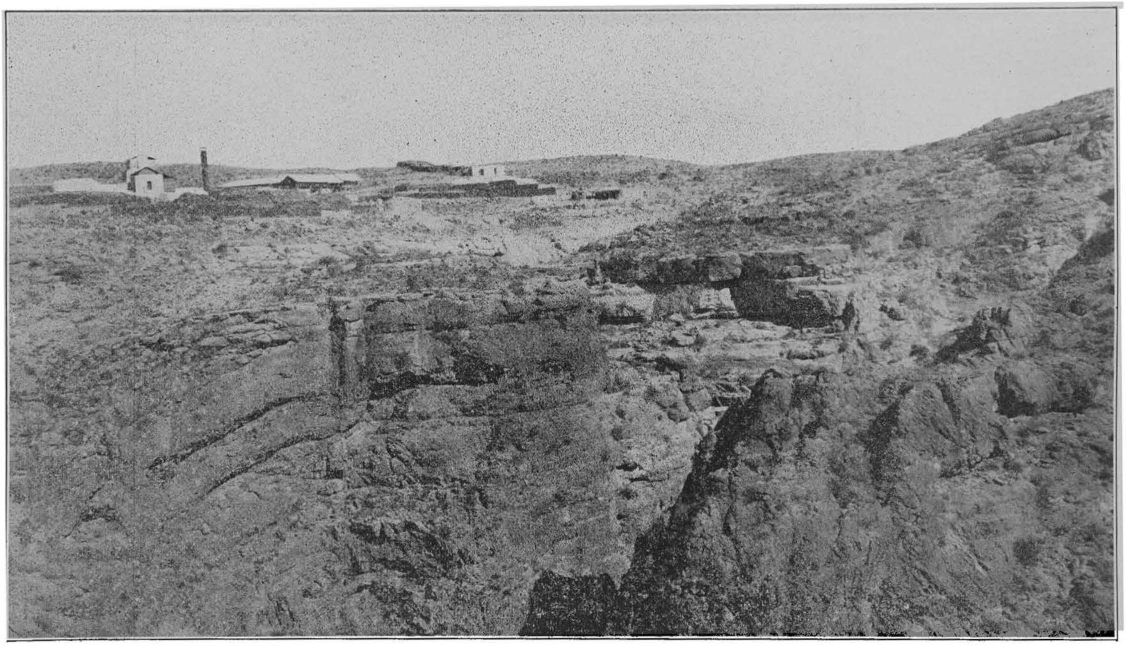
Publications Committee

THE UNIVERSITY OF TEXAS MINERAL SURVEY
BULLETIN NO. 4, OCTOBER, 1902.

THE TERLINGUA QUICKSILVER DEPOSITS, BREWSTER COUNTY.

BULLETIN OF THE UNIVERSITY OF TEXAS, NO. 15.
ISSUED SEMI-MONTHLY.

ENTERED IN THE POSTOFFICE AT AUSTIN AS MAIL MATTER OF THE SECOND CLASS.



LOOKING ACROSS CROESUS CAÑON TOWARDS MARFA & MARIPOSA FURNACE.

THE UNIVERSITY OF TEXAS MINERAL SURVEY

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NOTICE.

Owing to an unavoidable delay in the preparation of the topographic map to accompany this Bulletin we are unable to send it out at this time. It will be mailed separately as soon as possible, but may not be ready before December 1, 1902.

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LETTER OF TRANSMITTAL.

Hon. Wm. L. Prather, President, The University of Texas.

SIR: I beg herewith to transmit a Report on the Terlingua Quicksilver Deposits, Brewster County, as Bulletin No. 4 of The University of Texas Mineral Survey.

The special report on this district has been prepared by Mr. B. F. Hill, Assistant Geologist, and to it has been added some additional matter by way of correllation of these with other deposits now producing quicksilver. The topographic map was prepared by the United States Geological Survey, the party being in charge of Mr. Arthur Stiles, topographer, under a plan of co-operation which enabled us to avail ourselves of the excellent facilities offered by that Survey.

Very respectfully,

WM. B. PHILLIPS,

Professor of Field and Economic Geology and Director of the Survey.

Austin, Texas, October, 1902.

ANNOUNCEMENT.

The University of Texas Mineral Survey has a well-equipped laboratory at its disposal and is prepared to undertake all kinds of investigations of ores, clays, cements, building materials, water, etc. Prices will be quoted on application. Address all communications to the Director of The University of Texas Mineral Survey, Austin, Texas.

CONTENTS.

THE TERLINGUA QUICKSILVER DEPOSITS, BREWSTER COUNTY, TEXAS.

BY

BENJ. F. HILL,
ASSISTANT GEOLOGIST.

INTRODUCTION.

The field work upon which the preparation of this report is based occupied the writer for three months—March, April, and May, 1902. All the workings and prospects in the district were examined carefully, and the general geology studied in some detail, with especial reference to the structure. This structure is, as a whole, quite simple, the sedimentary rocks involved belonging to the Cretaceous and Tertiary. Though the country has been badly broken and faulted, and has been subject to intrusions of later eruptives, their relations to each other are plain.

It has not been considered necessary to go into any detail concerning the paleontology of the sediments involved. Many fossils are present. They are being collected and will be described and classified elsewhere than in this report. The divisions of the Cretaceous have been recognized in most cases by type fossils, and in other cases by their association in the geological scale with known divisions.

It must be borne in mind that in the treatment of the methods of deposition of the ore, the criteria used were practically surface indications. The development in the district has not been varied or extensive. Considerable ore has been taken out and considerable quicksilver has been produced; but exploration and prospecting, except with pick and shovel on the surface, has not been resorted to extensively. A few shafts, all less than 100 feet deep, have been sunk, with varying results. In some instances the veins seem to continue in depth. More often what has been assumed to be a vein, pinches out or disappears. Only the future can furnish positive evidence of the character and permanency of the deposits.

The writer is greatly indebted to the property owners and to the officers of the various companies for facilities for investigation extended to him, especially to Messrs. I. A. and R. A. Dewees, of the Terlingua Min-

ing Co. (formerly Lindheim and Dewees); Mr. Montroyd Sharpe, of the Marfa and Mariposa Mining Co.; and to Mr. Wm. L. Study, who owns the property east of Terlingua creek; and to Mr. L. E. Tigner, of the Colquitt-Tigner Mining Co. Thanks are due to all the companies and many of the prospectors for handsome specimens of ore and associated minerals.

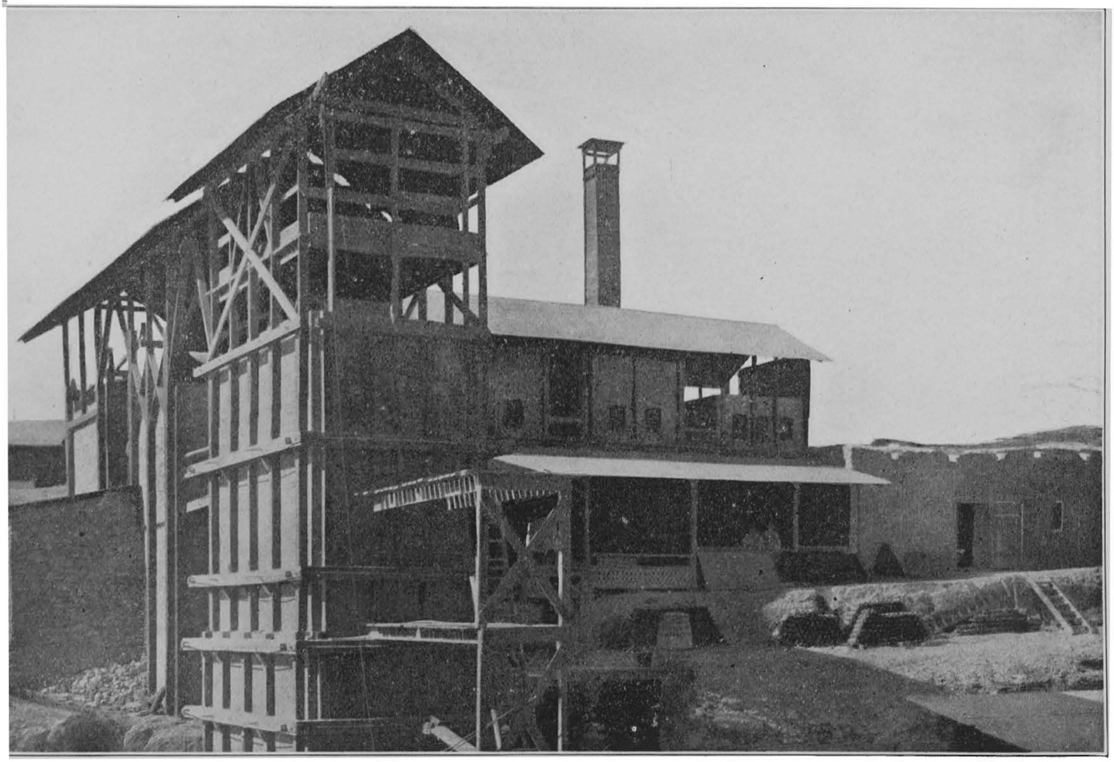
The literature on the district has been very meager, short articles having appeared in the *Engineering and Mining Journal,* and *The Transactions of the American Institute of Mining Engineers,* by Mr. Spaulding and Prof. Blake, respectively. The government publications on mineral resources have had short articles on the deposits.

The analyses used in the report have been made in the laboratory of the United States Geological Survey, at Washington, or in the laboratory of the Mineral Survey, in Austin. A great many thin sections of the various rocks of the district have been made and were studied by the writer in the office of the Survey. The micro-photographs were made in the Geological Laboratory of Columbia University, New York City.

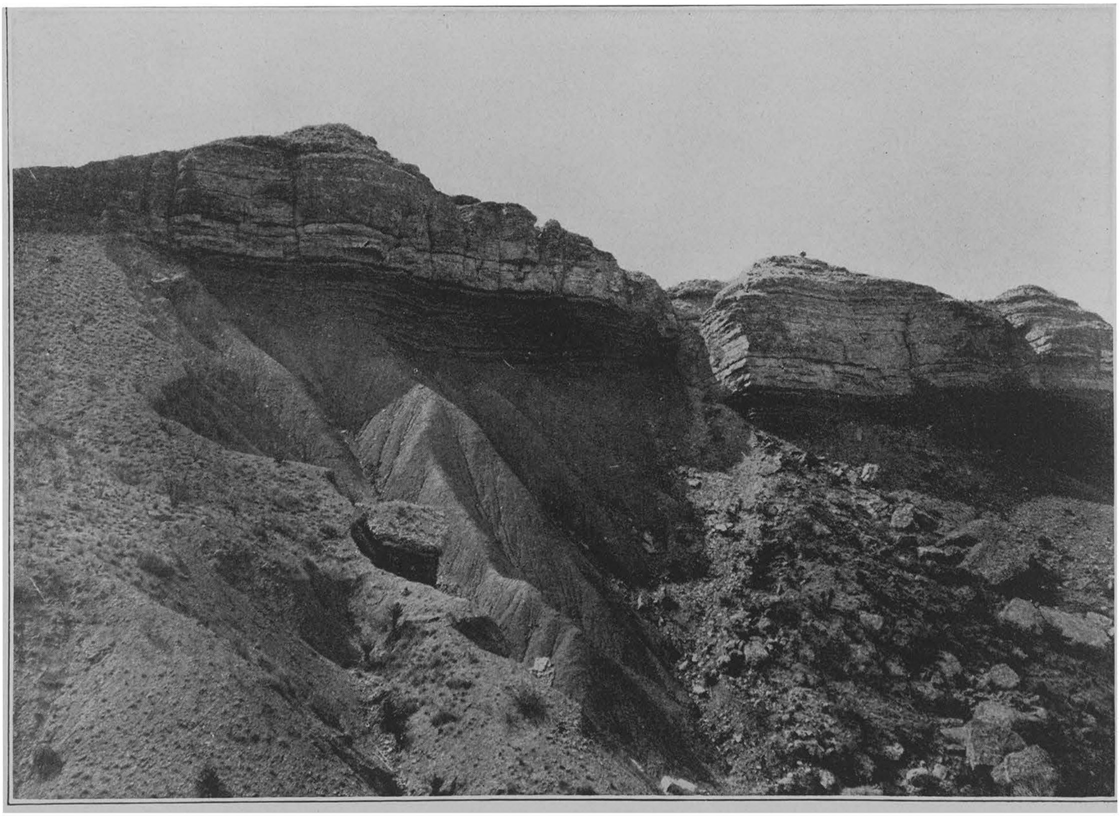
The topographical map of the district, called the "Terlingua Special," was made by the United States Geological Survey topographic corps, under the direction of Mr. Arthur Stiles. The expenses of the field work were borne by the University Mineral Survey.

Dr. Geo. F. Becker's report on the "Geology of the Quicksilver Deposits of the Pacific Slope," Monograph XIII., U. S. G. S., is the most complete and comprehensive treatise on quicksilver extant. In this volume he has entered into great detail concerning the theoretical and practical considerations governing the chemistry of the deposition of quicksilver. These considerations are just as true for Texas as for California. The writer of this paper will not attempt to go into the philosophical side of the questions, but will refer those interested in this very important side of the subject to Dr. Becker's monograph.

The writer is greatly indebted to Dr. Wm. B. Phillips, Director of the University of Texas Mineral Survey, for valuable suggestions and material assistance in the preparation of this paper.



MARFA & MARIPOSA MINING COMPANY'S NO. 1 FURNACE (10 TONS.)



FAULT IN VOLA LIMESTONE, SOUTH END OF SECTION 39, BLOCK G4.

CHAPTER I.

Location, General Conditions and History.

Although many metals or metallic minerals are known to exist in Texas, the value of the output of the State has been comparatively quite small. The Shafter Mine, of Presidio county, has been a heavy producer of silver for the last fourteen years, and the Hazel Mine, in El Paso county, produced considerable silver and copper during the period in which it was worked. Although localities are known to exist where gold, silver, copper and tin are in apparently paying quantities, little development along these lines has been undertaken.

In the last five years, however, a new industry has sprung up which has added very materially to the value of the output of metals from Texas, and which bids fair to increase until it becomes one of the most productive of Texas mining industries. Reference is made to the quicksilver mines of the Big Bend of the Rio Grande, in the southwestern part of Brewster county.

LOCATION.

The belt that may be designated as mineral bearing, as far as at present prospected, occupies a rectangular strip, approximately fifteen miles long and four miles wide, the greatest length being east and west. The longitude is about 104° West, and latitude 29° 30′ North. The Fresno cañon is the western boundary of the district, this waterway representing the western limit of the geological formation in which the quicksilver has been found to occur. The eastern end of the rectangle would be several miles east of the Terlingua creek.

While it is not at all sure, or even probable, that all the paying mines will be found within this area, still it may be stated that it will be within this district that nearly all the development of the near future will take place.

The district is about twelve miles from the Rio Grande, on an average; and, roughly speaking, lies parallel to the course of the river. The belt outlined above lies in blocks of the public lands which were surveyed by the railroads, on the alternate section arrangement. The blocks involved are Block G12, Gulf, Colorado & Santa Fe Railroad; Block 341, and Block G4, Texas Central Railroad, and Block G5. Of these Block G12 is the westernmost and Block G4 the easternmost. Most of the sections of these various blocks do not, so far as has been discovered up to the present time, contain quicksilver in paying quantities. Block G12 has been developed most, the discoveries and explorations there being the first in the district. It is only within the last few months that ore has been found east of Terlingua creek in Block G4. Block 341 lies between the two above-mentioned blocks. It must be borne in mind that one-half of the sections are patented land and have not been prospected to any considerable extent, but are being held by the owners to await the development on the State sections which are subject to mineral locations.

The Terlingua postoffice, which may be considered as the center of the district so far developed, is in Section 58, Block G12.

The following sections, of 640 acres each, have had mineral claims located upon them, or are contiguous to such sections, and may be considered as constituting the most promising belt of the district: In Block G12, Sections 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 55, 56, 57, 58, 59, 60, 69, 70; in Block G5, Sections 98, 99 and 100; in Block 341, Sections 69 and 70; in Block G4, Sections 295, 286, 298, 297, 216, 248. The individual sections (odd-numbered ones) are not, of course, subject to location by prospectors; but in all instances cited, the sections have been reported as actually showing the mineral, and in a number of instances are the most productive in the field.

GENERAL CONDITIONS.

The location of the district is one of the drawbacks encountered by the developers. The remoteness from railroad facilities, and the inhospitable aspect of the country, are deterring influences in the opening up of the district. Terlingua postoffice is 105 miles from Marfa by wagon road, from Alpine 95, and from Marathon 90, all these being stations on the Southern Pacific Railway, from 200 to 250 miles south of east of El Paso. The wagon roads are fairly good, but lack of water on the Marathon and Alpine roads in the dry season is a source of great inconvenience to freighters. The elevation of the mines above the sea level is about 3200 feet, while the points of shipping on the railroad vary from 4000 to 4689 feet. This is an advantage in the haulage of freight, such as heavy machinery and supplies, to the mines. The grades are for the most part very gentle.

Except in the rainy season, which lasts theoretically from June until October, the water used at the main camps is hauled for distances varying from six to twelve miles, the sources of supply being Cigar springs, Terlingua creek and the Rio Grande. The method of transportation is by wagons carrying metallic tanks of from 350 to 500 gallons capacity. The prices of water per tank vary from $2.50 to $3.50. It is most fortunate for the operators that no water is required in the reduction of the quicksilver from its ores, all the water being used for domestic purposes.

Reservoirs have been constructed in numerous cañons and draws for the storage of storm water. In some instances great difficulty has been encountered in getting them to retain the water, owing to the fractured condition of the limestone, in which they are built. However, the three larger companies now have tankage of considerable capacity available for use.

In addition to these artificial reservoirs, there are numerous natural tanks, or "tinajas," which hold considerable quantities of water, some lasting through the entire year. The open workings along the veins, too, hold considerable water, which is utilized by freighters for stock water, while it lasts.

A few attempts have been made to get water by sinking wells. So far only very shallow wells have been dug in arroyos. A little water has been found, but it is badly impregnated with mineral matter, chiefly gypsum. The possibility of getting deep artesian water has been considered, but no experiments have been made up to this time. However, the badly faulted condition of the country is a drawback in this respect.

Altogether, the water problem is somewhat serious, and as the district develops will be more serious. The most feasible plan of obtaining water will be to construct more and larger reservoirs.

The vegetation in the district is very sparse, and consists entirely of the desert types. The most common plant encountered is the sotol (*Dasylirion heteracantha*), which is used by the miners for making huts and for thatching roof of temporary structures. It has been claimed that it is possible to use the sotol as a fuel, and in all probability the experiment will be made when the scarcity of wood causes the fuel problem to be serious. Other abundant types are the lechuguilla (*Agave heteracantha*), the okatilla (*Fonguiera splendeus*), palma and palmilla, and nopal. In the immediate vicinity of the mines there are a few stunted mesquite bushes and in the draws the mesquite and catsclaw (*Acacia weightii*) grow to be sufficiently large to be used for fuel for the furnaces. However, a very large proportion of the wood is hauled from the valley of the Rio Grande, from twelve to twenty-five miles from the mines.

The climate is mild in winter, but the summer months are very warm. The flats, especially, are almost uninhabitable on account of the high temperature. However, the nights are always pleasant enough to allow comfortable rest, which is a great necessity after the exhausting temperature of the day.

HISTORY.

At Comanche spring, a small "seep," seven miles north of the Rio Grande, the gray limestone bluffs have been covered in a number of places with rude paintings of characteristic Indian designs. The artists were without doubt the Comanche Indians, and the vermillion pigment used by these aboriginal artists was prepared from cinnabar. This cinnabar must have been obtained from the outcrops of the veins and pockets in the neighborhood of California Hill, the locality that has yielded several thousand flasks in the last few years.

The Indians disappeared from the country and nothing was heard concerning the presence of quicksilver until about the year 1887, when rumors reached the stations along the Southern Pacific Railroad that ore was plentiful in the country west of Boquillas and east of Presidio. No record has been kept of any authentic find or locations. The Geological Survey of Texas had reconnaissance parties in the regions west of the Pecos, in the years 1889-90, and Mr. von Streeruwitz, who was in charge, mentions that the presence of cinnabar had been reported to him, but that he had been unable to find traces of it. (Geol. Survey of Texas, 1889, page 225.) Mr. E. T. Dumble, also, states in his general report, that no confirmations had been made of reported localities. Dr. Becker, in his monograph on the "Quicksilver Deposits of the Pacific Slope," gives a very complete account of the then known quicksilver localities, not only of the United States, but of the world; but no mention is made of the Texas deposits.

