing the deposits is rugged, which makes it costly to haul ore to the mill. Ore from El Porvenir was taken to the mill partly by burro and partly by truck; a circuitous truck road extends from the mill toward the deposit for 5 kilometers, but ends about 800

meters short of the deposit. Ore from El Lucero was moved entirely by truck, over a road about 4 kilometers long, but the road was in such poor condition that truck maintenance was probably expensive.

When the company started work, the workings on El Porvenir property consisted of an open pit 7 meters long, 4 meters wide, and about 6 meters deep. Just south of this pit the company sank a shaft 18 meters deep, from which it drifted north for 14 meters and south for 18 meters, and crosscut eastward for 17 meters (pl. 46).

The ore was in brecciated rhyolite, along nearly vertical fracture zones trending about N. 20° E. Parts of the breccia contained cassiterite accompanied by much specularite, both minerals occurring as relatively thin coatings on the faces of blocks in the breccia and as incoherent fillings between blocks. Much of the breccia seemed to contain little or no cassiterite. The size of the breccia bodies is not great. The zone exposed in the old open-cut is there half a meter to a meter in thickness, but it pinches out in the north drift and is probably cut off by a fault on the south. It is developed for a length of 25 meters and to a depth of 18 meters, and contains 500 to 1,000 tons of breccia. Parallel breccia zones are indicated, but they are not sufficiently developed to show their value or even their size.

According to T. M. Edwards, manager of the Mae-Tex Company, tin in the ore from El Porvenir was tested by milling 140 tons of selected material, mostly from the new mine workings but partly from the old dump. All the material was hand picked, 2 or 3 tons of obviously barren rock being discarded for every ton milled. Although no exact records of the results were kept, Mr. Edwards recalled that the concentration ratio was 75 to 1, and that the concentrate contained 21.5 percent of tin. The selected material thus contained less than 0.3 percent of recoverable tin, and the original run-of-mine ore only a third or a fourth as much.

At the El Lucero property, the workings consist of four hillside open-cuts, the largest 10 by 7 by 3 meters. The pits are irregularly spaced in a row for a distance of 60 meters. The rock exposed is porous, altered rhyolite, much brecciated and jointed, with the more conspicuous joints striking N. 35° E. and dipping 50° S. Specularite is fairly abundant, but cassiterite can be found only by close inspection. The specularite is unevenly scattered, and presumably the cassiterite is even more so.

About 180 tons of ore from El Lucero was milled, with some selection but not much. Most of the ore, according to Mr. Edwards, was passed through the mill repeatedly, some of it five times, in attempts to recover everything possible; but the concentrates recovered from the entire 180 tons weighed only 240 kilograms, and they contained only

8.5 percent of tin. This indicates that the ore milled contained only about 0.01 percent of recoverable tin, and there is no evidence that the remaining ore is any better.

The Luquin deposit lies 1,300 meters N. 35° W. of the Mae-Tex mill, on a flat-topped ridge, at an altitude of 2,210 meters. This property was not tested by the Mae-Tex Co., and it has no ore in sight, although it evidently was prospected in a way that is unusually systematic and thorough among these tin deposits. Apparently the prospecting was done shortly before 1944, but no information was available as to who did the work.

The old workings, which are the largest on the property, include an open-cut 10 meters long and 3 wide at the north end of which there is a shaft at least 8 meters deep leading into a narrow stope. These workings were flooded 5 meters below the surface and could not be examined, but the smallness of the dump shows that the deeper workings cannot have been very extensive. The workings are on a fault or fracture zone that strikes N. 35° E. and dips 60°–75° SE.

The recent prospecting is represented by no less than 47 pits, scattered in an area about 100 meters across. Each pit is 1 to 2 meters in diameter; about two-thirds of them are 1 to 2 meters deep, the others less than a meter. At all the pits the soil, which is only a few centimeters deep, was completely stripped away and some bedrock taken up. All loose rock was carefully removed, and joint blocks and breccia were picked out in a way that indicates that no explosives were used. The material from each pit was piled alongside it, with coarse blocks separated from fines. There is a level concrete platform near the old workings, evidently prepared for crushing and splitting samples, and two inclined concrete platforms (planillas) suitable for washing out concentrates by hand. Not much use can have been made of these platforms, for there is little waste beside them. The work seems to have uncovered nothing of value. Cassiterite was noted in a fragment on the dump of one new pit, and a weathered cassiterite-bearing veinlet 1 millimeter thick was seen in an old pit. At all the other pits the material in the dumps and in place appeared to be barren.