The Mexican miners on their trips between the Shafter mines and Boquillas would in all probability pass near the localities that have since been found to be quicksilver producing. Some of these miners were familiar with cinnabar, or "azogue," as the Mexicans call it, but its presence so far as can be learned was not reported to the Americans at Shafter or Boquillas. According to accounts, early in the year 1894, some Mexicans residing on a small irrigated farm at the mouth of Terlingua creek, obtained some pieces of rich cinnabar float, and took them to the village of San Carlos on the Mexican side of the river. From San Carlos they were carried to Chihuahua.

Mr. Geo. W. Wanless, of Jimenez, Mexico, who was agent at that point for the Rio Grande Smelting Works, learned of the finds and obtained directions from the Mexicans how to reach the locality. He, together with Mr. Chas. Allen, of Socorro, N. M., went to Marfa and from thence down to the locality indicated by the Mexicans. They found the veins and located claims. Shortly after this time Prof. Wm. P. Blake and Mr. Jos. P. Chase, of New Mexico, visited the locality, and Prof. Blake's description of the deposits, published under the title of "Cinnabar in Texas," in the *Transactions of the American Institute of Mining Engineers,* Vol. XV, page 68, is the first notice of importance that we have of the region.

Messrs. Chase and Allen acquired Sections 41 and 59. After doing a small amount of work they left the country and subsequently sold their holdings to Messrs. Turney, Wright, Chase, Woods and Combs, and it became known as the California property.

In the winter of 1896 and the spring of 1897, a considerable amount of prospecting was carried on in the district. About this time Messrs. Thomas Goldby and G. H. Normand made a prospecting trip to the district and obtained samples, which were assayed and found to contain quicksilver. The land situation was in a chaotic state and no claims were filed by them at this time.

Meanwhile Mr. I. A. Dewees had become interested in the field, and, in company with Mr. Hess, of Marathon, and Mr. Reid, spent considerable time prospecting over the entire district, which resulted in his locating valuable claims for Lindheim and Dewees in various parts of Block G12.

Other prospectors to locate claims at the time were Messrs. Gaughran, McGuirk and McKinney and Parker.

In December, 1898, Messrs. Normand, Sharpe and Goldby took up claims on Sections 38, 40 and 58, and in August, 1900, began to treat ore in a ten-ton furnace that had been erected by Mr. Robt. Scott, of California, after models of the furnaces in use at New Almaden. The ore treated was principally from Sections 38 and 58, the ore from Section 38 being hauled two miles over very rough roads.

Mr. W. E. Bell had meanwhile secured an option on the California property, and had done considerable prospecting and development work, and had erected retorts and produced some quicksilver.

Mr. Dewees also retorted ore successfully. His retorts were located on Terlingua creek, nine miles south of the mines.

Hess and Gaughran put up a retort on their property, known as Excelsior, on Section 38, and produced some quicksilver; and later McKinney and Parker and Dr. Coltrin retorted ore, producing some quicksilver.

In February, 1901, Messrs. Normand, Sharpe and Goldby purchased the California property from W. E. Bell, and their holdings are at present worked by the company composed of these gentlemen, and is known as the Marfa and Mariposa Mining Company. In the Spring of the present year an additional ten-ton furnace was added to their plant. This company has produced a large proportion of the output of the field, and is at present in successful operation.

In the early part of the present year the Terlingua Mining Co. (Lindheim and Dewees) had built for them a forty-ton Scott furnace of the most improved type, and produced considerable quicksilver. This company is said to have had several thousand tons of ore on the dumps when operations were commenced.

Messrs. Hess and Gaughran, owners of the Excelsior claims on Section 38, have disposed of their property to the Colquitt-Tigner Mining Company. A furnace is now being erected for this company and mining is being carried on in anticipation of an early completion of it.

The latest discoveries of any importance were made in January, 1902, when quicksilver was found on Section 216, Block G4, and later on Section 248, Block G4. Mr. W. L. Study, of the Marfa and Mariposa Company, has located claims and will develop the property on Section 216.

The country, as a whole, has been fairly well prospected. Many claims have been located whose value is at best uncertain. The individual sections, in some instances, promise good values, but the owners are in no hurry to develop or dispose of them, preferring to wait and profit by the experiences of others.

Allusion has been made to the remoteness of the country, the lack of water, etc., as being deterrent influences in the rapid development of the district.

CHAPTER II.

The Geology and Topography of the District.

The study of the geology of the Terlingua district involves the study of a considerable scope of country, if its general relations are to be understood. By the Terlingua district here is meant the area between the Fresno cañon on the west and the foot hills of the Chisos mountains on the east, the Grand Cañon mountains on the south, and the Alamo de Cæsario and Terlingua creek on the north. Within this district are encountered extensive series of sedimentary and volcanic rocks, whose mutual relations will be described hereafter.

North of the district the country is a high plateau of volcanic material. This plateau extends from north of Marfa to the Fresno cañon, sloping gradually from Alamito southwards. The plateau is not level, but has many mesa-like hills of lava and volcanic tuffs, no sediments except of volcanic origin being visible until the conglomerates and thin-bedded marls and limestones of the Fresno are encountered.

East of this plateau the underlying sediments are exposed on the Marathon and Alpine road in the neighborhood of Santiago Peak, a single mountain of granitic acidic eruptive rock, quite distinct from the flows making up the plateau. The sediments are of two distinct series, the lower of which is upper Cretaceous, the higher members immediately underneath the volcanic complex being in all probability divisions of the Tertiary. The strata exposed on the east are practically the same that are exposed above the Cretaceous in the section along the Fresno cañon. The eruptions furnishing the enormous masses of volcanic rock were probably in the latter part of the Tertiary period.

East of the Fresno and south of Alamo de Cæsario the country changes its character entirely. Instead of the volcanic tuffs and lavas with the associated Tertiary sediments, there are present massive thick-bedded limestones of the Lower Cretaceous, overlaid by the thinner bedded series of the Upper Cretaceous. These Cretaceous sediments dip sharply to the west and northwest at a high angle, and furnish evidence of a great fault having a northwest southeast trend that can be traced from Alamo to beyond the Rio Grande. The Tertiary sediments and tuffs are laid down horizontally on the steeply inclined strata of the Cretaceous. West of the Fresno cañon, and north of Polvo on the river, these volcanic flows and Cretaceous sediments are seen in great development, and extend into Mexico west of the fault line that forms the western scarp of the Grand Cañon mountain. The valley between this mountain-block and the plateau upon which the mines are situated represents a dislocated block, three to five miles wide and of indefinite length. On the north side of the valley the heavy Lower Cretaceous strata dip to the south and southwest at a high angle, being almost perpendicular in some localities. The south line of the block fault which is the north scarp of the Grand Cañon mountain plateau shows vertical bluffs that reach the height of 1200 feet. The strata dip gently towards the southwest at an angle of ten degrees to fifteen degrees. The Grand Cañon de Santa Helena, which traverses the fault block, is an enormous shut-in with perpendicular walls varying in height from less than 100 to more than 1800 feet in height. It is in the neighborhood of this cañon that the most complete section of the heavy sediments of the Lower Cretaceous may be obtained.

The eastern limits of the heavy limestone in the Terlingua district is a cañon that represents a north and south fault line. This cañon shows the Lower Cretaceous sediments on the west side with the thin-bedded Upper Cretaceous members on the east side. It is near this cañon that the mines of McKinney and Parker are located. The down throw is to the east and the displacement probably seven hundred feet. This fault can be traced northward in the direction of Agua Fria for several miles, the displacement becoming constantly less towards the north.

The heavy sediments that form the body of the plateau dip to the north and to the west, under the volcanics and Tertiary sediments mentioned before. It will be seen that there has thus been produced a large area of the heavy limestones dipping in three directions. The flanks of the area are covered by the sediments referable to the Upper Cretaceous and to the Tertiary, and all are cut in various places by dikes and bosses of late igneous rocks. These eruptions are most common and the flows most extensive along the fault lines.

TOPOGRAPHY.

The topography of the district is very distinctive, being due to the deformation beds that are of such physical construction as in some cases to resist, while in others to yield quite easily to erosion. The structure. due to extensive faulting, is also quite an important factor in the shaping of the topography. The highest part of the district is along the northern scarp of the uplift that lies to the eastward of the Fresno cañon. Here the highest beds of the Lower Cretaceous form a serrated ridge somewhat less than 4000 feet above the sea level. The Lower Cretaceous sediments have been eroded from the summits, but are seen along the flanks, as mentioned before. From this highest part of the district the general dip is southerly and southwesterly, although there are many subordinate valleys and ridges within the various limits of the uplift. At no place on the uplift are the remains of the Tertiary to be seen, although in one of the valleys, caused by a subordinate block fault, Cretaceous strata are exposed immediately underlying the Tertiary.

One of the most conspicuous topographic features of the district is Block Mesa, which consists of a dome of Lower Cretaceous limestone, having a general elliptical shape, its longest axis being northeast and southwest. This mesa dips in all directions from the summit, forming a particularly fine example of the qua-qua-versal type of fold structure. Erosion shows the cause of the uplift to be a mass of igneous material near the center. This mass never reached the surface and was laccolitic in nature, the erosion of the limestone allowing it to be exposed. The dips on the slopes of the hill are quite uniform, having a general average of forty degrees. The dip, however, flattens out towards the base of the hill and faults occur on four sides, making the mesa a detached block. The displacement, however, is not great.

The character of the limestone and the thickness of the beds in the Lower Cretaceous series is favorable for the formation of numerous deep and vertical walled cañons. These cañons, all of which are dry except in the rainy season, traverse the country in every direction and make it very difficult to build roads, or even trails.

Probably the most distinct and characteristic feature of the topography of the district are the clay hills with their cappings of white limestone. The hard limestone has protected the softer clay and shales from complete erosion, and in many places the mesa-like structure due to these two strata is still prominent. These beds occur in the geological section as the uppermost members of the heavy limestone series. Owing to the fault system of the district these beds are found at various elevations. In studying the structure of the country they are most useful, as they furnish a distinct horizon in the section whose rocks in many places are not of so varied a character as to be readily distinguishable. In addition to being prominent in the fault valley, and on the summits of the mesas; these beds are in a number of cases, notably at California Hill and Clay mountain, intimately associated with the igneous intrusions, in which cases the contrast between the pure white limestone and the dark colored clays and lavas make prominent landmarks. Along the fault line on the south and west side of the Terlingua plateau these beds are prominently exposed and mark the boundary between the upper and lower strata of the series.

Off the flanks of the plateau or uplift the surface has been more easily eroded, and the soft beds have been worn away, leaving the hills much lower and less abrupt, except where they have been cut by igneous flows and intrusions. East of the fault line marking the erosion limit of the massive limestones, the most conspicuous features of the topography are the volcanic neck and bosses that rise from the comparatively level plain formed by the thin beds of the Upper Cretaceous and the Tertiary. In some instances these masses attain the height of more than a thousand feet. The sediments are often capped by thin flows of lava, and in a number of instances dikes radiating from volcanic necks may be traced across the country for miles.

GEOLOGY.

The rocks of the area, as before stated, may be divided into two classes, those of sedimentary origin, and those of igneous origin. The rocks of the igneous class may be subdivided into those which came into their present positions in the molten state, and those which, though of igneous material, have been laid down in beds, as volcanic ash and tuffs. These latter are important only on the outskirts of the district proper, as along the Fresno cañon, for instance.

Except for minor unconsolidated deposits of recent origin, all the sediments present in the district are marine, although they indicate that the conditions under which they were deposited varied to a considerable extent, as there are present deep sea and shallow water deposits, with many intermediate varieties.

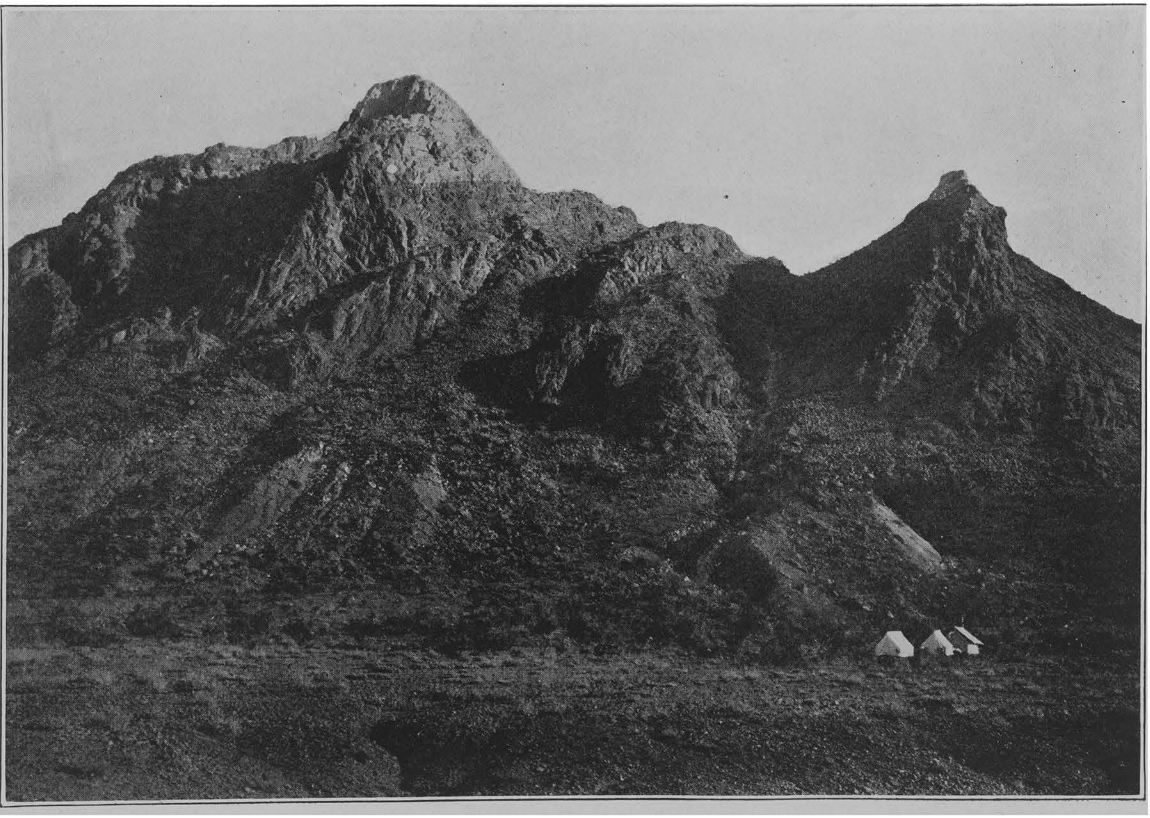
The sediments belong to two periods, the Cretaceous and Tertiary. The Cretaceous section is quite extensive, and has representatives of both the Lower and Upper divisions. The total thickness of the Cretaceous is in the neighborhood of 2000 feet, while the Tertiary, with the volcanic tuffs and ashes, represent several hundred feet more. There has been no attempt to subdivide the Tertiary, and the Cretaceous has been studied in a general way with the view of obtaining an understanding of the structure.

Mention should be made of the extensive gravel and "adobe" deposits that occur in the district. These are in some cases more than 50 feet in thickness and are the results of deposition from the drainage ways. However, most of the surface is uncovered and the country rock is nearly always in evidence.

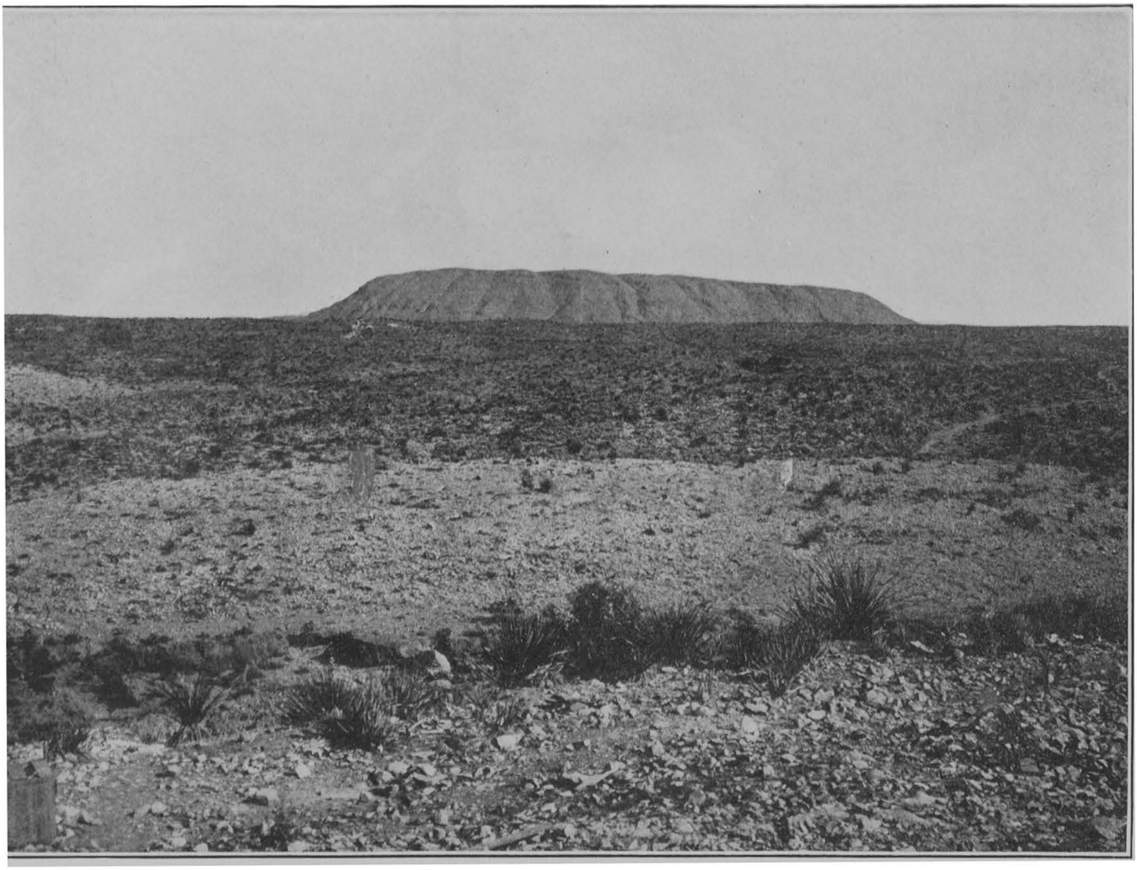
THE LOWER CRETACEOUS (FREDERICKSBURG DIVISION).

The oldest sediments exposed in the area studied are those of the Fredericksburg division of the Lower Cretaceous or Comanche series. The bottom of this series is not exposed in the region. so far as has been ascertained. The lowest member found exposed in the high bluff along the north side of the Grand Cañon mountain is the Comanche Peak limestone. This formation is exposed along the fault scarp about five miles northeast of Terlingua. In the Grand Cañon mountain section the Comanche Peak beds are at the base of the cliffs on both sides of the Rio Grande. Over 100 feet of these beds are exposed in each of the localities mentioned. The limestone is rather thick bedded, massive, and is of a bluish gray color. It has quite characteristic nodular weathering. The most common fossil recognized is the oyster "Exogyra texana."

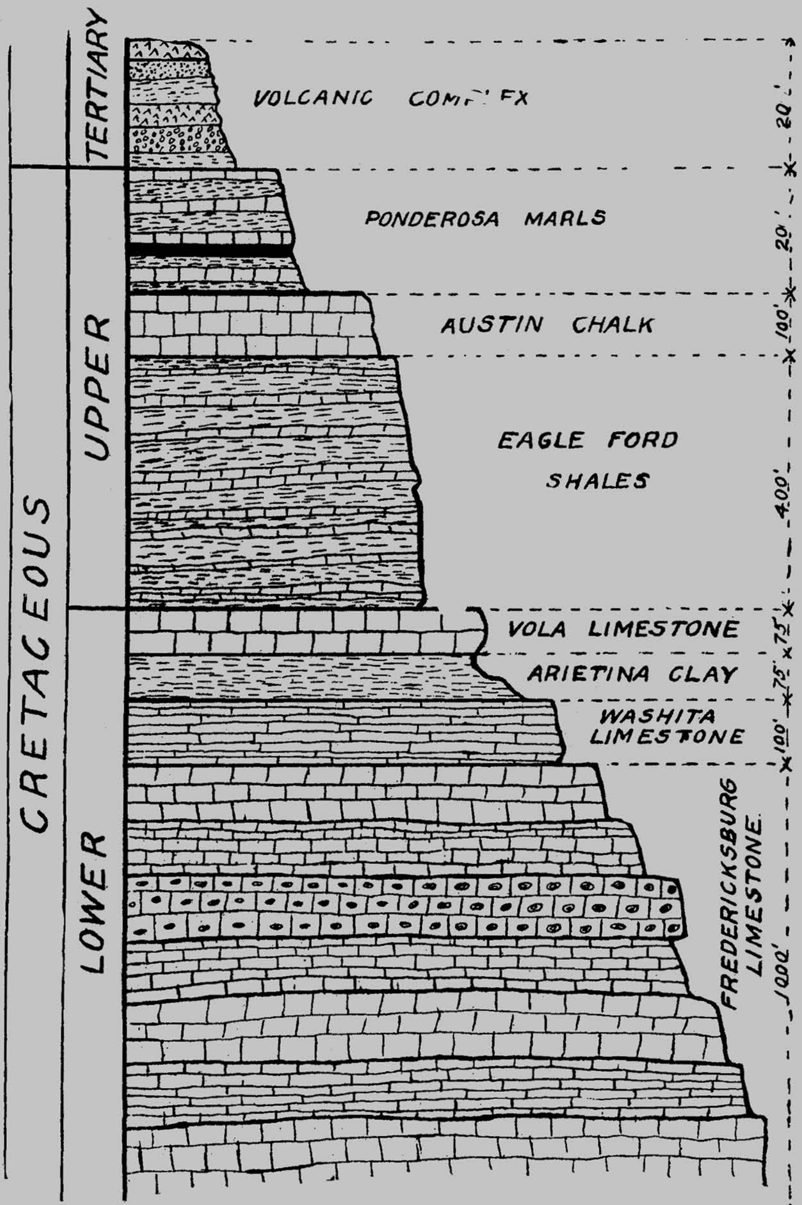
Above the Comanche Peak formation is the Edwards limestone. This formation outcrops in many places over the whole area and is the most exposed of the whole Comanche series. It is seen outcropping in the range of hills east of the Fresno fault, in the hills south of the Alamo de Cæsario, and its outcrop forms, for the most part, the escarpment of heavy limestone running northwest and southeast, that forms the eastern



IGNEOUS ROCK, ELEPHANT HEAD.



BLACK MESA FROM MARIPOSA STORE.



General View of the Geology of the Terlingua District.

limit of the Lower Cretaceous in the Terlingua district. It is present in the Crœsus cañon, and in Black Mesa, and is the material underlying the formations that are the most productive of quicksilver.

There is no breach between the Comanche Peak and the Edwards limestones. They can be easily distinguished, however, by their different physical characteristics. It is thick bedded for the most part, but carries in some horizons thin-bedded marly streaks, whose softness contrast strongly with the hard, indurated surfaces of the greater part of the formation.

Fresh pieces of the limestone from various portions of the section show the color to vary from pure white to blue, cream and yellow, but the weathered surfaces always present a dull gray color, whatever the original color may have been.

A very characteristic feature of the Edwards limestone is the occurrence in it of beds carrying large numbers of flint nodules. The flint horizons, of which there are several, vary in thickness from 30 to 80 feet. The flints differ in size, shape and color, though kidney-shaped masses of a dark red, about two inches in length, are the most common. In some of the beds of the Edwards limestone the siliceous material is not all segregated, but is disseminated through the beds, causing cherty patches.

The total thickness of the Edwards limestone in the Terlingua district is about 750 feet. It is probable that the complete section is present in the Grand Cañon mountain exposures, but no attempt was made by the writer to subdivide it into its various horizons. The Edwards limestone carries quicksilver ore in several localities north and west of Terlingua postoffice, but only in its upper divisions.

The upper part of the formation is characterized by numerous caves, some of which are of considerable extent.

The most common and characteristic fossils present in the Edwards limestone are those of the "Monopleura," "Requienia" and "Nerineidae" genera.

WASHITA DIVISION.

Above the Fredericksburg division of the Lower Cretaceous are the members of the Washita division. No structural break has taken place, and in its lower members no great physical difference in the character of the beds is to be noted. Near the top of the series, however, a series of clays and calcareous shales is present that differs materially from the great masses of thick-bedded limestone of the Fredericksburg.

In extent the members of the Washita are very similar to the Edwards limestone, especially the lower members that rest directly on the Edwards. The uppermost members have been eroded for the most part, but there are still present a very great number of particles of the "Exogyra arietina" (Del Rio) clay and the Vola (Buda limestone), whose mesa-like structure is a characteristic feature of the topography.

The lowest members of the Washita series is the Fort Worth or Washita limestone. This formation carries a large proportion of the deposits of quicksilver so far exploited. This limestone outcrops at Terlingua postoffice and vicinity, and all the development in that neighborhood has been carried on in this formation. Its thickness is apparently somewhat more than 100 feet, and may be considerably more, as it is impossible to establish the exact demarkation between its base and the upper bed of the Edwards. The lower beds of the Washita are heavy and thick, while the upper portion is quite thin-bedded and has present in it numerous strata of marly limestone of only a few inches thickness. The color of the limestone varies from bluish at the base to almost pure white at the top. The characteristic color of the weathered surface is gray except where traversed by iron veins, when it becomes reddish brown. The formation is greatly faulted, and in a number of places has been locally metamorphosed by igneous intrusions. Veins of calcite and aragonite cut the formation in every direction. In some localities the characteristic fossil of the Fort Worth formation "Kingena wacoensis" is abundant.

Above the Fort Worth limestone is a series of clays, argillaceous and arenaceous shales, and thin-bedded limestones, of a blue green and brown color. This formation is the stratigraphic equivalent of the "Exogyra arietina" beds or the Del Rio clays. The thickness is from 60 to 100 feet, and in all cases it is covered with a capping of hard white limestone to which is due its preservation from erosion. These clays carry large quantities of iron pyrite and gypsum. In no case, however, has cinnabar been discovered in them, although it is abundant in the Fort Worth limestone immediately below. Fossils are present in great abundance, the most common varieties being Nodosaria texana, Exogyra arietina, Exogyra drakei, Gryphaea pitcheri, and numerous Echinoderms.

The Del Rio clays are always capped by a white, extremely pure limestone, whose thickness approximates 100 feet. It weathers in a rather characteristic manner, the exposed surfaces breaking up into a mass of angular fragments. The undecomposed rock possesses a very distinct conchoidal fracture, a feature very noticeable at California Hill and Clay Mountain in the Terlingua district. The stratigraphic position of this limestone indicate that it is the equivalent of the Buda limestone of Prof. R. T. Hill. So far as known this limestone does not carry quicksilver, although in many places it is cut by numerous calcite veins. Fossils are not abundant except in the lowest beds. Several forms of Gryphaea were recognized.

THE UPPER CRETACEOUS.

In many localities in the Terlingua district the Buda limestone, the uppermost member of the Lower Cretaceous series, is overlaid by a great series of sediments, several hundred feet in thickness, characterized by a great development of lime shales, flags and clays. The highest divisions of the formation represent another period of thick-bedded limestone deposition.

The lowest member of this division is the Eagle Ford formation. It is made up of yellowish, thinly laminated argillaceous, arenaceous and calcareous material. In some instances beds of clay 8 to 10 feet in thickness occur in the series, while at other times bands of comparatively pure limestone are present. The most of the section, however, is made up of limy flag stones varying in thickness from 4 inches to 2 feet. The beds are traversed in all directions by seams of gypsum and calcite Pyrite is also present, though in most cases it has been oxidized by exposure. The veins in the clays and shales in a number of instances have carried cinnabar and native mercury.

The Eagle Ford formation is rich in fossils, the most common genera being "Inoceramus" and "Ostrea."

Owing to its physical characteristics the Eagle Ford formation has been denuded from the various uplifts in the district, and is present most conspicuously where it has been faulted into the position it now occupies. The formation is shown in great development on all four sides of the Lower Cretaceous block, the finest exposures being south of Terlingua, where the upturned edges of the inclined strata on the down-throw of the great Fresno fault may be seen. The thickness here is over 500 feet in the exposed beds. Somewhere between the Eagle Ford formation and the Austin chalk, the next highest division, there has been a break, but the complete section has not been worked out. The upper parts of the Eagle Ford are chalky and grade somewhat gradually into the chalk which is exposed near Lajitas on the Rio Grande and in the Fresno cañon. The horizon, which has been called Austin chalk, may be simply the upper part of the Eagle Ford formation. In the Fresno it allows a thickness of about 100 feet, while a somewhat greater thickness was observed near Lajitas. East of the Terlingua creek the same formation is exposed in many localities. Associated with it are beds of clay and lignite, some of which may prove of value in the future.

TERTIARY.

It is unnecessary to go into detail with regard to the rocks overlying the Cretaceous. The Tertiary is mainly interesting as being the probable age of the igneous intrusions that stimulated the ore-bearing solutions from which the quicksilver was deposited. While some limestones and shales are present, most of the material is of volcanic origin, rhyolitic and andesitic muds, and tuffs, accompanied by volcanic agglomerates and conglomerates of sedimentary material with volcanic cement. The Tertiary beds themselves do not, so far as known, carry quicksilver.

STRUCTURAL GEOLOGY.

The Terlingua area as a whole lies on the eastern flank of the Continental divide, but the mountain-making forces have been at work, although in a somewhat modified form. The immense series of deep sea sediments of Lower Cretaceous times, with the deposits of the constantly shallowing Upper Cretaceous sea, formed originally a section of about 2000 feet without structural break. Some time after the close of the Cretaceous, probably in the Eocene Tertiary, there was a series of disturbances causing an uplift of the Cretaceous strata. These uplifts resulted in a number of great faults having a northwest and southeast trend. The fault movement was accompanied by folding, which, however, resulted in a great number of minor faults, due to the brittleness of the beds involved. The amount of displacement on the different sides of the faults vary from less than 100 to more than 1000 feet.

Accompanying the faults, or the disturbances causing them, was a series of volcanic flows. It is probable that these flows continued for a long period after the main disturbance, and that minor changes in the structure took place after each flow. The main development of the volcanic rocks are on the three sides, north, east and west, of the Cretaceous

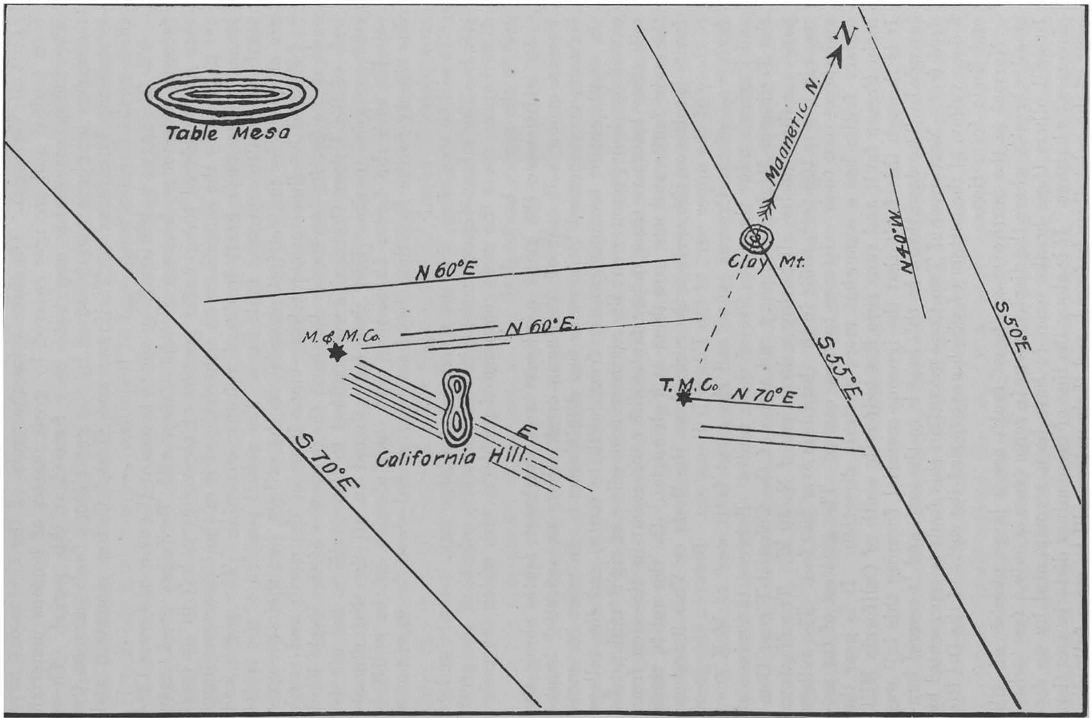


Diagram showing Relations of Fissure Veins to Fault Lines.

uplift of Terlingua. On three sides the rocks of the Cretaceous have been faulted and are now covered by great masses of igneous material. The Chisos mountains may have been formed at this period. These mountains occupy a region caused by the great block fault between the Cretaceous limestones of Terlingua and Grand Cañon mountain and those of the Carmen range, east of Boquillas.

The Terlingua uplift itself, by which is meant the area of Lower Cretaceous limestones, between Fresno Cañon and Terlingua creek, may then be considered the elevated portion of the country, left in its present position by the subsidence on either side of it of the Cretaceous limestones under their great loads of volcanic material. The north and south limits also represent fault lines. The actual position of the faults are obscured by the detrital material in the valleys, but their presence is indicated by the steep, pitching monoclines at the north and south ends of the uplift. As stated elsewhere, the exposures of the Eagle Ford beds of the Upper Cretaceous are confined to these valleys, but all the evidence goes to show that they have shared in all the disturbances equally with the Lower Cretaceous, and their absence on the uplift is due simply to the fact that they have been eroded since the movements took place.

It will be seen, then, that the structure, in a large way, is easily understood. The minor disturbances, with the secondary effects of the great disturbances, cause the most complicated problems with which the geologist in the region has to deal.

In addition to the great northwest and southeast faults along the Fresno cañon and east of Terlingua creek, there are parallel breaks between, accompanied by more or less displacement. In most instances the displacement becomes greater from north to south, and the valleys caused by their presence cut the southern monocline at right angles. In still other instances these minor faults differ somewhat in direction from the main faults and run into them at high angles. On the uplift, these faults involve on the surface the rocks from the Buda or Vola limestone to those of the upper part of the Edwards limestone. Between the great fault west of the Croesus cañon and the great fault west of McKinney and Parker's mine there are five of these faults. Between the mines of the Terlingua Mining Company and those of the Colquitt-Tigner Company are three faults, all having a direction of N. 50 W. The displacement in two is 100 feet, while in the third it is over 200 feet. The valleys and ridges owe their existence to these causes. The greatest of the secondary faults has a somewhat more westerly direction. It is near the main Fresno fault and runs into it a half mile south of California Hill. It is through this fault that the igneous material forming this hill was intruded. The downthrow in this case is to the east, and is several hundred feet. Northwest of Two Cone mountain this fault is represented by a deep valley, at the bottom of which are exposed the rocks of the Del Rio and Buda formations.

Normal to the northwest-southeast faults are a large number of still smaller breaks, where the displacement in some cases is only a few inches. In still others these breaks seem to have been accompanied by no displacement whatever. It is along the line of these minor disturbances that most of the quicksilver is found, and their nature will be more fully discussed under the treatment of the vein system.

THE IGNEOUS ROCKS.

The discussion of the subject of the igneous rocks of the Terlingua district will be confined to the statement of their location, relation to the sediments and the ore deposits, with a short petrographical description of the most common varieties. No attempt will be made to enlarge on the nature of their various relations with each other, nor to discuss fully their chemical and mineralogical characteristics. These questions may be discussed in a separate paper, when more time will have been given to their proper investigation.

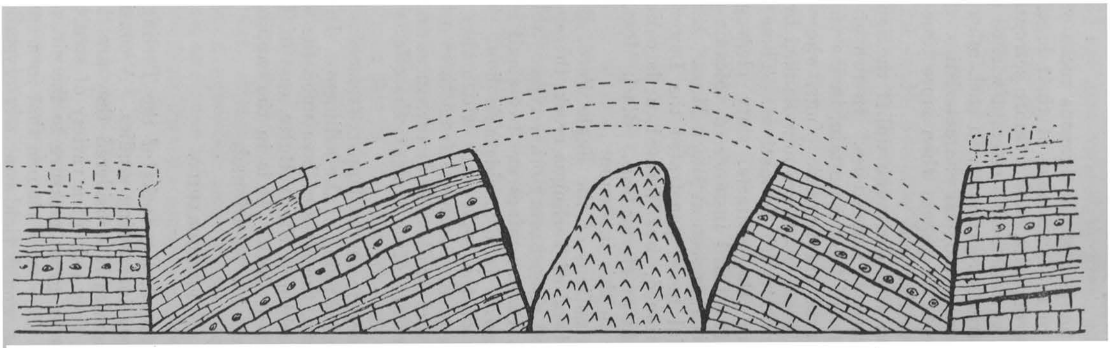
In three localities upon the Terlingua uplift the igneous rocks actually cut the Lower Cretaceous Limestones. In two of these instances, that of California Hill and of Clay mountain, in the vicinity of Terlingua postoffice, they occur as old volcanic plugs, whose upper portions have been eroded. Both these plugs are now flanked by the limestones and shales of the Buda and Del Rio formations. These rocks have been locally metamorphosed on the contacts, slaty cleavage having been induced in the shales. The third instance of volcanic material within the bounds of the uplift is that seen at Black Mesa. It is probable that here the volcanic material never penetrated the Lower Cretaceous, as in the cases just mentioned, but formed a laccolite between the Edwards limestone and the overlying beds. Black Mesa, described elsewhere, owes its existence to this intrusion.

In the thin-bedded formations of the Eagle Ford, along the Fresno fault and in the neighborhood of Terlingua creek, there are many bosses, laccolites, dikes, sheets and almost every other type of volcanic structure. Near the McKinney and Parker mines are two small intrusions, while one and one-half miles north is a considerable flow. These flows not only affect the character of the rocks with which they are in contact, but cause various degrees of displacement from their original positions. The beds yield readily, and while the disturbances in the immediate neighborhood of the flows are often violent, the effects are not widely extended.

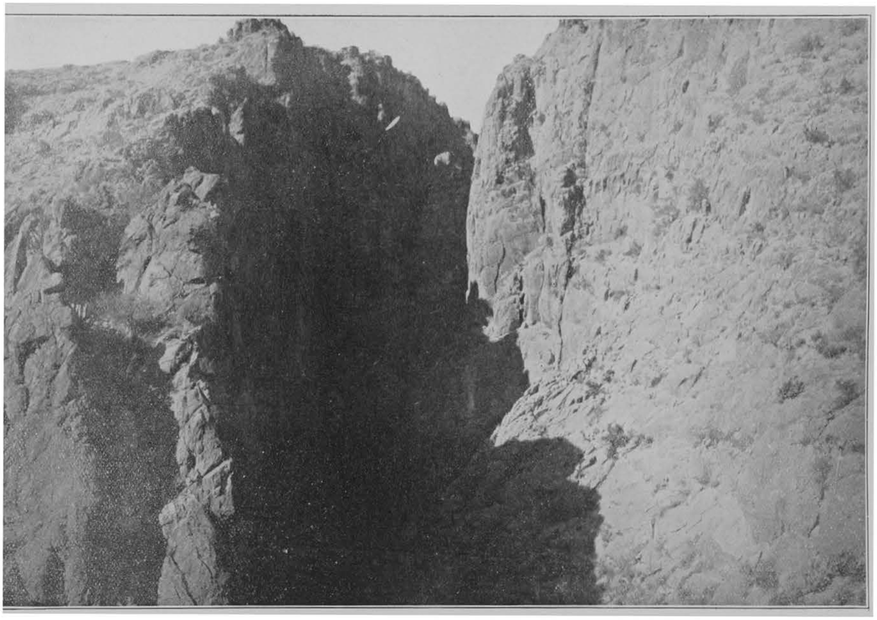
A common type of structure in the Upper Cretaceous area of Terlingua creek valley is the lava capping of the sediments. In some instances, as Cigar Springs mountain, the mass of lava upon the sediments is several hundred feet thick, while at Study Butte, east of Terlingua creek, the capping is about 40 feet thick. It is in the capping that the only quicksilver in igneous rocks has been found.