The Talismán mine, which lies about 8 kilometers northeast of the Mae-Tex mill, was locally regarded as a possible source of ore, but a brief examination showed it to be very small. The workings consist of two pits in rhyolite, one 6 meters long and 5 meters deep, the other 3 long and 3 deep. The rhyolite is jointed, and the faces of some of the joints are thinly coated with cassiterite and specularite, but neither a vein nor a well-defined breccia zone is exposed.

DEPOSITS SOUTHEAST OF RIO VERDE

The tin deposits southeast of Río Verde are sometimes referred to as the deposits of the Sierra de Cacaría, and less commonly the area containing them is called the Otinapa district. Their production has not been recorded, but it was estimated by Foshag and Fries[29] as possibly exceeding 30 tons per year, which appears to be a reasonable estimate. How much of this comes from placers is not known, but the yield of the placers probably exceeds that of the bedrock mines, although in this district the placer grounds are rather small compared with those in the América-Sapiorís district.

The mines (pl. 47) are in the Sierra de Cacaría, at altitudes near 2,600 meters; some are on the rolling upland in the center of the range, and others are in the marginal parts, which are deeply dissected and rugged. Although the mines are only 40 kilometers northwest of the city of Durango, they are not easily accessible because few roads enter the range. One way to reach them is to travel westward from the city of Durango, either by rail or over a partly improved truck road, for 80 kilometers to Otinapa railroad station, and then go northward for 20 kilometers by truck to the town of Río Verde, which lies at the west edge of the Sierra de Cacaría. It is possible to drive a good truck from Río Verde into some parts of the range, and nearly to some of the deposits, by using the maze of temporary roads that are tributary to the lumber camp at Aserradero Polonia, but to do this one must have a competent local guide. Some deposits can be reached only by travelling 2 to 4 hours on horseback from Río Verde. A road extends from Nicolás Bravo, a railroad station on the east side of the range, to Aserradero Polonia, but it is suitable only for large dual-wheel trucks.

The rhyolitic rocks that form the range in the vicinity of Río Verde consist of flat-lying layers. They appear thick and massive from a distance, but, when viewed closely, are seen to contain an abundance of faintly outlined flat fragments, the largest of which are about 3 centimeters long. These rocks may be welded tuffs, but further study of them would be required to establish the fact.

Of the deposits examined by the writers, four will be described in some detail because they are the largest and are entirely typical. These are El Diablo, La Marta, La Argelia, and La Providencia. The smaller deposits that were visited include the following: La Estrella, La Purísima, El Suspiro, La Escalería, Los Sacrificios, El Mammouth, La Iza, La Encantada, and El Reventón. Most of these deposits lie near San José, a mining camp 6.5 kilometers S. 45° E. of Río Verde, but the La Providencia is near the abandoned camp of Los Alamillos, which is 11 kilometers N. 40° E. of Río Verde.

[29] Foshag, W. F., and Fries, Carl Jr., op. cit., p. 168.

EL DIABLO

The El Diablo mine (pl. 48) has been the focus of interest among the tin deposits of the Sierra de Cacaría since tin was discovered there in 1870. The mine was the center of the first mining concession, obtained by Marcus Ison of Durango in 1873,[30] and it has been there that the principal attempts have been made in recent years to develop a large-scale operation. In 1881–82, the Durango Tin Mining Co. sank a shaft on the deposit to a depth of 83 meters. The last addition to the workings was a low-level adit that meets the shaft 50 meters below the collar. This adit was completed by M. D. Stackpole[31] in 1935. Stopes and drifts opened at various times in the upper part of the mine are said to extend 60 meters north of the shaft and a few meters south of it, but nearly all these are now caved or filled. A drift and an irregular stope on the adit level are still accessible.

The ore of the El Diablo mine is in a zone of breccia and sheared rhyolite, extending along a nearly vertical fault that strikes N. 35° E. The fault cuts across the rhyolite layers, which strike in the same direction but dip 10°–20° SE. The principal body of breccia is about 100 meters long, and has a maximum thickness of a meter and a half. Both to the northeast and to the southwest the breccia thins out and the fault is represented only by narrow shear zones. The breccia and the shear zones together have been traced for only 300 meters.