PETROGRAPHY.

Petrographically considered, the rocks of the Terlingua district and its surroundings form very interesting studies. A considerable variety is present, and while chemically considered they are, in a number of instances, closely related, they exhibit a variety of structure and mineralogical composition, due in great measure to the circumstances under which they were ejected. The same magma that in a surface flow without considerable thickness, would yield concisely crystalline or vesicular lava, in a boss or volcanic neck of any extent, would yield a finer grained porphyritic variety. While it is true that there has been considerable differentiation in the magmas furnishing the volcanic material, even when the eruptions have been practically contemporaneous, it is also



Diagrammatic Section of Black Mesa.



MOUTH OF CROESUS CAÑON.

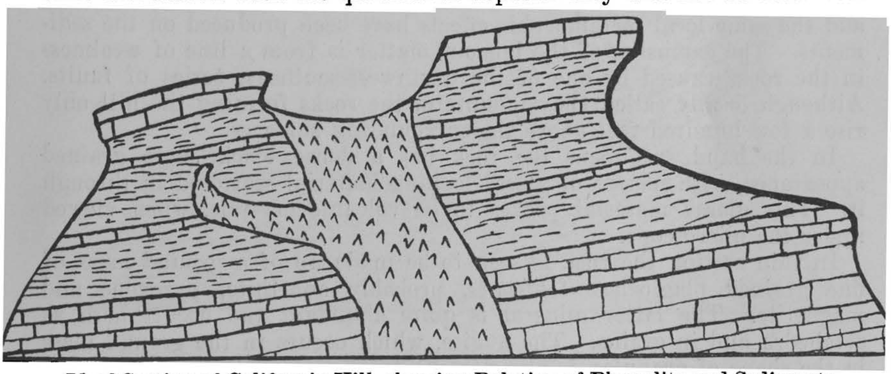
true that in the great flows along the Fresno Cañon a distinct relationship may be traced between the various flows.

But not all of the material is related closely enough to be considered differentiations from the same magma, as strongly contrasting types are present and often in close proximity. An interesting problem would be solved by a close study of the relations of the various volcanics in the field, with respect to their composition, method of occurrence and time of outflow. It has been impossible to give the proper attention to this side of the question here.

The rocks most commonly encountered, however, belong to two strongly contrasted groups, viz.: a series of basic basaltic rocks, and a more extensive series of acidic rocks, including phonolites, andesites and rhyolites.

A number of petrographic slides have been made of rocks from various localities. The phonolitic rocks may be represented by the outflow at California Hill, the basaltic by the flows at Clay mountain and the foothills of Grand Cañon mountain, the andesites by numerous varieties from the Fresno Cañon and Cigar Springs mountain, and the rhyolites from Study Butte and Black Mesa.

Many other localities show different varieties, but as they are not in close association with the quicksilver deposits they will not be described.



Ideal Section of California Hill, showing Relation of Phonolite and Sediments.

PHONOLITE.

California Hill, as before explained, is the remains of an ancient volcanic neck. It is of comparatively small extent, and its surface where exposed is greatly weathered. Associated with it are the limestones and shales of the Buda and Del Rio formations.

In the hand specimen, the rock is of a greenish gray, rather fine grained, porphyritic variety. When broken from boulders where intrusions are fresh, it breaks with a conchoidal fracture and gives out the ringing sound that originally gave phonolite its name.

Under the microscope the most abundant minerals of this rock are seen to be feldspars rich in the alkalis. They occur both as phenocrysts and as the chief element in the ground mass. The most prominent is usually the sanadine variety of orthoclase. The phenocrysts, which are usually much decomposed, are of a tabular habit, and are frequently twinned after the Carlsbad law.

The plagioclase feldspars, which are generally confined to the ground mass, show the albite twinning.

The nepheline of the rock is in most cases decomposed to zeolites, but there can still be distinguished the basal planes of hexagonal prisms, giving hexagonal and square sections.

The most common ferro-magnesian mineral of the rock is amphibole. It occurs in idiomorphic crystals and sometimes exhibits resorption phenomena. Of the pyroxenes the most common variety is augite. Biotite has not been identified, nor have haüyne and nosean. Magnetite is rather more common than in most phonolites and minute crystals of zircon are present.

The rock from California Hill bears a close resemblance to the phonolites from Uvalde county, as described by Prof. Cross in the "Uvalde Folio of the Geologic Atlases," page 4. The igneous rocks described by Prof. Cross have very much the same relation to the Cretaceous sediments as is found between the sediments and eruptives in the Terlingua area.

BASALT.

Structurally Clay mountain bears a close resemblance to California Hill. The same sediments occur in connection with the eruptive core, and the same local metamorphic effects have been produced on the sediments. The extension of the igneous matter is from a line of weakness in the rocks caused by one of the northwest-southeast series of faults. Although locally called Clay mountain, the rocks forming the hill only rise a few hundred feet above the surrounding surfaces.

In the hand specimens the rock has a dense black, close grained appearance, with masses of glassy looking material scattered in through it. This glassy material proves to be volcanic crystals, when viewed under the microscope.

In thin section the rock is seen to be made up of a ground mass of fine grained plagioclase feldspars, probably anorthite, pyroxene and magnetite. The latter mineral is quite abundant and occurs both as octahedra and in grains. The augite, which occurs in the ground mass in the shape of granules, is also present quite commonly as phenocrysts, where they show good crystal forms with octagonal cross section, frequently exhibiting twinning.

The feldspar phenocrysts, which are labradorite, show albite-lamellation, occasionally combined with pericline and Carlsbad twinning.

The most prominent of the phenocrysts are those of olivine. They are of large size and although some crystals show corrosion, are generally quite fresh. In some slides the olivine was noted as being altered into serpentine.

The rock resembles quite closely the basaltic material from the foothills of the Grand Cañon mountain.

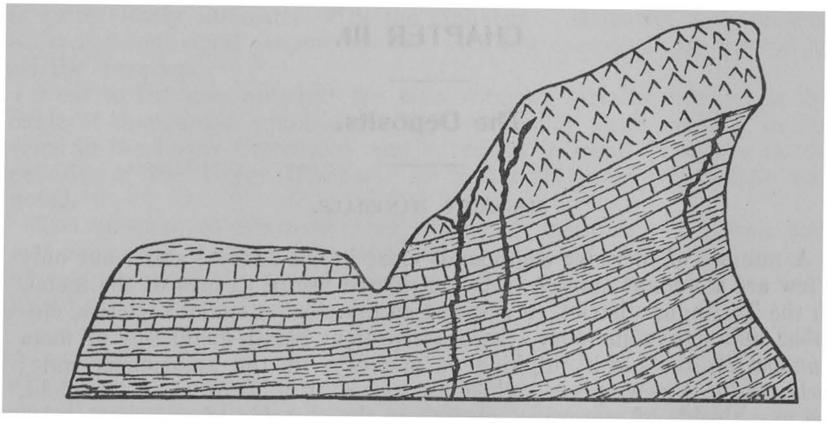
RHYOLITE.

The Black Mesa uplift, described elsewhere, has been the location of two eruptions of different age. The first and most extensive of the disturbances caused the strata to assume their present shape. Subsequently a flow of lava of slightly different character was ejected from a point north of the older outflow. Since the later eruption the whole district has been subject to the action of hot springs and silicification has been very extensive. The original character of the rocks has, in a great measure, been hidden, but the characteristics of a rhyolite lava may still be recognized from the material present.

Even before silicification this rock must have been the most acid in the field. Original crystals of quartz are abundant, and may be seen in the hand specimen. The rock is light colored and very hard, and often shows layers of a stony nature, which, under the microscope, are seen to be spherulitic. The ground mass varies in different specimens from glassy to crypto-crystalline, its true character often being obscured by alteration.

Next to quartz, which occurs in dihexahedral crystals, the most abundant phenocrysts are orthoclases of tabular habit. A very few crystals are present. It may be noted that the micas are almost lacking in all the rocks of the Terlingua district and vicinity.

The rhyolite from Study Butte east of Terlingua creek is almost identical with the rock just mentioned, except for the smaller amount of free



Ideal Section of Study Butte, showing Sediments and Rhyolite Capping.

quartz present in it. At this place it occurs as a cap flow of about 40 feet in thickness. The portion of the lava near the contact with the sediments is locally changed.

ANDESITE.

Although andesite is, on the whole, the most abundant of the lavas in the Terlingua district, it has not been found in direct association with the ore deposits. The flows along Fresno Cañon and at Cigar Springs mountain are beautiful and typical examples of augite-andesite, and need not be described in detail. Along the Fresno numerous outflows differ with respect to structure from compact fine grained to porous vesicular material. Much of the volcanic ash and the volcanic tuffs to the west of Fresno Cañon are of andesitic character.

The andesite from Cigar Springs mountain has augite developed to an extraordinary extent, but there is an entire absence of amphibole. In some localities in the district east of Terlingua creek the porphyritic texture of the andesite passes insensibly into the granitoid texture of diorite.

RELATION OF VOLCANIC ROCKS TO THE DEPOSITS.

Although the existence of the deposits of quicksilver depend on the presence of volcanic rocks, the relations are indirect. The deposition of the ore was dependent on the presence of hot springs, which were undoubtedly caused by the volcanic rocks. As pointed out by Prof. Becker (Monograph XIII, U. S. G. S., p. 417), such springs are most likely to occur at a very moderate distance from lava, but several miles may intervene. In the Terlingua district all the deposits are within a very short distance of volcanic rocks of some nature. In only one case is the cinnabar actually associated with the volcanic rock directly, but its deposition undoubtedly took place subsequent to the flow of the volcanic material.

CHAPTER III.

The Deposits.

MERCURY MINERALS.

A number of mercury compounds exist in the natural state, but only a few are abundant enough to be considered useful as ores of the metal. In the Terlingua district, in addition to the most common varieties, cinnabar and native mercury, there are present small quantities of meta cinnabarite, the black sulphide of mercury, in the amorphous state; terlinguaite, a new species, which is, according to Prof. S. L. Penfield, the oxychloride of mercury; calomel, or the chloride of mercury, and a compound of mercury and antimony which as yet has not been definitely determined. It is probable that other scientifically interesting but commercially unimportant species will be identified from this field. By far the most common of the ores is cinnabar, or the sulphide HgS which contains, when pure, 13.8 per cent. sulphur and 86.2 per cent. mercury. The cinnabar is generally mixed with impurities such as clay or oxide of iron. In the Terlingua district the cinnabar occurs in a number of forms. Beautiful crystals of a ruby-red color, often three-quarters of an inch long, have been found, intimately associated with calcite and native mercury. The crystals are usually acicular prismatic, but are occasionally of a thick tabular habit. The prismatic crystals have been observed only in calcite veins. Large quantities of cinnabar that is crystalline occurs in granular masses, often of large size. These masses show distinct grains and under the microscope exhibit crystal faces. The color of the granular aggregates varies from bright vermilion to dark reddish brown. The cinnabar also occurs in large amorphous masses, sometimes admixed with the granular material. The amorphous variety presents the same variation in color as does the granular.

The native quicksilver is present in a number of localities in the field and sometimes in considerable quantites. It is generally intimately mixed with crystalline masses of calcite, occurring in the interstices between them, in the form of globules. Cavities in the calcite veins have been pierced that yielded over twenty pounds of the native metal. Native mercury has also been found in the clay fillings of seams. In this case the globules are so fine as to be almost invisible to the naked eye. Native mercury also occurs in a close grained cream-colored limestone.

ASSOCIATED MINERALS.

In the Terlingua district the ores of mercury are associated with few metallic minerals except those of iron. Of the iron minerals the oxides are much more abundant than pyrite. In the deposits of quicksilver ore in rocks of the Lower Cretaceous formation the presence of the sulphide is extremely rare, but in deposits in the Eagle Ford formation the pyrite is quite closely associated with the cinnabar. Hematite and limonite occur in about equal proportions and with few exceptions are present in all the workings.

Next to the iron minerals the most common metallic mineral is the oxide of manganese, pyrolusite. This mineral is quite common in the veins in the Lower Cretaceous, and is present in small quantities in the deposits of the Upper Division. In a few instances psilomelane was noted.

The presence of mixtures containing small quantities of arsenic and antimony, and perhaps selenenium has been noted. So far as known, no compounds of silver, lead, copper or zinc are present. Gold has been found in the pyrite from the Eagle Ford.

Among the gangue materials by far the most common is calcite. A noteworthy fact in connection with the deposits is the total absence of crystallized quartz, usually one of the most commono of the associated minerals. In a number of instances the clayey material present in the vein contains considerable quantities of silica, and in a few openings chalcedonic material is present, but in the deposits in the neighborhood of Terlingua postoffice there is a total absence of it.

The calcite is the chief vein material, and is present in a number of forms. The most common is the ordinary calcite in great masses of rhombic prisms, dog-tooth spar of scalenohedral form, satin spar, of fibrous and silky structure, and amorphous chalk material. The various varieties of calcium carbonate show variations in color from purely transparent and pure white to red and black, due to the presence of iron. In the case of the dog-tooth spar, the crystals exhibit a zone-like structure. Often the interior of the crystal is colored red by the iron oxide, while the exterior shell is perfectly transparent.

Aragonite is a common gangue mineral in the district, and in some cases its crystals are of considerable size. Dolomite and barite occur sparingly, and are confined to the veins in the Upper Cretaceous formations.

Gypsum is often present in the veins, especially in the thin-bedded clays and slates of the Eagle Ford formation. The gypsum is present both as selenite and silver spar, and occasionally in long stalk-like crystals, especially in caves.

In one instance in the district bituminous material is found associated with the quicksilver. This will be referred to when the deposit in question is described. Fluorspar has also been found.

VEIN MATERIAL.

Among the materials, the brecciated limestones and clays are of great importance, and will be discussed in connection with descriptions of veins in which they occur.

THIN SECTIONS OF MERCURY MINERALS.

A number of thin sections of mercury minerals have been studied under the microscope. The associations are always very similar, the only exception being the chalcedonic slides from Section 100. Here the cinnabar occurs as granules in narrow bands in chalcedonic materials.

In all other slides studied the cinnabar is associated with calcite, being crystallized in direct contact with it. The cinnabar itself usually shows no crystal faces, but are crystalline aggregates. Microscopically, however, many beautiful crystals were examined.

THE ORE DEPOSITS.

The mining operations that have been carried on in the Terlingua district have been practically all on the surface. The ore has been found along certain lines that bear definite relations to the structure of the rocks, and in masses that seem to have no visible definite relationship to the rocks or to other deposits. There are distinctly defined calcite veins that contain large quantities of quicksilver ore, while contiguous parallel veins of precisely the same general character may not carry a trace. Masses of brecciated limestone and iron-stained clay material may carry large quantities of cinnabar or may be completely devoid of it. The position of the deposits is influenced by the system of faults already mentioned.

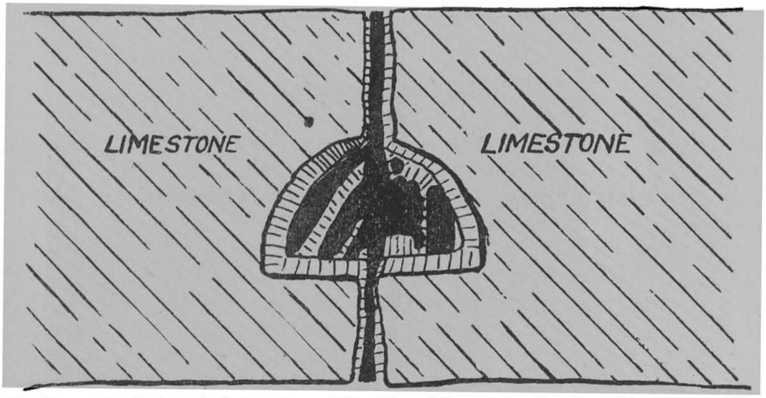
The deposits in the neighborhood of Terlingua postoffice which include the workings of the Marfa and Mariposa Company, the Terlingua Mining Company, the Colquitt-Tigner Company, and numerous small prospects belonging to various companies or individuals, are all in the limestones of the Upper Cretaceous, between the upper members of the Edwards limestone and the base of the Del Rio clays. Although the Buda limestone and the Del Rio clay are present in many localities within the neighborhood, in no case have they been known to contain deposits of quicksilver. The greatest number of the deposits will be seen to be in the Fort Worth limestone, which formation is the present surface of the faulted block referred to elsewhere as the Terlingua uplift.

Mention has been made of the parallel system of northwest and southeast faults, whose trends are from north 50 east to north 30 east. In two instances veins approximately parallel to these courses have been quicksilver bearing, but nearly all the ore has been and is being obtained from fissure veins whose direction is approximately normal to these directions. In close proximity to local disturbances caused by the injection of volcanic material, as at California Hill and Clay mountain, the direction of the veins is variable, and in some instances veins that are parallel at some points of their courses run into each other. However, without considering the local variations it may be stated that the approximate directions of most of the quicksilver bearing veins is northeast to southwest.

The veins are the results of the filling of the fissures caused by the disturbance of the rocks. It is unnecessary to give various types of veins encountered in the broad subject of ore deposits, but an attempt will be made to describe only such kinds as exist in the field under discussion.

FORMS OF DEPOSIT.

In a discussion of the form of the deposits carrying quicksilver ore it must be borne in mind that they are the results of conditions similar to those present in a large proportion of all metaliferous deposits. The fissures and spaces formed by dynamic forces were filled by depositions from ore bearing solutions that contained, among other things, mercury. Had these solutions not been of a certain chemical and physical nature



Section of a Lateral Extension of the Excelsior Vein, Section 38, Block G12.

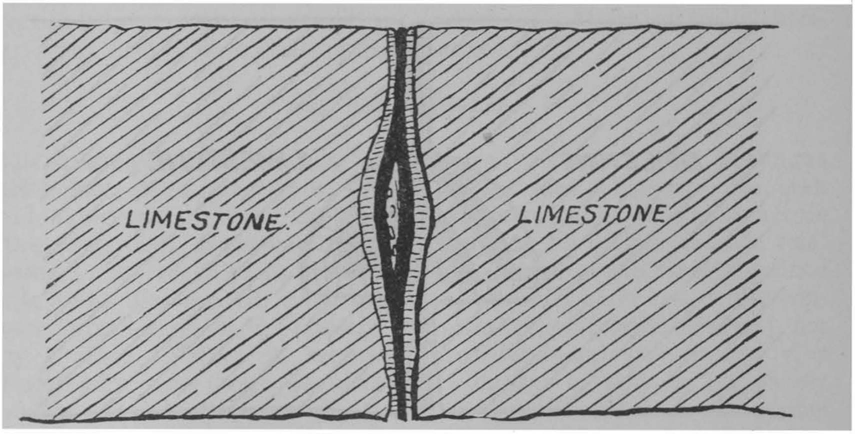
they could not have held the mercury in solution, and had not the conditions been changed, these solutions would not have deposited their burdens.

The deposits, as seen at present, exhibit the effects of the forces, and it is our purpose to state what these effects are.

As explained elsewhere, the facilities for observation have been limited to what is practically the surface. In many instances, however, the surface characteristics are sufficient to allow an intelligent estimate of the conditions below the surface.

FISSURE VEINS.

There are several types of deposit carrying the quicksilver ore in the Terlingua district. The most usual one is the fissure vein filled with calcite gangue carrying cinnabar and the iron oxides. These fissures are of variable width and linear extension, but taken altogether are the most persistent of all the forms of deposit. The veins of this type are in two systems, having courses at right angles to each other. The northeast-southwest veins are the most productive of quicksilver, those normal to this series rarely carrying even a trace of the metal. In most cases the fissure is practically vertical, although slight dips have been observed. This type of vein is most common in the parts of the district most remote from the volcanic disturbances. A typical example is the Excelsior vein, the property of the Colquitt-Tigner Company on Section 38, Block G12. The vein is a distinct well filled fissure varying in width from 8 inches to 3 feet. It has been opened for a distance of several hundred feet along its course, northeast and southwest, and has been sunk on to a depth of over 80 feet in one place. Near the west end of the present workings it has been displaced by a lateral thrust of about 30 feet. The surface of the ground here is represented by the thinnest bedded division of the Fort Worth limestone, the strata being from 1½ to 3 feet in thickness with the layers of marly material between the harder portions. In the lower part of the workings, where the limestone is thick bedded and solid, the ore bearing vein is confined to narrow limits, often a few inches only, but where the fissure traverses the



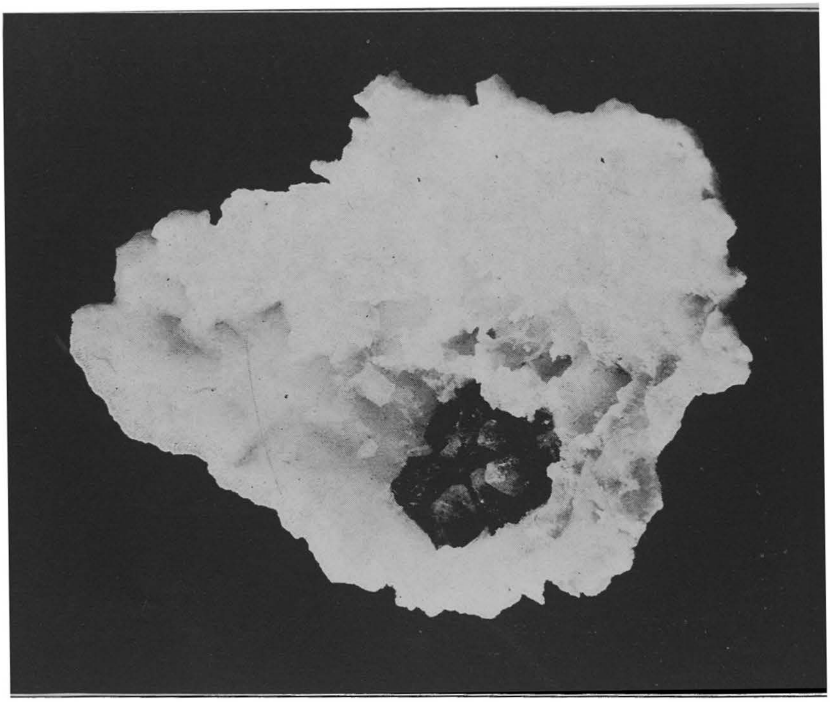
Section of ordinary Fissure Vein

thin-bedded portions mentioned, the vein material extends laterally into the bedding planes several feet.

The filling of the vein is largely calcite. Usually a distinct banding arrangement is visible, the bands differing in color, size of crystals, and amount of iron and cinnabar present. Generally in the calcite veins the cinnabar is in crystalline aggregates, but amorphous masses are sometimes present in connection with the crystalline variety. Vuggs frequently occur in this type of vein. A common variety is made up of an exterior shell of limonitic material with an interior lining of calcite crystals, generally of the dog-tooth spar variety. The crystals of spar are thinly coated with small crystals of cinnabar, causing the appearance of solid crystals of cinnabar. In no cases has the cinnabar been found actually crystallized within the calcite, but the calcite crystals are often filled with iron colored material.

From the Excelsior vein masses of almost pure cinnabar weighing several hundred pounds have been taken. The veins are by no means uniformly rich. Often the ore bearing streak may diminish to a thread and spread out several feet. The cinnabar is generally near the center

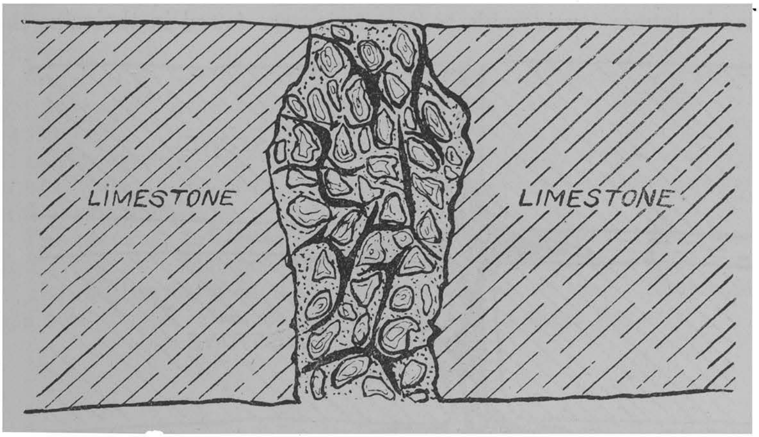
CALIFORNIA HILL FROM THE EAST.



CRYSTALS OF ARAGONITE IN CALCITE.

of the vein, but stringers extend not only through the calcite to the walls of the veins, but sometimes for short distances into the country rock.

The iron associated with the calcite and cinnabar in the fissure veins is always in the form of the oxides, when the wall rocks are the Lower Cretaceous series. In no instance was undecomposed pyrite found in veins in these formations when cinnabar was present. Veins in the Del Rio clay often carry considerable quantities of pyrite, but no cinnabar is present, nor does a careful analysis of the masses of pyrite reveal the presence of the metal. The oxides are both limonite and hematite, crystalline and amorphous. They are often accompanied by oxides of manganese. The fillings of the true fissures are generally confined to these materials. Sometimes, however, masses of clay are encountered in the vein. The clay often contains finely divided native mercury, but more often it is quite barren of the metal.



Section of Brecciated Vein.

SHEAR VEINS.

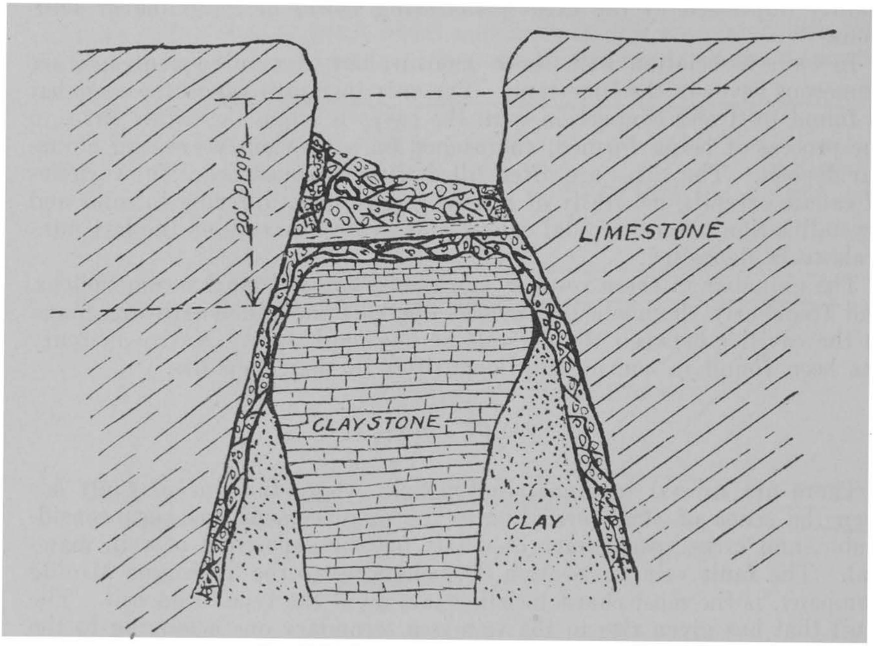
In the veins just discussed, of which the Excelsior is a type, there has been practically no displacement. The strata on opposite sides of the vein occupy corresponding positions. A very common type of the fissure vein is the variety in which there has been movement, attrition and stress along the fissure that have resulted in movement accompanied by brecciation. In a great number of instances in the Terlingua district slickensides have been observed whose appearance indicates that the movement had been almost horizontal, with little or no vertical displacement. A number of the fissures, however, showed a combination of the two movements. The least common type of the brecciated or shear vein is the one in which the displacement is vertical without a horizontal thrust. In fact, it is reasonable to suppose that the horizontal movement produces a greater shearing effect upon the limestones than do the vertical thrusts.

In width these brecciated veins vary from 2 to 10 feet, and the walls are not nearly so well defined and distinct as in the ordinary fissure. The material between the walls is in great measure broken frag-

The stratified filling of the space between the walls does not carry cinnabar in this vein. The same character of material is found in several other veins in the field, but the material itself is always barren. It is quite common, however, to find ore between this material and the walls.

IRREGULAR DEPOSITS.

From the point of view of ore contents, perhaps the most productive of all the classes of deposits in the Terlingua district are the irregular deposits that have taken place in fissures and spaces caused by various combinations of forces, the resultant effects of which have been apparently detached ore pockets, stock-werken, chambers, impregnations, reticulated veins and so forth. The most conspicuous example of this class



Fault Vein on Section 39, Block G12.

of deposits are seen in the working just west of the Marfa and Mariposa Company. The space between the hill and the fault to the west is almost filled with surface workings, in nearly all of which is cinnabar. The ore occurs in chutes between limestone, or clay walls, in calcite veins, in clay, in stringers in the solid lime rock, and in pockets that have no apparent connection with a fissure system. The zone of fracture seems to have been the passageway of rich ore-bearing solutions, whose burdens were deposited in whatever space was available. A curious feature, however, is the fact that in the overlying Del Rio shales and in the phonolite of the hills, the cinnabar is lacking.

The cinnabar is found in clay deposits that have been formed by the washing of the triturated vein material into basins in the limestone. In connection with the cinnabar in these resident clays are considerable quantities of gypsum. Pieces of charcoal have also been found.

The pockets of cinnabar found in such associations are sometimes very large; instances have occurred in the field where several tons of almost pure mineral have been taken out. These pockets may be taken out so that not a sign is left to indicate that ore has been present.

CHALCEDONY VEINS.

Among the variations from the ordinary type of deposit with calcite and iron fillings may be noted a series of veins exposed in the workings of Mr. Lowe on Section 100, Block G12. These deposits are a mile northwest of Black Mesa. Here there is an extremely limited amount of calcite, the vein filling being chalcedony, flint, iron and manganese. The limestone has been silicified extensively. The fissures are not so well defined as to wall rock as are the calcite veins, but are of considerable width, though the ore-bearing portions are narrow. The cinnabar occurs in minute stringers or threads in an extremely hard chalcedonic gangue, with which is associated large quantities of limonite and hematite, with the oxides of manganese.

The neighborhood of Black Mesa contains many of the so-called iron "blow-outs," most of which contain traces of cinnabar. So far, however, only small quantities of ore have been discovered and its association is not favorable for mining and sorting. The deposits are unique, however, on account of the gangue material associated with the cinnabar. The origin of the gangue material can be referred only to the former presence of hot alkaline springs which held in solution the silica and mercury.

ARAGONITE VEINS.

West of Terlingua postoffice in Sections 44, 45 and 48, numerous veins have been discovered carrying more or less cinnabar. The veins are characterized by a decrease in the quantity of calcite, aragonite being the chief vein material. Fissure veins are not so common as bedded veins in this portion of the district. The prospects opened up have shown some good ore, though little development has taken plaçe.

DEPOSITS OF THE UPPER CRETACEOUS.

Cutting the thin-bedded shale, slates, clays, and limestones of the Eagle Ford formation of the Upper Cretaceous ore numerous fissures carrying calcite, clay, iron oxides, iron sulphide, gypsum, cinnabar and native mercury. The character of the rocks covered by the fissures is such as to cause variations in the width, course and dip of the veins. The wall rocks are rarely well defined, the vein material penetrating them often for considerable distances. The veins often, too, pinch out altogether and then suddenly reappear.

Only one of these veins has been exposed to any considerable extent. McKinney and Parker have opened a vein in such material and have taken out a considerable quantity of good ore. In these workings the vein structure is sometimes entirely invisible, the ore being carried apparently along a zone in the stratified rocks. The characteristic ore from these workings is found in a black lime shale which dips at a high angle. The shale has seemed to be in a measure the channel for the ore solutions. Cinnabar of a dark reddish brown color, with which is associated much pyrite occurs in considerable quantities and it carries a little gold, $2.40 per ton. Associated with the shale are zones of calcite, which also carry cinnabar and native mercury. The shale is rich in carbonaceous and bituminous matter, which has interfered considerably when the ore was heated in retorts. Some oil has been obtained from the retorts.

Northeast of the property of McKinney and Parker are numerous openings showing the presence of cinnabar, but development has not been sufficient to enable one to discuss their nature fully.

In the neighborhood of the McKinney and Parker workings are two small andesitic outbreaks, which undoubtedly exerted an influence on the formation of the deposits.

DEPOSITS IN RHYOLITE.

East of Terlingua creek on Section 216, Block G4 are prospects showing cinnabar in an association slightly different from the ordinary types. The rocks involved are the thin-bedded sediments of the Eagle Ford formation, including limestone, shale, clays and marls, all of which are capped by a flow of rhyolitic lava. In the limestone underlying the lava, in the clays underlying the limestone, and in the lava itself are numerous veinlets of cinnabar often unassociated with any other mineral. The discovery of these deposits has only recently taken place, and up to the present no distinct vein has been discovered. The presence of the veinlets in the rocks, however, would indicate that an ore channel as yet undiscovered has been connected with them. The cinnabar, which is generally crystalline, is of a dark color and is unaccompanied by native mercury. In the clay shales considerable marcasite is present. The limestone immediately underlying the lava cap has been metamorphosed but still contains considerable quantities of bituminous matter. The rhyolite is badly shattered and decomposed. The cinnabar in it occupies minute spaces from which some of the material forming the rhyolite has been dissolved and removed.

CHAPTER IV.

Mining and Reduction.

METHODS OF MINING.

As stated elsewhere the methods of mining employed in the Terlingua district have been up to the present of rather a simple and crude character. The mining machinery in use is confined to picks, shovels, drills and sledges. Windlasses are used in the shafts, few of which are over 20 feet in depth; and in the deepest shaft in the field, about 80 feet (August, 1902) the material was hoisted to the surface in rawhide buckets upon the backs of the Mexican miners, who climb the notched poles or chicken-ladders with great agility.

The location of the vein is generally determined by trial workings of surface material in a horn spoon. The heaviness of the cinnabar makes its separation from the calcareous and ferruginous materials of the vein quite easy, and the presence of cinnabar can be detected when only a small amount is present.

The calcite veins are almost indistinguishable on the weathered surfaces of the limestone, as the calcite takes the same tint as the crumbling rock. The veins containing considerable quantities of iron, however, are in evidence on account of the rusty color imparted to the material. In the Terlingua district there are many of these iron veins whose course may be traced for considerable distances by means of the distinct rusty outcrops.

After cinnabar has been found in a vein its course is traced by shallow pits along it, from which washings are taken. The veins are generally quite narrow, often less than 1 foot. But whatever the width, the usual custom is to excavate a pit from 3 to 8 feet in width along the course. Portions of the excavated material showing cinnabar are thrown into separate piles, according to the apparent richness. In the open cut works along the veins one object has been the opening up of the ore to sight. In view of the irregularity of the deposits, the liability of the ore to disappear from a vein, this method has been a most useful one to empoly.

The companies operating in the field have so far been satisfied to take the ore where it is closest to the surface. It is questionable whether the ore near the surface would be easier to mine than ore in depth, but at least it is "there." The deposits are assumed to continue in depth, but no important attempts have yet been made to prove it.

In addition to the open cut method of following the vein, the ore is obtained by the method of drifting along the course of the vein from the shallow shafts. Tunnelling has been carried on in a few instances where the topography has been favorable, but a very large proportion of the ore has been obtained from workings open to daylight.

The deposits differ greatly in the ease with which they may be worked. A large proportion of the calcite veins carrying cinnabar are narrow, which entails the removal of some of the wall rock. Generally these limestone walls are hard and compact and require considerable powder to break.

In the brecciated veins and the veins with clay filling, the vein material generally has a sufficient width to make the removal of the walls unnecessary.

The hardest material in the field to mine is the ore that occurs in the chalcedonic gangue. The cinnabar occurs as thin plates and stringers in masses of silica of flint-like appearance. The accompanying vein materials, however, are fortunately generally quite soft.

The veins traversing the thin-bedded foundations of the Upper Cretaceous, as the deposits at McKinney and Parker's, are accompanied by calcareous clay and shales, and are as a rule easily mined.

The ore at the prospects east of Terlingua creek belonging to Mr. Study, occurs in stringers in a decomposed volcanic rock. This material is soft and easily worked.

HANDLING THE ORE.

After being taken from the openings the ore is sorted by hand and as much as possible of the waste is discarded. The fine material, which is often quite abundant, is tested by means of washings in the horn spoon. The ore is put into piles according to richness, and is transported to the furnaces by means of ore wagons drawn by mules. The haul is often over a mile in length and the roads are bad. The installation of trams or cables would seem to be desirable in some of the workings.

The ore wagons discharge their loads either on the floors of the crushers or in piles from which it is taken by wheel barrows to the crushers.

THE PLANTS.

The crushers used at both reduction works are of the Blake type of jaw crusher. They have capacities greater than the furnaces, and it is necessary to run only a few hours of the day. The crushers are operated by Fairbanks-Morse gasoline engines, which are more convenient than the steam engines on account of lack of water and fuel. The crushed material is carried by belt conveyers to the ore bins. From these bins, which are above the level of the top of the furnaces, the ore is taken through chutes into cars of a cubic yard capacity. The ore put into the furnace at the top descends through the arrangement described elsewhere, and is burned. The spent ore is drawn from the base of the furnace into iron cars and dumped into the cañons.

TREATMENT OF THE ORE.

The extraction of mercury from cinnabar, which is practically the only ore of importance of this metal, is effected either by oxidation of the sulphur by the air, and the volatilization of the liberated metal, or by the use of reagents, with which the sulphur enters into combination, while the liberated mercury is distilled and condensed. In the former case, which applies to the continuous furnaces in operation in the Terlingua district, the operation may be expressed simply by the equation:

$$HgS+O_2=SO_2+Hg.$$

When lime is present with the cinnabar and heat is applied, the reactions may be represented by this equation:

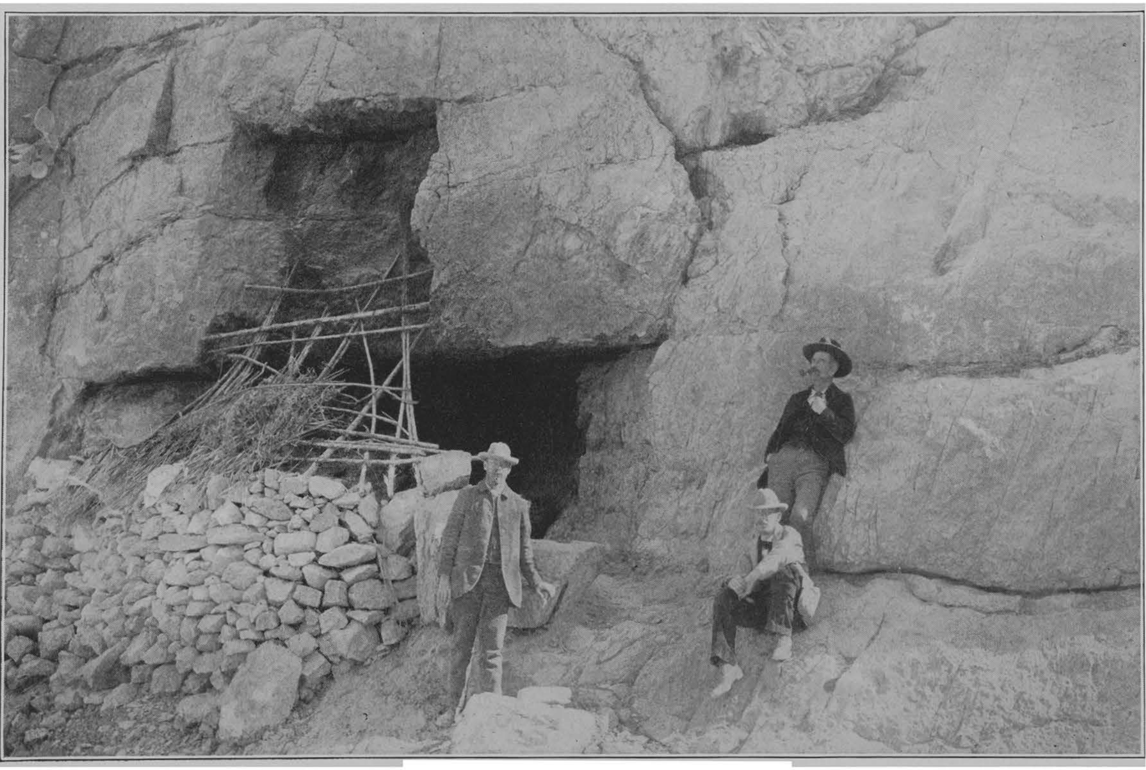
$$(HgS)_4+(CaO)_4=(CaS)_3+Hg_4+CaSO_4.$$

This is the reaction that takes place in the retort.