As the breccia is far from uniform in character and the cassiterite is distributed unevenly, no valid estimate of the grade of the ore can be based on inspection of the breccia at the few places where it is exposed. Some parts of it are made up of dense though broken rhyolite, little different from the solid rhyolite forming the walls of the fault. Other parts consist of porous, friable material, and others are altered to clay. The cassiterite occurs in thin veinlets and stringers, and in thin coatings on blocks of the breccia. Pockets of nuggets also are said to have been found.

The ore mined in the nineties is reported to have contained, on the average, over 2.5 percent of tin.[32] The rock now exposed appears very much leaner, but a need for careful sampling is indicated by the great difference in tin content of two samples cut at the north face of the adit level. Sample no. 26, from a channel 1.30 meters long across the face including a vein 1 centimeter thick, assayed 0.09 percent; sample no. 27, representing the vein only, assayed 4.05 percent.

The amount of breccia above the adit level was originally between 2,000 and 10,000 tons, and the amount left is somewhere between 1,000

[30] Ingalls, W. R., The tin deposits of Durango, Mexico: Am. Inst. Min. Eng. Trans. vol. 25, p. 159, 1896.
[31] Personal communication.
[32] Ingalls, W. R., op. cit., vol. 25, p. 159.

and 8,000 tons. This cannot be called ore because its grade is unknown, and to judge from the available evidence it is too lean to be mined profitably.

A zone of small parallel veins has been traced in trenches west of the main workings (pl. 48). These are narrow and contain no measurable ore.

LA MARTA AND OTHER MINES

The La Marta mine is situated about 900 meters S. 60° W. of the El Diablo. The mine was idle in 1944, and little work appeared to have been done there since 1935, when M. D. Stackpole[33] recovered about 50 tons of concentrates that contained 18 to 30 percent of tin. The workings, shown in plate 49, consist of a branching adit and two open cuts. The cut east of the adit yielded a part of the ore mined by Mr. Stackpole; the other was only a prospect.

The ore was taken from two sets of nearly vertical fractures, one set striking N. 5°–10° E. and the other N. 50°–60° E. The best ore was probably localized at the intersections of the fractures, for there are stopes at two of the intersections. The largest stope extends 4 meters above the adit and is about 6 meters long. Breccia and clayey material along the fractures attains a maximum thickness of 40 centimeters. Small seams and pockets of specularite appear sporadically along the fractures; they seem to be more abundant in those that strike N. 50°–60° E. than in the others. Cassiterite is present in the pockets of specularite, but nowhere in great abundance.

The mine had no ore in sight at the time of the examination, but it seemed like a good place to prospect for additional pockets of ore suitable for selective hand mining. If the adit were extended another 25 meters southward, it would reach the projected position of the vein that was mined from the eastern open-cut (pl. 49), with a fair chance of finding ore. Unfortunately, however, there is no assurance of the size of the ore that might be found, or its grade.

La Providencia mine is a kilometer S. 65° W. of the ruins of Los Alamillos, a tin-mining camp that was active prior to 1910. The largest opening at the mine is a shaft 4 meters in diameter and 15 meters deep, which it was not possible to examine. Open-cuts that extend 20 meters S. 40° E. from this shaft expose a zone of curved, branching fissures that dip 65° S. to vertical. A second row of open-cuts, beginning 15 meters northeast of the shaft, has been opened along veins that strike N. 70° E. These veins are cut by smaller ones that strike N. 40°–50° W. At one pit a shaft 10 meters deep provides entry to short drifts that extend toward the main shaft. The only other opening seen is an irregular pit that lies 60 meters north of the main shaft.

[33] Personal communication.

This pit, which was about 10 meters in diameter and 4 meters deep, exposed a mass of confusedly jointed or brecciated rhyolite, in which no one direction of fracture predominated. The pit is said to have yielded some bismuth ore as well as cassiterite, but no specimen containing any bismuth mineral was seen by the writers. The small size and irregular shape of the workings indicates that the ore was pockety. The mine is unpromising, either for hand mining or as a source of mill ore.