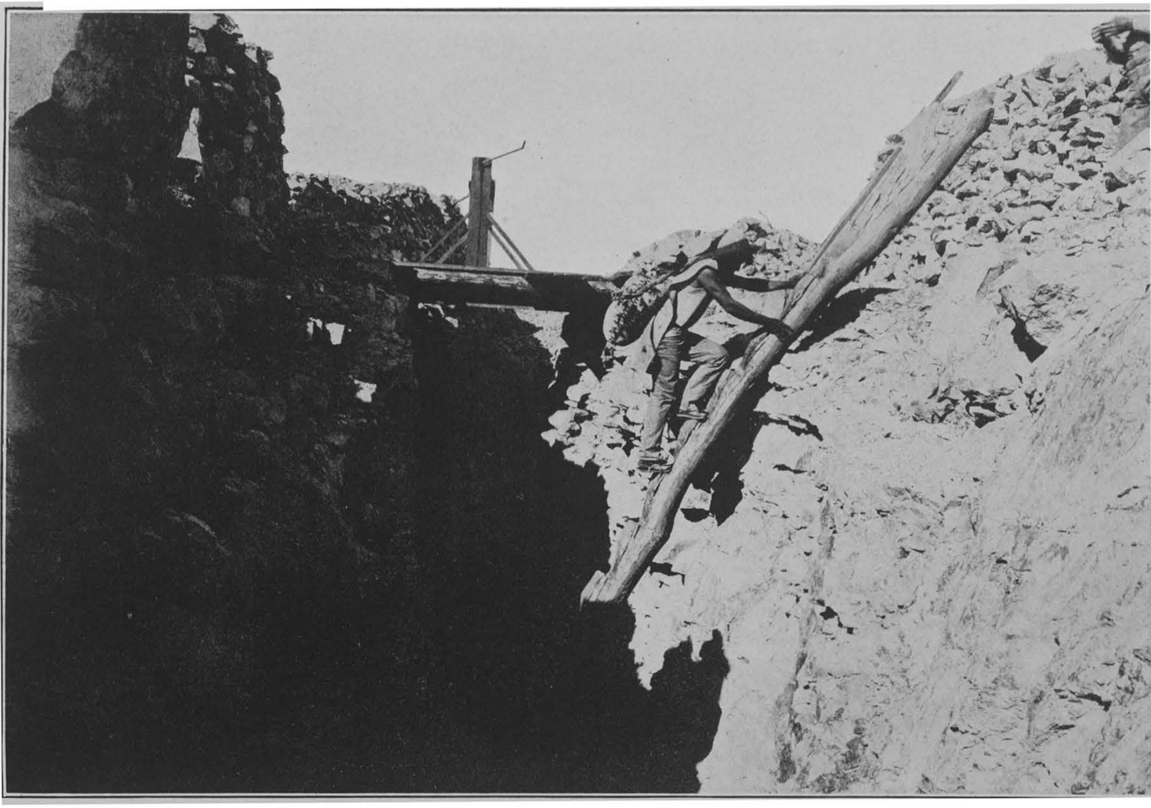
RETORTS.

Although at present all the quicksilver produced in the Terlingua district is from continuous furnaces, when the field was first opened a considerable quantity of metal was produced from retorts, about ten of which were operated in various parts of the district.

The largest amount of quicksilver from retorts was produced by Lindheim & Dewees, whose plant was situated on Terlingua creek, about ten miles from the mines, as it was found easier to haul the rich ore to the wood and water than vice versa. Here several hundred flasks of quicksilver are said to have been produced, the ore consumed having been very rich cinnabar. In fact only very rich ore can be treated by the retort method, as the waste is very great. The retorts were found to be very short-lived, and burned out rapidly in spite of precautions taken to prevent it.



BOTTOM OF CROESUS CAÑON.



MEXICAN CLIMBING LADDER WITH SACK OF ORE.

McKinney and Parker produced considerable quicksilver from retorts at their mine; and Messrs. Bell, Gaughran and Coltrin produced a few flasks. While it is impossible to get exact figures, it is probable that about one thousand flasks were produced by this means.

THE FURNACES.

The furnaces used in quicksilver reduction in the Terlingua district all belong to the same class of continuous furnaces. They are slight modifications of the Scott-Hüttner furnaces used so extensively in California, and were built by Mr. Robt. Scott himself.

Three furnaces have been built, one of 40-ton normal ore capacity belonging to the Terlingua Mining Company, and two 10-ton furnaces belonging to the Marfa and Mariposa Company. The latter company have the condensers arranged in battery form, allowing the last four condensers of the eight to be used by both furnaces.

Prof. S. B. Christy has given a very complete description of these types of furnaces in his "Quicksilver Reduction at New Almaden," published in the *Transactions of the American Institute of Mining Engineers,* Vol. XIII, page 547. He gives many plans, sections, and dimensional measurements, which are highly interesting and important, but which would be useless to repeat here, as his discussion has covered the ground quite thoroughly.

The California, or rather New Almaden, practice of separating the ore into classes of various sizes and richness, as "tierras," "granzas," and "granzita," is not employed at Terlingua. The ore has a large proportion of fine material in it as it is mined, and the large lumps are as a rule crushed to about 1 to 2 inches, which would place it in a class between the "granzita" and "tierras" of California. The average of from 1 to 3 per cent. corresponds also to the value of the California ore of the class mentioned.

It may be remarked in passing, that the operators in the Terlingua field have been most fortunate in having the benefits of the results of long years of experimental work in quicksilver reduction. The furnaces employed have been evolved with much labor and expense, and it has been possible for the Texas miners to attain good results without passing through the long and expensive experimental stages. Of course, some slight modifications have been made from the California types, but for the most part they are quite unimportant. The scarceness of water has made it necessary to cool the condensers by air entirely, and has also been prohibitive of allowing the fines of ore to be made into "adobes."

In general the idea of the furnace is as follows: It utilizes series of inclined shelves placed in the opposite walls of narrow vertical shafts. These shelves retard the descent of the columns of fine ore. The shelves are inclined at an angle of 45 degrees to the walls, and each shelf is, therefore, perpendicular to the next lower one in the opposite wall.

Thus, ore fed into the furnace from the hopper at the top runs from one shelf to the other until it reaches the bottom, when it forms a continuous zig-zag column of ore from the top to the discharging apparatus. The end walls of the ore chambers are pierced with rectangular openings, allowing the flames to pass from the fire place through the ore on the shelves to the vapor chamber, and from there they pass into the condensers. Arches over the fire-box and across the vapor chambers cause the air and fumes to make four passages across the furnace before going into the condensers. This, of course, renders the furnace more economical of fuel and less liable to waste on account of the high temperature of the gases, as they go into the condensers, than a single passage of the flames would. The arches cause the air that enters the fire place to be drawn through roasted ore, thus heating the air and absorbing quicksilver vapor from the ore. Then the hot products of combustion pass through the partly roasted ore, raising its temperature, and then pass back and forth through the comparatively cold ore of the upper part of the chamber. This method has the advantage of heating the cold ore and cooling the hot fumes, which when they leave the furnaces for the condensers are only slightly above the boiling point of quicksilver.

The device at the base of the ore chamber for discharging the burnt ore is easily operated, and is arranged in such a manner as to allow the same quantity of unburnt ore to enter the furnace from the hopper at the top as is drawn from the bottom. The frequency and quantity of discharge and charge of the burnt ore is, of course, regulated by the capacity of the furnace.

In the 40-ton furnace the ore remains in the ore chamber somewhat over thirty hours.

In speaking of the Scott and Hüttner furnaces, Prof. Christy says, in the article already referred to: "They utilize the principle of opposed currents; they allow the ore to cool in the furnace itself before it is drawn, thus utilizing the heat and removing the last traces of quicksilver. The stirring of the ore is entirely automatic and very thorough; for each time the ore passes from one shelf to the next opposite one the ore which lay at the bottom of the layer, next to the surface of the upper shelf, and out of contact with the air, is on the next lower shelf brought to the surface where it is directly exposed to oxidation. This operation is repeated 20 to 30 times according to the number of shelves in the chamber. The feeding and discharge of the ore and waste is affected with a minimum of labor and without the use of power. Add to this that the whole operation is under perfect control and may be modified at any time, according to the nature of the ore, without stopping the regular operation of the furnace, and also that the repairs are slight and inexpensive, and we have a very good showing for the furnace."

CONDENSERS.

As pointed out by Prof. Christy in his article on "Quicksilver Condensation at New Almaden" (*Transactions of the American Institute of Mining Engineers,* Vol. XIV, page 206) the complete condensation of mercurial fumes in a large way presents numerous practical difficulties. The quicksilver fumes from the roasting furnace are often less than 1 per cent. by volume of the various products of combustion with which they are mixed, and the proportion by weight is also small. This, of course, makes it necessary that a very large volume of gas must be cooled to allow the quicksilver to be liquefied, and the whole mass must be kept moving to furnish draft for the furnaces. This draught makes it easy for considerable quantities of very finely divided mercury to be carried off through the smoke stack. The liquid mercury, on account of its high gravity, is liable to find its way into walls and foundations. The sulphuric acid formed by oxidation of the sulphurous acid in the fumes attacks the material from which the condensers are made.

The principles upon which the most successful condensers have been constructed are as follows:

1. Cooling of the furnace fumes by contact with large radiating surfaces exposed to the air.
2. Sedimentation of the condensed quicksilver particles in enlarged chambers where the velocity of the gaseous mixture is reduced.
3. Constant exposure to friction surfaces, cross-currents, and vortex motions to remove the globules of metal by calling into play the force of adhesion.

The condensers in use have been built on these principles. The material is brick, which is acted on less than any other available material for furnace construction.

The condensing systems of these furnaces consist of brick chambers connected to the furnace by pipes. These chambers are tall, narrow structures, divided into compartments having openings about 2 feet square at the top and bottom to allow cleaning. These openings are closed by iron plates held in position by wooden bars across the front, and are made tight by setting with clay and ashes. The floors of the condensers, which are very carefully constructed of cement, slope each way from the center to the sides, so as to allow the condensed mercury and acid water to be delivered to the side, and to facilitate the handling of the soot. Along each side of the condensers are inclined gutters of brick, about 18 inches deep and 9 inches wide, which carry the condensed mercury and acid water to receiving vats.

The condensers are built with air spaces between them to facilitate the cooling of the fumes. No water backs are used on the Terlingua plants, the cooling being entirely due to radiation. The fumes after leaving the furnace pass into the first condenser near the top, pass down the compartment on that side, thence through an opening in the partition wall into the other compartment of the condenser, up which they pass to be discharged into the next of the series of condensers through iron pipes. These connecting pipes have valves to regulate the draft.

The plant of the Terlingua Mining Company has all the condensers, eight in number, arranged in a straight row. The first condensers are used as a dust chamber, and little or no mercury is obtained from it, on account of its high temperature. Most of the mercury is obtained from the second and third chambers, while scarcely any is obtained from the last three. Between the eighth condenser and the smoke stack an arrangement has been devised for increasing the draught through the condensers by means of a fire, thus pulling the gases along the line of communication between the condensers.

The plant at the works of the Marfa and Mariposa Company are arranged somewhat differently, as is seen in the diagram. The two condensers next to each of the two furnaces in this case yield a great proportion of the mercury, with very little after the fourth or the first in the battery used by the two furnaces in common.

PRODUCT OF CONDENSERS.

The condensers when cleaned yield other materials besides the quicksilver, which are to be taken into account. Ore dust is invariably present in the first condenser; in fact, as before mentioned, this condenser at the Terlingua Mining Company's mill yields little quicksilver and is used for a dust chamber. Considerable quantities of ore dust beyond the first condenser furnishes evidence that the furnace is not working properly.

The whole series of condensers have the interiors coated with soot, which covers walls, roofs and floors. This soot is due to the unburned carbon and hydrocarbons from the wood used as fuel.

Large quantities of quicksilver are mechanically intermixed with this soot, the greater proportion of which is removed by mechanical treatment. As to the percentage of quicksilver that the soot carries, it depends entirely on the position of the condenser with regard to the furnace. The soot contains in the cool condensers large quantities of acid water, while in the hot ones it contains little or none. In the condensers remote from the furnace the soot is intimately mixed with acid water and becomes a black slime carrying very small quantities of finely divided quicksilver.

The methods used in cleaning the condensers is as follows: The iron manhole at the base of the condensers is opened and the operator removes the soot that has accumulated along the lower walls and the floor, by means of a long hoe, made of square pieces of thick rubber, supported by iron plates, the handle being attached at the center. The rubber is used to prevent wear on the floors and walls. The soot is drawn down the inclined floor to the manhole and is there kneaded back and forth with the hoe. This causes the quicksilver particles to cohere and run out of the soot into the channels leading to the receiving vats. Before reaching the vats, however, the quicksilver runs through settling boxes of wood and is filtered through charcoal. From the bottom of the settling boxes it flows through a goose neck into the vats. By this means it has been freed from particles of soot and acid water and is "dry" and ready for bottling. The operations from the gutter to the vat are of course conducted by gravity.

When the soot at the manhole has been worked until most of the quicksilver has been removed, the residue is taken from the floor and treated outside. When the soot on the floor is too dry to readily yield up its quicksilver, water is added; when too wet, dry ashes are added. From long experience the workmen who are in charge of the "clean-ups" have come to recognize the exact amount of moisture necessary for the easiest working off the soot. The method of handling the hoe in stirring and kneading the soot is also of great importance.

After the soot has been taken from the floor of the condensers it is placed on an inclined sheet iron box, under which a fire has been built. Here water or ashes are added from time to time as is necessary, and practically the same operation as was used on the floor of the condenser is gone through. The quicksilver that is freed from the soot goes down to the lower end and runs into a sheet-iron bucket. The residue of the soot from this method of working is charged back into the furnace. The waste from the soot, therefore, is significant, as it goes through the furnace time and again.

The operation of cleaning the condensers is carried on without interrupting the working of the furnace. Only one manhole at a time is opened and the inward draught is sufficient to prevent the escape of fumes. At Terlingua, once a week is the usual frequency for cleaning the condensers that carry most of the quicksilver, though in some cases they are cleaned oftener. The last condensers of the series are very seldom cleaned.

At stated intervals the condensers are cleaned out in a more complete and thorough manner than is the case when the ordinary cleanings take place. The furnace is shut down and all the walls, floors and roofs of the various condensers scraped and cleaned. Considerable quantities of metal are obtained from these clean-ups.

After one of these clean-ups, or when a new furnace is started, a considerable time elapses before the walls are coated and the condensers produce.

As to the percentage of loss that takes place in the furnace and condensing operations, no definite data can be given. The custom in the Terlingua field is for the furnace to make its own assay, i. e., the percentage of the ore is calculated from the number of tons heated and from the amount of quicksilver produced. Systematic sampling and assaying of the ore before roasting is not practiced, and for this reason no definite knowledge of the efficiency of the furnace can be obtained.

Prof. Christy has pointed out that the sources of loss may be classified as follows:

1. Furnace Loss: Loss in residues from roasting furnaces.
2. Condenser Loss: Loss of vapor or liquid in condenser structure.
3. Chimney Loss: Loss of quicksilver in escaping gases, either in the form of vapor or as quicksilver "mist."

Of these sources of loss, the first two are unimportant, as it is possible to prevent them by proper construction and skillful management, and close watchfulness of the residue dump, and the draft. The escape of gases through the chimney, therefore, must account for the most serious losses.

After the quicksilver has passed through the filtering box into the vats it is ready for bottling. The standard unit of the quicksilver trade is the "flask," which contains 76½ pounds of the metal. These flasks are cylindrical wrought iron vessels, fourteen inches long and five inches in diameter. The stopper consists of a threaded plug which screws firmly into the top of the flask. Before filling the empty flask is set upright into a frame and fastened firmly. The mercury, which has been weighed in an iron bucket with a spout, is then poured in. The screw plug is then inserted, and is tightened by means of a long lever. In this way leakage is prevented. The flasks are now stacked to wait shipment.

CHAPTER V.

Mode of Occurrence of Ores—Future Possibilities of Field.

MODE OF OCCURRENCE.

Although at present there are no active hot springs in the vicinity of Terlingua district, all indications point to the fact that at one time they were extremely active. Actual sinter deposits are not common, but it must be borne in mind that erosion has taken place and superficial evidences would be destroyed. The great development of vein materials which could only be deposited from solution is ample proof of their existence. The extensive cave system of a later period is also important as indicating conditions with which was associated underground water.

The discussion of details of theories explaining the presence of the mercury would be out of place here. The theories formulated by Prof. Becker in connection with the California deposits seem to be perfectly applicable here. A summary will be quoted.

In his "Monograph upon the California Quicksilver Deposits" (Monograph XIII, U. S. G. S, p. 473), in summarizing his views upon the solution and precipitation of cinnabar and other ores, Dr. Becker says:

"The waters of Steamboat Springs are now depositing gold, probably in the metallic state; sulphides of arsenic, antimony and mercury; sulphides or sulphosalts of silver, lead, copper and zinc, iron oxide and possibly also iron sulphides, and manganese, nickel and cobalt compounds, with a variety of earthy minerals. The sulphides, which are most abundant in the deposits, are found in solution in the water itself, while the remaining metallic compounds occur in deposits from springs now active or which have been active within a few years. * * * A sulphur bank ore deposition is still in progress. The waters of the two localities are closely analogous. Both contain sodium carbonate, sodium chloride, sulphur in one or more forms, and borax as principal constituents, and both are extremely hot. * * * In attempting to determine in what form the ores enumerated can be held in solution in such waters, it is manifestly expedient to begin by studying the simplest possible solutions of the sulphides, especially cinnabar. * * *

It was found that, provided a small quantity of sodic hydrate be present, one molecule of mercuric sulphide unites with two molecules of sodic sulphide to form freely soluble sulphosalt, and that an excess of sodic hydrate is without effect upon the solubility. Even when sodic hydrate is entirely absent, mercuric sulphide is freely soluble in aqueous solutions of sodic sulphides, though the contrary has repeatedly been asserted; but either one molecule of mercuric sulphide then unites with three of sodic sulphide instead of two, or a mixture of sulphosalts nearly corresponding to this compound is formed.

"Sodic sulphydrate when cold is absolutely without effect upon mercuric sulphide, but when the mixture is heated in a water bath, the sulphydrate is decomposed and sodic sulphide is formed; it unites with mercuric sulphide in the proportion of four molecules of the former to one of the latter. A perfectly limpid solution results. The same compound is produced when mixtures of sodic sulphide and sodic sulphydride are brought in contact with mercuric sulphide. The presence of sodic carbonates demonstrates the solubility of mercuric sulphide, but does not prevent solution. Ammonium carbonate completely prevents solution at temperatures below boiling point, but not at 145° C.

"These facts suffice to lead to important conclusions with reference to spring waters, such as those mentioned above. When natural sodic carbonate is treated with sulphydric acid at ordinary temperatures, sodic sulphydrate forms. At temperatures approaching the boiling point, it is probable that a certain quantity of sodic sulphide is also produced. At these higher temperatures either of these sulphur compounds will dissolve cinnabar and the presence of sodic carbonates will not prevent solution. These conclusions are amply verified by direct experiments.

"Mercuric sulphide may be wholly or partially precipitated from solutions in the sulphosalts in many ways: by excess of sulphydric or other acids, by borax and other mineral salts, by cooling (especially in the presence of ammonia), and by dilution. In the last case, a certain quantity of metallic quicksilver, as well as mercuric sulphide, is formed, and this is very probably one of the methods by which native quicksilver has been produced in nature. * * *

"Natural solutions of sodic carbonates and sulphides, which are common components of hot spring waters, are thus capable of dissolving at least five of the principal metals, as well as sulphur, arsenic and antimony. Combinations of these elements form a large part of minerals found in mines. There is little or no doubt that the cinnabar of the California deposits has been dissolved and precipitated as indicated above, * * * but I by no means assert that natural deposits of cinnabar have never been produced in any other way."

FUTURE POSSIBILITIES.

The natural questions that come up in the discussion of the Terlingua district are whether or not there will be in the future a larger development in the present area known to be quicksilver bearing, and whether this area is likely to be extended and other workable deposits discovered.