La Argelia mine is just north of San José on the hillside overlooking the camp. The workings are open-cuts and pits along a zone of nearly parallel veins that strike N. 30°–35° E. and dip 60°–80° E. The largest cut is 21 meters long and 6 meters deep. The veins attain a maximum thickness of 40 centimeters, but at most of the faces they are less than 20 centimeters thick. The thicker parts consist mainly of breccia; the narrower parts are more sheared and contain much clay. The deposits are of the typical narrow fissures that are suitable for hand mining and are likely to yield pockets of rich ore from time to time, but they offer no promise of providing a worth-while tonnage of mill ore.

The smaller deposits display little variety. Open-cuts and shallow shafts are the only workings on most of them. The veins occupy narrow fissures, vertical or nearly so, most of them striking northeastward. No ore has been developed in them. The following table, in which the deposits are listed in the order of their distance from San José, summarizes much of the available information regarding these small deposits.

Description of small prospects southeast of Río Verde

Name	Character and extent of workings	Strike and dip of veins
La Estrella [1]	Open-cut 8 meters long	N. 20° E., vertical.
La Purísima	Open-cuts 13, 14, and 6 meters long; shaft 4 meters deep.	N. 35° E., vertical and N. 20° E., 65° E.
La Encantada	Three pits, largest 2 by 5 by 2 meters.	
La Iza	Open-cut 12 meters long	N. 30°–40° E., vertical.
Los Sacrificios	Open-cut 10 meters long	N. 30° E., vertical.
El Mammouth	Open-cut 6 meters long	
El Suspiro	Open-cuts 25 and 10 meters long.	N. 40° E., 80°–90° E.
La Escalería	Open-cuts 25 and 8 meters long; shaft 10 meters deep.	N. 30° E., vertical.
El Reventón	Shaft 15 meters deep; open-cut 10 meters long.	N. 65° E., 70° S.
La Estrella [2]	Adit 25 meters long; open-cut 15 meters long.	N. 45° W., 75° S.

[1] 750 meters northeast of San José.
[2] About 1 kilometer southeast of Los Alamillos.

A number of other deposits are known in the district, and the locations of some of them are shown on the map. These are similar in size and character to the ones that were visited, but according to the local guides they are less promising.

DEPOSITS IN SOUTHERN AND WESTERN DURANGO

Since most of southern and western Durango is underlain by rhyolitic rocks, the occurrence there of typical tin deposits is to be expected. Only a few that lie southeast of Durango have been mentioned in published accounts, but a wide distribution is indicated by information which the writers gathered through conversations with engineers, miners, ore buyers, and others in Durango. There was no opportunity to visit any of the reported occurrences, and the accounts told little about their size, grade, production, or history. Regarding many of the deposits, nothing was learned except their location and the way to get to them. Such as it is, however, the information gathered will be summarized in the hope that it may be of some use to future investigators.

ECONOMIC POSSIBILITIES

Although some of the deposits have been known for many years,[34] only a few of them have been worked, and these probably produce only a few tons a year. The main reason for the inactivity of the deposits is presumably that they, like the better-known deposits in central Durango, are small and of low grade. A contributory reason may be the inaccessible nature of the country and an indifference, or actual hostility, to mining on the part of the inhabitants. It seems inevitable that as the country opens up, more tin will be produced, but there is no basis for even a rough guess as to how large the production will be.

GEOGRAPHY

A part of the Sierra Madre Occidental extends through western Durango, from the southern end of the state northwestward. This great range stands between the low country along the west coast and the high plateau of central Mexico. Parts of the crest of this range are gently rolling or mesalike and are easily accessible from central Mexico, but most of the western slope is deeply dissected by streams that flow to the Pacific Ocean through precipitous gorges called "quebradas." Among the quebradas are some of the deepest valleys on the North American continent. Where the Río Mezquital, for example, crosses the main range, the altitude of its valley floor is about 600 meters, while 10 kilometers north of the river stands the peak

[34] Foshag, W. E., and Fries, Carl Jr., op. cit., pp. 164–165.

of Cerro Gordo at an altitude of 3,100 meters. Equally great relief—2,500 meters, or about 8,000 feet— is found at the Quebrada de Ventana, south of Cerro Huehuento (altitude 3,150 meters), and at the Quebrada de Basís.

Travel within the Sierra Madre Occidental must nearly all be done on foot or horseback, because the ruggedness of the terrain has restricted the construction of roads and railroads to the margin adjoining the central plateau. The country northwest of Durango can be approached from the railway stations Tepehuanes and Santiago Papasquiaro, and the country to the southwest from Otinapa and El Salto. Lumber companies have built roads that extend beyond these points, but only for short distances. There is one longer truck road, built for a mining company, extending westward from Otinapa to Borrego. The country south of Durango may be entered by way of three truck roads, one passing Santiago Bayácora, one ending at Mezquital, and the other having two branches that end at El Capulín and Alemán.

The relation of the people in the Sierra Madre Occidental to tin mining may be summarized as follows. Throughout the mountain country the people sustain themselves mainly by farming and hunting. Those in the west and northwest work intermittently in the lumber camps along the uplands, and those at the extreme west work intermittently in the gold and silver camps of the quebrada country. Wages have been fairly good, because labor has been scarce, and apparently the local inhabitants have found independent tin mining less profitable than other work. The country has been pretty thoroughly prospected, however, and tin deposits are known to be widely scattered in the western and northwestern parts of the State. In southern Durango the people are mostly Indians, who have kept themselves largely self sufficient. Not only have these Indians made no effort to develop the natural resources of their land, but they have been directly hostile to penetration and exploitation by outsiders. Only in the last few years has this hostility been broken down by a few lumbermen. Tin has been mined only at the margins of this region, but occurrences within it are now known.

LOCATION OF DEPOSITS AND ROUTES OF ACCESS

The location of the tin occurrences was mostly described to the writers in terms of routes, and as this method seems to be convenient and practical it will be followed here. Some geographic names will be used that do not appear on the accompanying index maps (pl. 24 A and B). Most of these can be found on the Culiacán and Guadalajara sheets of the 1 : 1,000,000 series of the American Geographical So-

ciety, but a few are unpublished names that are used because they are important local points of reference.

The best of the present routes from the city of Durango to the tin deposits of the southern area goes through Nombre de Dios to Vicente Guerrero ("Muleros" on the Guadalajara sheet), then southwestward to Michilia, from which one road goes to El Capulín and another goes through San Juan de Michis to Alemán. Alemán is about 10 hours by truck from the city of Durango.

The deposit in Cerro de Guanajuatillo is east of San Juan de Michis, near the Zacatecas border. During the nineties, according to Ingalls,[35] about 590 kilograms (1,300 pounds) of concentrates from this deposit were smelted and found to yield 13.1 percent of tin. The deposit was described as having veins of ferruginous tin ore that were in places as much as 4.3 meters (14 feet) wide. The deposit seems to be all but forgotten, however, for no one who was questioned in the city of Durango had heard of it.

A deposit at Cerro Blanco, north of El Capulín, has also been known since at least the nineties, for it is mentioned by Ingalls,[36] who says that the ore is in ill-defined veins 45 to 65 centimeters (18 to 26 inches) wide, in decomposed "trachyte." M. D. Stackpole[37] reported that in 1943 he bought 5 tons of concentrates from Cerro Blanco, and that it contained, on the average, 30 percent of tin.

Tin occurrences at three places south of Alemán and El Capulín are reported by Thomas Frothingham.[38] Near Ojo de Angel, which is a perennial spring about a day and a half by horse south of Alemán, Frothingham in 1943 mined 7 tons of cassiterite-rich ore from an outcropping vein; the grade of the ore and the quantity of concentrates recovered were not reported. Another vein is exposed in the same locality, but it was not prospected. At Las Ventanas, a well-known viewpoint about 10 hours west-southwest of Ojo de Angel, on the trail toward Santa María de Ocotán, Frothingham found a second group of cassiterite-bearing veins, but did not prospect them. At Los Gavilanes, a day and a half by horse south of Ojo de Angel, there is another outcropping vein, also unprospected. This is the southernmost deposit reported in Durango.

Another truck road entering the southern part of the State extends from the city of Durango to Mezquital. It is sometimes used as a route to El Capulín, because horses are easily obtained at Mezquital, but the ride to El Capulín is over a steep trail and requires a long day. Tin is reported to occur at San Miguel de Temoya, south of Mezquital, but the deposit is said to be small.