The first question can be answered in the affirmative, there being reason to suppose that the deposits continue in depth. It is not at all certain that the veins, where distinct veins have been exploited, will be quicksilver bearing indefinitely, but there seems to be no very good reason for believing that they should not carry ore in some quantity through the whole Cretaceous series, which, in the district, is certainly more than 1500 feet thick.

The only tenable theory as to the original source of the quicksilver is that it comes from "below." This is indefinite, it is true, but is more reasonable than theories referring the contents of the veins to origins within the country rock traversed by the veins, or to the theory that the quicksilver solutions came from "above," depositing their contents in pre-existing fissures.

If the veins continue to be ore bearing in depths, which is at present an assumption that has not been proved, as only exploitation could prove such points, it is very possible that they will not carry such high percentages of ore as they at present carry at the surface. The great mines in California were extremely rich at surface, but as they became deeper they became poorer. In the nature of things, there are certain conditions of heat and pressure that would be most favorable for the deposition of the minerals from solution. These conditions may exist in zones that are comparatively near the surface, but it is not reasonable to suppose that these conditions prevail only at the surface. The conditions for deposition may become less and less favorable as the deposit increases, for the reason that the heat and pressure being greater as the depth increases, the minerals in solution would not be freed from the solution.

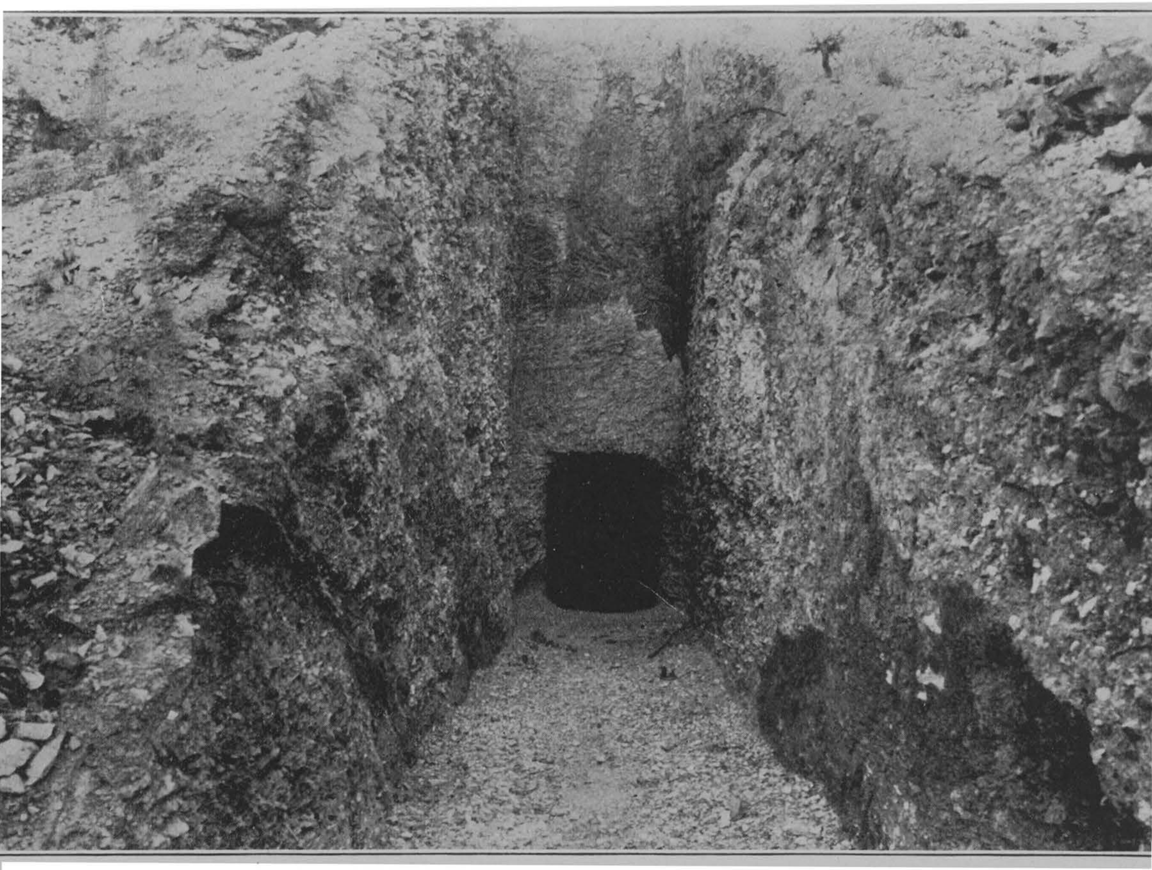
The original source of the mercury is unknown. The eruptives that pierce the sediments are of a comparatively late age. Analyses of these rocks have failed to show the presence of quicksilver. The sediments underlying the Cretaceous in this district are not visible in any outcrops for long distances, and at present it cannot be stated whether they rest on the Paleozoics that are seen in the mountain ranges one hundred and twenty-five miles to the north; or whether the Triassic or Jurassic here takes a place in the geological section. Only a detailed study of the geology of the country as a whole can determine these points.

The future development of the district as now constituted will depend to a considerable extent on the finding of ore in depth. While a considerable quantity of ore has been taken from the surface, and while it is true that a great deal of surface territory known to be quicksilver bearing has not been touched, to become a great factor in the quicksilver production of the world, the ores must be proven to be something more than surface deposits. It must not be understood that it is necessary for profitable mining that the ore be continuous in depth. On the contrary, the easily worked surface deposits furnish cheap ore, and it is on this very account that so little exploitation in depth has been made. The operators view the question in this light: "Here we have ore on the surface. We can take it out with pick and shovel. Why sink shafts, run levels, install hoists, etc., etc." They are not disposed to take chances along the line of development when they have surface ore in sight. This is unfortunate for the geologist who endeavors to make a study of the form and character of the deposits, nor is it entirely certain that the methods in vogue are the most profitable for the miner. However, it is only a question of time when on some of the properties at least systematic explorations in depth will be carried on. As mentioned elsewhere, a few efforts in this line have been made.

As to the question of the extension of the field, we are still in the realm of speculation. The field has grown from its original small area, and it is certainly possible for it to grow very much more. Ore has been found in the various subdivisions of the Cretaceous, Upper and Lower It is found in the massive Caprina limestone and the thin-bedded marls and Eagle Ford shales. Such formations, with accompanying volcanoes of the same types found in connection with the quicksilver, occur north, south, east and west of the present district. Cinnabar has been found on the Mexican side of the river at a distance of less than twenty miles from the Terlingua mines, in identically the same surroundings. The territory intervening is of the same geological formation. The Grand Cañon mountains are made up of the same identical strata, and have the same volcanic flows cutting through them. The flat between these mountains and the dome-like uplift of the Cretaceous rocks of Terlingua shows exposures of the same sediments that carry the quicksilver at McKinney & Parker's mine. The country east of Fresno Cañon and south of Alamo de Cæsario (McGuirk's ranch) present the same characteristics. From Terlingua creek to the foothills of the Chisos mountains the same series of sediments and associated eruptives that carry the quicksilver at Study's mine are present.

It is thus readily seen that in so far as territory favorable to the occurrence of the metal is concerned there is a great extent of it. Part of it has been prospected very thoroughly, though other parts have been somewhat neglected, notably, the Grand Cañon mountain. Quicksilver has been found in small quantities in many places, in considerable quantities in a few places. The development of the future will depend largely on the degree of success attained by the mines that are at present in operation.

LINDHEIM & DEWEES' FORTY-FIVE-TON FURNACE.



OPEN CUT IN ORE, STUDY'S MINE, SECTION 216, BLOCK G4.

CHAPTER VI.

COMPANIES OPERATING.

At the present time (August, 1902) there is one company in the field actually producing quicksilver, the Marfa and Mariposa Company. The furnace of the Terlingua Mining Company was closed down in May. In addition to these, the Colquitt-Tigner Mining Company and McKinney & Parker are mining ore, but are not treating it. The former company, however, has a furnace in the course of construction, and will begin producing in a few months. In addition to these, there are a number of companies and individuals who own ore-bearing property, which for various reasons are not being operated.

Geologically considered, the properties may be all discussed together, as the types of the veins, etc., are confined to no particular properties except where noted in other discussions. The claim map accompanying this report will be useful in showing the geographical position of the various holdings.

A very brief discussion will be given of the companies at present operating without attempting to go into detail in regard to the ore deposits or their various properties.

The Marfa and Mariposa Company, from whose property a large proportion of the total output of the field has been produced, are the owners of a considerable number of claims located upon State land, and in addition hold several sections of patented land. The ore mined by the company has been taken from patented Sections 41 and 59, and from claims located on Sections 58, 40, 38, 60 and 70 of Block G12. At present most of their operations are confined to the property close to the reduction works. The property southwest of California Hill has yielded and is still yielding a considerable percentage of the ore produced. The richest deposits that have been yet found in the field are located here, the ground worked being the northwest part of private Section 59. The development consists of numerous open cuts, shallow shafts and drifts along the vein just beneath the surface. Near the contact between the sediments and the igneous rock of California Hill prospect shafts are being sunk, and a tunnel is being run into the body of the hill on the contact between the Del Rio clay and the eruptive. However, serious attempts to discover the depths of the deposits have not as yet been made. After the surface ore has been exhausted other methods of mining will have to be adopted.

The deposits in the locality just mentioned are quite irregular. The proximity to the igneous outflow has caused a local disturbance that has in a great measure caused the irregularity. The deposits are not continuous, but are apparently the result of the deposition of mineral from an ore bearing solution that permeated the irregularly fractured and brecciated zone between the volcanic outbreak and the northwest and southeast fault to the west.

Within this area the cinnabar is not accompanied by as large a proportion of calcite as is commonly encountered in the district. The iron bearing solutions have been much in evidence, and practically the whole of the limestones is permeated and colored.

East of California Hill considerable ore has been taken out, but at present the workings are idle, although the deposits are by no means exhausted.

The company owns several claims on Section 39, from which most of the ore treated in the furnace before the acquisition of the California property was taken. The distance from the furnace is the chief disadvantage of this locality. It is probable that in the future a furnace will be built to handle this ore.

The company owns two 10-ton Scott furnaces, which are kept in constant operation. An average of one hundred miners are upon its pay rolls.

THE TERLINGUA MINING COMPANY.

This company, formerly Lindheim & Dewees, are the owners of a number of claims on State Sections 40, 60 and 70, in addition to owning outright a number of patented sections, among which are 33 and 39.

They have mined considerable ore from extensive cuts on Section 40 and 39. The veins are generally distinct fissure types on Section 40, while considerable ore has been obtained from the fault vein on 39, which is described elsewhere.

The company owns a 40-ton Scott furnace, which was started in operation near the beginning of the year. Litigation has prevented the continual operation of the properties of this company. This is reported to have been settled and the development will continue rapidly. The furnace was started in January, and closed down in May.

THE COLQUITT-TIGNER COMPANY.

This company owns claims on Section 38 and 44, and in addition controls a number of other properties. Most of the ore mined has been taken from the Excelsior vein, which is described elsewhere. A ten-ton furnace is being built.

M'KINNEY & PARKER.

This company holds several claims on Section 70. A considerable quantity of ore has been taken from workings on the property, whose characteristics have been described elsewhere. This company has retorted a small quantity of quicksilver, and has some high class ore on its dumps. No furnace has been built.

Many individuals and companies own claims that have been worked only sufficiently to comply with the mining law.

LABOR CONDITIONS, ETC.

The labor of mining in the Terlingua district is performed almost entirely by Mexicans. The prices paid per day of ten hours' work ranges from $1.00 to $1.50, according to the experience of the miner. It is doubtful whether this class of labor is economical even at the low wage rates. The Mexican miner, when closely superintended, can do a great amount of labor, but left to his own resources he displays a surprising lack of intelligence. If they can be worked in compact bodies and can be under the eye of a white boss at all times they are fairly efficient, but scattered in small groups along an extensive open cut they can do a surprisingly small amount of work. As handlers of powder they are not efficient. However, they are indispensable on account of their hardiness, being able to stand the very high temperature of the summer months.

The foremen and mill hands are almost invariably white men, whose wages range from \$2.50 to \$5.00 per day.

The operating expenses of plants in the Terlingua district are increased by the scarcity of wood and water. The methods of procuring water have been described elsewhere. Wood, which is hauled from distances of twenty-five miles, is sold at from \$4.50 to \$6.00 per cord, but these prices are rising all the time as the wood gets scarcer. Up to the present time little timber has been needed in the mines. A few poles have been brought from the Chisos mountains for the construction of ladders and windlasses.

The haulage item is quite serious in the district. The most advantageous arrangement is to give contracts to the Mexican teamsters for delivering the ore at the furnaces from the various workings.

The buildings of the furnace plants are expensive on account of the difficulty in getting the irons and timbers for construction. Fortunately, excellent brick is made from clay deposits in the neighborhood by Mr. Harry Dryden.

THE PRODUCTION.

The Terlingua district, as a producer of quicksilver, has had to encounter many drawbacks, which have resulted in keeping the production down to a much lower figure than would have been the case had the district been situated under more normal conditions.

Among the causes that have held back production may be mentioned the remoteness of the district from adequate transportation facilities, adverse climatic and labor conditions, lack of capital on the part of a number of the owners of good properties, and uncertainties in respect to laws governing the occupation of mineral bearing land, with which was coupled litigation respecting land lines and titles.

The latter causes have been, in a great measure, removed by process of law, and it is entirely probable that development will be carried on steadily in the future, and an increased yearly output may be looked for for some years to come.

Except the production from the various retorts in the field, the whole output of quicksilver up to the end of 1901 is to be credited to one 10-ton Scott furnace, operated by the Marfa and Mariposa Company In 1901 this single furnace produced 2932 flasks of quicksilver. During the current year there were in operation two 10-ton Scott furnaces belonging to the Marfa and Mariposa Company, and one 40-ton Scott furnace belonging to the Terlingua Mining Company. In addition to these furnaces there is another 10-ton furnace of the same type being constructed for the Colquitt-Tigner Mining Company, which will be a producer before the end of the year.

In some cases in the field valuable property is lying idle from lack of means to work it properly. In still other cases holders of land having paying quantities of ore upon it are refraining from development for various reasons. Owners of detached claims whose production would not warrant the construction of furnaces are at present unable to realize upon their resources. It is possible that this difficulty will in the future be obviated by the construction of custom furnaces for the purchase and treatment of ore. Should the district develop toward the east, a custom furnace in the neighborhood of Terlingua creek would be in an advantageous position for the treatment of ore. In addition, such a location would be easier of access from the railroad station at Marathon or Alpine than are the present producing mines and furnaces.

Although some ore was mined in the district in 1899, it was not until the following year that any considerable quantity of metal was produced. So far as can be ascertained from operators in the field the production in 1899 was confined to fourteen flasks. In 1900 the production was increased considerably. A number of retorts were in operation during that year, and in August the first furnace was put into operation. The production for this year was 754 flasks, exclusive of the quicksilver produced by Lindheim & Dewees in their retorts on Terlingua creek. The exact amount of their production is not available, but it was several hundred flasks.

In 1901 the total production was 2932 flasks, giving a total production for the field up to the end of that year of 3700 flasks exclusive of that of Lindheim & Dewees.

No figures are available for the determination of the total amount of ore treated in order to furnish this output. The ore treated by the retort method carried a much higher per cent. of mercury than the furnace ore. The per cent. of the retorted ore was reported as ranging from 8 to 25. In the case of the ore treated by furnace, the average percentage of mercury in the ore treated will hardly exceed 3 per cent. It is claimed by operators in the field that one-half per cent. ore can be profitably treated in the furnace.

A small quantity of the quicksilver from the Terlingua district has been sold at the Shafter silver mines, but practically all the product goes to New York and to San Francisco. The prices have fluctuated slightly, but have been fairly steady. The limit prices have been $48.00 to $44.00 per flask f. o. b., the average price obtained being $45.00. The value of the quicksilver produced in the field up to the end of 1901 was $267,500.

The output from the Terlingua district furnished about 10 per cent. of the total production for the United States, which in 1901 amounted to 29,727 flasks, of which California contributed 26,720 flasks, Texas 2,932, and Oregon 75. The aggregate value of the total production for the year was $1,382,305.

The demand for quicksilver, while quite steady, is comparatively small. This is due, in great measure, to its restricted use. A very large proportion of all the metal produced is employed in amalgamation of ores and in the manufacture of vermillion. A small amount is consumed in medicine and arts, so the price of it is regulated by the demand for it in the two instances cited above, and as a result fluctuation in the price of silver affects the price of quicksilver. At present, however, the demand for it is quite strong, a considerable quantity being exported to Mexico for purposes of amalgamation and to China for making pigment.

Unless, therefore, commercial conditions change materially, or more extensive and more easily worked deposits are opened up, the price of the metal will remain comparatively stable, and production even under such disadvantages as exist in the Terlingua field will be profitable.

CHAPTER VII.

Quicksilver—Occurrence, Production, Prices, Etc.

BY

WM. B. PHILLIPS.

In the Mineral Resources of the United States, 1892, United States Geological Survey, Dr. George F. Becker has a condensed paper on Quicksilver Ore Deposits. In this he gives a table showing the minerals associated with a number of quicksilver deposits in various parts of the world, arranged so as to set forth the prevalent, abundant. occasional and rare minerals that have been found. He quotes from 28 localities, and the minerals observed, up to that time, were bitumen, free sulphur, stibnite (sulphide of antimony), and other antimonial ores, realgar (sulphide of arsenic), mispickel (sulphide of arsenic and iron), gold, silver ores, galena (sulphide of lead), chalcopyrite (sulphide of iron and copper), zincblende (sulphide of zinc), pyrite and marcasite (sulphides of iron), millerite (sulphide of nickel), quartz, calcspar, gypsum, fluorspar, barite (heavy-spar, sulphate of barium), and borax. Of these the pyrite and marcasite are the prevailing minerals, occurring in 20 of the 28 localities; then come quartz and calcspar. Bitumen is abundant in 8 localities. Gypsum is abundant in 3 localities only, so that it is relatively unimportant.

The presence of bitumen and bituminous compounds (they are abundant in 8, met with now and then in 5, and rare in one instance, altogether in 14 cases out of 28), is a noteworthy fact.

In order to present the matter in a convenient form a table has been prepared somewhat on the lines of Dr. Becker's table, but with no attempt to arrange the associated minerals in the order of relative frequency of occurrence. The minerals mentioned have been found in quicksilver deposits in different localities. To the table is also added information respecting the geological formation and the associated rocks.

No attempt has been made to give this data for any but the districts of commercial importance, the quicksilver deposits of Canada, Germany, China, Japan, Australasia, Peru, United States of Colombia, etc., not coming within the scope of this discussion.

Table showing the Geological Formation, Associated Rocks and Minerals in productive quicksilver deposits:

Country.	Geological Formation.	Associated Rocks.	Associated Minerals.
Austria.	Upper Triassic.	Dolomite. Sandstone. Schists. Slates.	Quartz; feldspar; mica; hornblende; calcite; pyrite; epsomite; copperas; gypsum; idrialite; graphite; anthracite; bitumen; calcium phosphate; fluorspar; marcasite; barite; calomel.
Italy.	Eocene. (Tertiary) Cretaceous.	Various lavas, such as trachyte, andesite, rhyolite, &c. Marly limestones and clays.	Bitumen; free sulphur; realgar; pyrite; marcasite; quartz; calcspar; gypsum.
Mexico.	Cretaceous? Jurassic?	Porphyry. Limestone. Slates.	Silver and antimony ores; gypsum; calcspar; fluorspar; free sulphur; quartz; calomel.
Russia.	Carboniferous.	Sandstone. Quartzite.	Stibnite; pyrite; calcspar.
Spain.	Upper Silurian and Devonian.	Slates. Limestones. Sandstones. Schists. Diorite.	Calcspar; pyrite; galena; quartz; barite; arsenical pyrite.
United States.	Early Cretaceous or late Jurassic. In the Tertiary, and in Quarternary Alluvium.	Granitic detritus. Limestones. Shales. Serpentine. Sandstones. Slates. Rhyolite, andesite, basalt, &c.	Calcspar; pyrite: barite; quartz; gypsum; borax; stibnite; free sulphur; mispickel; chalcopyrite; bitumen; marcasite; millerite; gold and silver ores; fluorspar; copiapite; knoxvillite; redingtonite; calomel; terlinguaite.