[35] Ingalls, W. R., Notes on the tin deposits of Mexico: Am. Inst. Min. Eng. Trans., vol. 27, p. 429, 1898.
[36] Ingals, W. R., op. cit., p. 428, 1898.
[37] Personal communication.
[38] Personal communication.

The third route southward from the city of Durango is a truck road built for hauling lumber; 78 kilometers of this road was built in 1943–44, and the road was to be extended later. This route passes at Kilometer 28 through the village of Los Astilleros, a few kilometers west of which is the placer camp of Santiago Bayácora, said to produce a little tin each year. J. M. Salcido [39] says that Santiago Bayácora is at the north end of an extensive tin-bearing zone that probably contains both placer and vein deposits; he has seen veins south of Ayala and east of Jesusita, which are villages near Santiago Bayácora.

At Kilometer 64 on the same truck road at a village called La Colgada, a trail leads off southward to the Quebrada de la Guacamaya, a 5-hour ride away. A placer in the confluence of this quebrada with that of a branch called Arroyo de las Espinas is said to be promising, though unworked. About a day's ride farther south lies a better-known placer on the northwest slope of Cerro Gordo. This was being worked in September 1944, and production was said to attain 100 kilograms of concentrates a week.

In traveling to several tin occurrences southwest of the city of Durango, it is possible to go part way by rail to El Salto or to Las Animas. Near Las Animas lies the El Regocijo deposit, also known as the Santa Rosa de la Cruz, which is 5 or 6 kilometers southeast of a railroad station called El Regocijo. Several attempts have been made to mine this deposit. The last shipment from it is said to have consisted of 2 or 3 tons of concentrates sent to the city of Durango in 1942 or 1943. These concentrates contained much iron. At Los Molinillos, which is about 20 kilometers southwest of El Regocijo station, there is a small vein from which there has been no production. About 20 kilometers southwest of El Salto is another vein, but this occurrence is not marked on the index map because the various accounts of its location could not be reconciled.

At La Libertad, about 35 kilometers (airline) south of the peak Cerro Huehuento, near the south rim of the deep Quebrada de Ventana, there is said to be a promising but unexplored vein deposit,[40] most easily reached from El Salto.

A long truck road extending westward from Otinapa to Borrego provides access to the area south of the Quebrada de Basís and north of the Quebrada de Ventana. This road passes a placer deposit at Cuevillas, about 60 kilometers northwest of Otinapa; and 40 kilometers farther west there is an unnamed group of tin veins and placer grounds through which passes a horse trail leading from the south rim of the Quebrada de Basís down to the old mining camp of

[39] Personal communication.
[40] López, Apolonia, personal communication.

Basís. The road ends at Las Truchas. About 17 kilometers (airline) farther west, according to López,[41] is a small tin vein at Huachumeta de Abajo. About 10 kilometers farther west there is a tin placer called El Lebrillo, which López regards as one of the more promising in the region, and 24 kilometers still farther west is a placer of nearly equal importance called El Tominil. Both El Lebrillo and El Tominil deposits have produced some concentrates, but the amount is unknown. Nearly 3 kilometers south of Borrego, near a small ranch called Las Palmas, is the placer ground of Señora Margarita Damm from which several tons of concentrates were recovered in 1944.

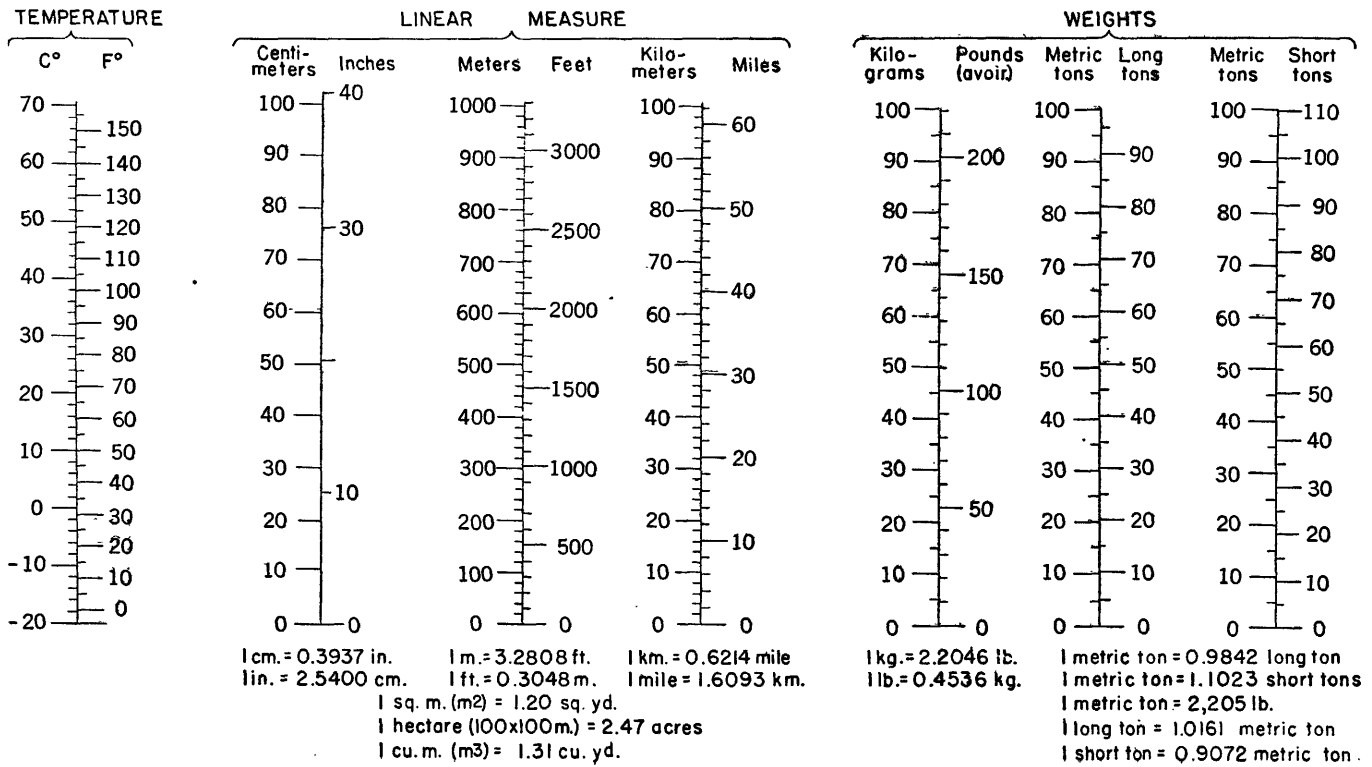
Two tin deposits lie between the road to Borrego and the Quebrada de Ventana. One is the El Piloncillo deposit, described as a zone of tin-bearing veins that begins south of Miravalles and extends more than 20 kilometers southward. Although tin is said to occur at several places in this zone, none of it has been mined. The other deposit is a placer on the southeast side of the Cerro Huehuento, the highest peak in Durango. J. M. Salcido[42] made a brief panning test at this placer in 1936.

The northern part of the quebrada country is entered through Santiago Papasquiaro which is reached from the city of Durango either by rail or by a truck road. From Santiago Papasquiaro, a truck road extends southwestward 20 kilometers across the rolling upland, but travel beyond that distance must be made on horseback or on foot. The main trail leads to Piélagos, where it branches westward to Otáez and southward to Basís. Otáez is a long two days' ride from Santiago Papasquiaro.

At Piélagos both placer and vein tin was seen by López,[43] who also saw another deposit at Cerro del Gallo, 5 kilometers north of Basís, on the north rim of the Quebrada de Basís. Other occurrences lie west of Otáez: one is at Bonome, about 12 kilometers west of Otáez, between San Pedro de los Azafranes and Zapotes; another is at La Soledad, in the Quebrada de San Juan and about 46 kilometers west-northwest of Otáez. La Soledad is more accessible from the western coastal side of the Sierra Madre Occidental than from the city of Durango. North of Otáez, and reached by diverging from the trail to Otáez, are Cerro de la Mesa and the village of Los Lobos, both reported to have tin placers.

[41] Personal communication.
[42] Personal communication.
[43] Personal communication.

METRIC EQUIVALENTS



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Geologic Investigations in the American Republics 1948

GEOLOGICAL SURVEY BULLETIN 962

This bulletin was printed as separate chapters, A–D, inclusive

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1950

UNITED STATES DEPARTMENT OF THE INTERIOR

Oscar L. Chapman, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

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