The minerals of natural occurrence which have been found to contain quicksilver are given in the following list (Dana, A System of Mineralogy, 1900). As remarked under the heading cinnabar this is the only important source of the metal.

Amalgam: A compound of mercury and silver containing from 27.5 to 86.3 per cent. of silver, the remainder being mercury. Color, silver-white. In isometric crystals; also massive in plates, coatings and grains. Hardness 3 to 3.5. Gravity 13.75 to 14.1. Gives silvery luster when rubbed on copper.

Ammiolite: A compound of mercury containing antimony and copper, with a little sulphur and iron. The content of mercury varies from 19.8 to 23.6 per cent. It is an earthy powder of a deep red, or scarlet color. It may be antimonate of copper mixed with cinnabar. Rare.

Aragotite: A volatile hydrocarbon related to idrialite. Rare.

Arquerite: A species of amalgam.

Barcenite: Related to ammiolite, but contains no copper. May be an antimonate of mercury. Rare.

Calomel: Chloride of mercury, containing, when pure, 15.1 per cent. of chlorine and 84.9 per cent. of mercury. Tetragonal crystals. Color, white, yellowish gray, yellowish white and brown. Hardness 1 to 2. Gravity 6.48. Translucent. Fracture conchoidal. Sectile. Not abundant enough to be regarded as a source of mercury. Native corrosive sublimate (the other chloride of mercury) is reported to have been found in the desert of Atacama, Chile.

Cinnabar: Sulphide of mercury; when pure, contains 13.8 per cent. of sulphur and 86.2 per cent. of mercury. Has an uneven fracture. Hardness (talc=1) 2 to 2.5. Crystallizes in rhombohedrons and trapezehedrons; also massive. Color, cochineal red, sometimes brownish-red and dull gray. Gravity (water=1) 8 to 8.2. Chief source of quicksilver.

Cinnabarite: Same as cinnabar.

Coccinite: Iodide of mercury. Color, fine red to yellow, sometimes green and greenish gray. In needle-like crystals; also massive. Rare.

Coloradoite: Telluride of mercury. Color, iron black to gray. Hardness, 3. Gravity, 8.62. Has metallic luster. Massive, and granular. Rare.

Guadalcazarite: A sulphide of mercury containing zinc and selenium. Rare.

Idrialite: A hydrocarbon containing mercury. White when pure, but in nature always colored blackish or brownish by bituminous substances. Rare.

Kongsbergite: A species of amalgam.

Lehrbachite: A compound of mercury with selenium and lead. Color, lead gray, steel gray and iron black. Massive, and granular. Brittle. Gravity, 7.80. Rare.

Leviglianite: A species of guadalcazarite containing iron.

Livingstonite: A double sulphide of mercury and antimony, containing from 14 to 22.61 per cent. of mercury. Metallic luster. Color, bright lead gray. In slender prismatic crystals, and resembles stibnite. Hardness, 2. Gravity, 4.81. Rare.

Mercury: Native. Sometimes contains a little silver. Rare.

Metacinnabarite: Same composition as cinnabar, but occurs in isometric crystals; also massive and amorphous. Luster metallic. Color, grayish black. Streak black. Brittle. Hardness, 3. Gravity, 7.81. Not abundant enough to be important as a source of quicksilver.

Onofrite: A sulphide of mercury containing selenium. Rare.

Tennantite: A variety of tetrahedrite, containing a double sulphide of mercury and copper with sulphide of antimony. It may contain also iron, zinc, silver, lead, cobalt and bismuth. Rare.

Terlinguaite: An oxy-chloride of mercury from Terlingua, Brewster county, Texas, of yellowish color. Complete analyses and examinations not yet made.

Tiemannite: A compound of mercury and selenium; may contain, also, a little cadmium and lead. Luster metallic. Color, steel-gray to blackish lead gray. Streak nearly black. Brittle. Hardness, 2.5. Gravity, 8.19. Rare.

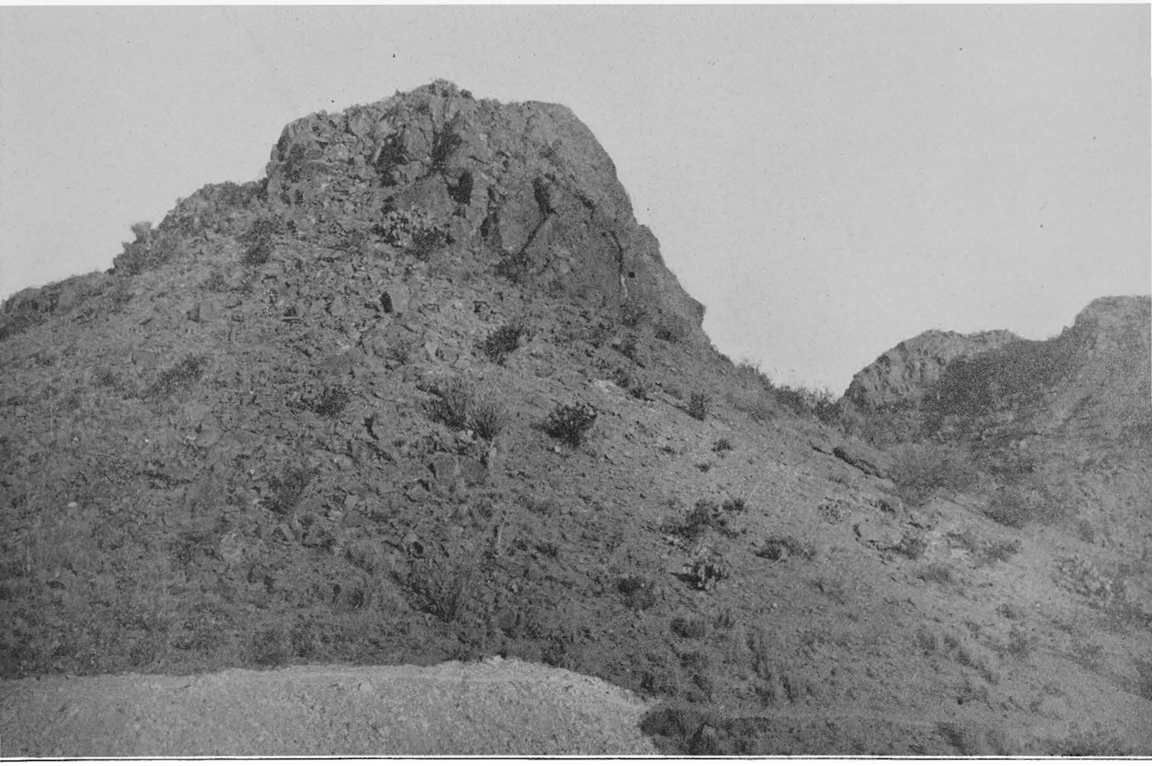
Tocornalite: Silver iodide containing mercury, the percentage rising to 3.90. Color, pale yellow. Granular and massive. Compare coccinite. Rare.

Sulphate of mercury has been observed as a product from the quicksilver furnaces at Idria, but is not of native origin.

The production of quicksilver in the United States in 1900 was 28,317 flasks of 76½ pounds each, or a total of 21,662,505 pounds. By far the greater amount of this was yielded by the California mines, Texas and Oregon alone of all the other States contributing to the output. Quicksilver mining began in California prior to 1850, but reliable statistics are available only since that year. In 1850 the production was 7,723 flasks, all credited to New Almaden. From 1850 to 1861, inclusive, the New Almaden mines, in Santa Clara county, alone produced 250,720 flasks, an average of 20,893 flasks per annum. Up to the close of 1899 these mines produced 972,231 flasks, an average of 19,444 flasks a year for 50 years, and they are still heavy producers. The Redington mines, California, began shipping in 1862, and yielded to the close of 1899, 108,648 flasks, an average of 2,859 flasks a year for 38 years. The New Idria mines, California, produced, between 1858 and 1866, 17,455 flasks, and are credited with 150,600 flasks to the close of 1899, an average of 3,502 flasks a year for 43 years. In 1873 the Great Western began shipping, and is credited with 89,691 flasks, an average of 3,322 flasks a year for 27 years. The Sulphur Bank began shipping in 1874 and is credited with 93,274 flasks, an average of 3,886 flasks a year for 24 years, no returns having been made for 1897 and 1898. The Napa Consolidated began shipping in 1876 and is credited with 114,317 flasks, an average of 4,763 flasks a year for 24 years. These are the principal producing mines in California, although the Great Eastern is credited with 30,409 flasks, the Mirabel with 28,806 flasks, the Aetna with 26,912 flasks, the Altoona with 16,077 flasks, the Abbott with 5,903 flasks and various other mines with 194,154 flasks, to the close of 1899. The total production of all the California mines from 1850 to 1899, inclusive, is 1,831,022 flasks, and of this amount the New Almaden mines have produced nearly one-half.

The maximum production in any one year by any one mine was 47,194 flasks, by the New Almaden in 1865. To the close of 1899 all of the quicksilver produced in the United States was from California, with the exception of 65 flasks from Oregon in 1887 and 1000 flasks from Texas in 1899.

The production and value of quicksilver in the United States from 1880 to 1900, inclusive, is given in the following table, taken from "The Mineral Resources of the United States," U. S. Geol. Survey, 1901:



PEAK OF ERUPTIVE ROCK (ANDESITE) NEAR CALIFORNIA HILL.

LOOKING EAST FROM CALIFORNIA HILL.

Production and Value of Quicksilver in the United States, 1880-1900. Flasks of 76½ pounds:

Year.	Production.	Value. Per flask.	Value. Total.
1880	59,926	$ 30.00	$ 1,797,780
1881	60,851	29.00	1,764,679
1882	52,732	28.20	1,487,042
1883	46,725	26.83	1,253,632
1884	31,913	29.34	936,327
1885	32,073	24.85	797,189
1886	29,981	35.35	1,060,000
1887	33,825	42.25	1,429,000
1888	33,250	42.50	1,413,125
1889	26,484	44.95	1,190,500
1890	22,926	52.50	1,203,615
1891	22,904	49.61	1,036,386
1892	27,993	44.49	1,245,689
1893	30,164	36.75	1,108,527
1894	30,416	30.71	934,000
1895	36,104	37.03	1,337,131
1896	30,765	34.63	1,075,449
1897	26,648	37.28	993,445
1898	31,092	38.23	1,188,627
1899	30,454	47.70	1,452,745
1900	28,317	46.00	1,302,586
Total and average	725,523	37 46	$ 27,175,900

Imports and Exports of Quicksilver into and from the United States, 1880-1900:

Year.	Imports. (Duty 7 cts. per pound.) Quantity pounds.	Imports. Value.	Exports. Quantity flasks of 76½ lbs. net.	Exports. Value.
1880	116,700	$ 48,463	37,210	$ 1,119,952
1881	138,517	57,733	35,107	1,025,299
1882	597,898	233,057	33,875	988,454
1883	1,552,738	593,367	30,072	808,353
1884	136,615	44,035	7,370	199,685
1885	257,659	90,416	6,802	209,753
1886	629,888	249,411	8,091	204,956
1887	419,934	171,431	11,394	441,112
1888	132,850	56,997	10,684	406,899
1889	341,514	162,064	5,111	213,717
1890	802,871	445,807	2,069	93,192
1891	123,966	61,355	3,714	145,502
1892	96,318	40,133	3,518	133,626
1893	41,772	17,400	16,631	542,410
1894	7	6	14,408	397,528
1895	15,001	7,008	15,542	482,085
1896	305	118	19,944	618,437
1897	45,539	20,147	13,173	394,549
1898	81	51	12,830	440,587
1899	131	83	16,517	609,586
1900	2,616	1,051	10,172	425,8[illegible]2
Total, or Flasks	5,452,920 71,541	$ 2,200,133	324,234	$ 9,881,494

From 1880 to and including 1885 the returns are for the fiscal year ending with June; from 1885 on for the year ending with December.

During this period of 21 years the production was 725,523 flasks and the imports 71,541 flasks, a total supply of 797,064 flasks. The exports were 324,234 flasks, so that, disregarding stocks on hand, the total domestic consumption was 472,830 flasks, an average of 22,515 flasks a year. This is about what the country at large will consume in amalgamation, for pigments, medicinal preparations and other like purposes. Dividing this period into 3 groups of 7 years each, we find that from 1880 to and including 1886 the average annual domestic consumption was 28,644 flasks; from 1887 to and including 1893 it was 24,289 flasks; and from 1894 to and including 1900 it was 16,084 flasks.

By far the greater amount of quicksilver used is in the amalgamation of gold and silver ores, so that a decreasing domestic consumption would mean that the mills are using less quicksilver, or that a considerable portion of the gold and silver formerly won by amalgamation is now obtained through smelting processes. Perhaps both these causes are operative, but we can not pursue the matter further at this time.

According to *The Mineral Industry,* 1892-1901, the average price per flask of quicksilver in San Francisco and London was as follows:

Average Price of Quicksilver per flask in San Francisco and London, 1850-1900:

Year.	San Francisco.	London.			Year.	San Francisco.	London.		
		£.	s.	d.			£.	s.	d.
1850........	$ 99.45	14	1	3	1876......	$ 44.00	9	18	9
1851........	66.93	13	0	0	1877......	37.30	8	6	3
1852........	58.32	10	8	9	1878......	32.90	6	16	3
1853........	55.45	8	8	9	1879......	29.85	7	6	3
1854........	55.45	7	10	0	1880......	30.35	6	17	3
1855........	53.55	6	13	9	1881......	28.97	6	6	8
1856........	51.65	6	10	0	1882......	28.43	5	19	0
1857........	49.73	6	10	0	1883......	26.83	5	7	3
1858........	47.82	7	7	6	1884......	29.34	5	10	4
1859........	63.13	7	2	6	1885......	30.52	5	17	4
1860........	53.55	7	0	0	1886......	35.44	6	9	7
1861........	42.10	7	0	0	1887......	38.73	7	8	2
1862........	36.35	7	0	0	1888......	40.11	8	1	11
1863........	42.07	7	0	0	1889......	45.71	8	11	0
1864........	45.90	8	5	0	1890......	52.01	9	5	0
1865........	45.90	7	18	9	1891......	43.29	8	0	2
1866........	51.63	7	8	9	1892......	38.80	6	14	0
1867........	45.90	6	18	0	1893......	40.42			
1868........	45.90	6	16	6	1894......	34.39			
1869........	45.90	6	16	6	1895......	39.06			
1870........	57.37	8	8	0	1896......	36.86			
1871........	63.10	10	10	0	1897......	38.56			
1872........	65.98	11	10	0	1898......	39.37			
1873........	80.32	16	0	0	1899......	44.29			
1874........	105.18	22	10	0	1900......	50.10			
1875........	84.15	16	18	9					

NOTE—In 1893 London prices ranged from £ 11 5 s. to £ 5 1 s. 6 d. In 1894 from £ 10 7 s. 6 d. to £ 5 10 s. In 1895 from £ 9 to £ 5 10 s. In 1896 from £ 7 7 s. 6 d. to £ 6 7 s. 6 d. In 1897 from £ 8 to £ 6 16 s. 3 d. In 1898 from £ 7 15 s. to £ 7. In 1899 from £ 9 12 s. 6 d. to £ 7 15 s. In 1900 from £ 9 12 s. 6 d. to £ 9 2 s. 6 d.

In 1898 the San Francisco price ranged from \$43.00 to \$39.00 for domestic and from \$38.00 to \$35.00 for export; in 1899 from \$52.00 to \$42.00 for domestic and from \$47.00 to \$37.50 for export; in 1900 from \$52.00 to \$48.00 for domestic and from \$47.50 to \$45.00 for export.

The price of quicksilver for exportation is always lower than for metal intended for domestic use, the tariff being subtracted from the domestic quotations.

From the table it will be seen that since the year 1894 to the close of 1900 the average price of quicksilver, per flask of 76½ pounds net, has ranged from \$34.39 to \$50.10, domestic. Unless otherwise stated the quotations given are for domestic.

For purposes of comparison the quicksilver production of the various countries, since 1894, is given in the following table, the figures being taken from the volumes of *The Mineral Industry,* the metric ton of 2204 pounds there employed being converted into flasks of 76½ pounds net. The American, Russian and Italian flasks contain this amount, the Mexican flask 75 pounds, and the Spanish flask 76 pounds. *The Mineral Industry* uses, at times, the figures given in the Annual Metal Circular of W. T. Sargant & Sons.

Quicksilver Production of the World, since 1894, in flasks of 76½ pounds net:

Year.	Austria.	Canada.	Italy.	Mexico.	Russia.	Spain.	United States.	Total.
1894	15,010	....	7,433	7,721	5,637	47,624	30,416	113,841
1895	15,413	72	5,733	4,609	12,503	42,754	36,104	119,188
1896	14,971	57	3,802	6,280	17,775	43,589	30,765	117,239
1897	15,326	8	5,511	8,470	17,746	49,783	26,648	123,492
1898	14,125	....	4,984	10,169	10,429	48,717	31,092	119,516
1899	15,442	....	5,906	9,334	10,371	39,095	30,454	110,602
1900	15,845	....	6,338	9,651	9,795	32,007	28,317	101,953

During the 7-year period ending with 1900 there was a decrease of 11,888 flasks in the world's production, shared by Italy, Spain and the United States. Austria gained 835 flasks, Mexico 1,930 flasks, and Russia 4,158 flasks. There was a gain of 6,923 flasks and a loss of 18,811, making a net loss of 11,888 flasks. During this period Italy lost 1,095 flasks, Spain 15,617, and the United States 2,099. The Spanish production has been declining for several years.

A brief description of the quicksilver industry in the several countries will now be given.

AUSTRIA.

The principal mines are at Idria, a town in the western part of Carniola, in the southwestern part of the Empire. Cinnabar was discovered here between 1490 and 1497, and the mines shared with the Almaden mines, in Spain, almost the entire quicksilver trade for four centuries. The ore-bearing rocks are of Upper Triassic age, the sandstones and schists of Carboniferous age that occur above the ore having been placed there by dislocation. The foot wall of the ore-bearing beds is magnesian limestone, with small veins of calcspar and layers of flint. Above this comes a 30-foot bed of what is locally called sandstone, but which R. Meier has shown to be a bedded tuff-like stone consisting of quartz, feldspar, mica and hornblende. Above this lies a bed of soft, bituminous slate which carries the ore.

The hanging-wall of the slate carrying the ore is a bed of dolomite of a thickness of 120 feet, either close-grained, as a conglomerate or as a breccia, and it carries cinnabar in the crevices. Above this is a bed of gray clay slate, 480 feet thick, which sometimes carries native quicksilver on its planes of fracture and bedding, with occasional traces of cinnabar. In it are lens-shaped inclusions of pyrite, containing quicksilver.. In addition to pyrite, the dolomite and the clay slates contain also graphite, anthracite, calcspar, epsomite (sulphate of magnesia), copperas and gypsum.

The content of quicksilver in the ore varies from 0.60 per cent. to 1 per cent, the average being nearer the lower figure. Th coarse handpicked ore, from an inch to 4 inches in size, carries generally 0.35 per cent of metal (7 pounds per ton); the medium sized ore, from ½ inch to 1 inch, 0.50 per cent. (10 pounds per ton), and the fine ore, up to ½ inch size, 0.9 per cent (18 pounds per ton). The finer material is thus seen to carry nearly three times as much metal as the coarse material.

It has been customary at Idria to concentrate the ore from 0.65 per cent. to 0.85 per cent. before sending it to the furnaces.

When the old furnaces, that had been in use for more than 100 years were torn down in 1868 to 1878, there were recovered from the masonry, foundations, etc., 150 tons of quicksilver, equivalent to 4,322 flasks, which had been absorbed during this time. The loss at present may be taken at about 8 per cent., which, with an ore of 1 per cent, would mean that the burned ore would contain 0.125 per cent. of quicksilver.

At Idria the ore-bearing slates do not cary a uniform amount of quicksilver, and pockets of ore are not infrequent. Cinnabar is found also in a limestone conglomerate and in a dolomitic breccia. There are also beds of a dark bituminous sandstone and slate intermixed with dolomite which are ore-bearing. In this latter case when cinnabar is present the sandstones and slates are highly bituminous and generally carry pyrite. Idrialite (a hydrocarbon containing quicksilver) and anthracite are also found.

Four varieties of ore occur. The first is free from bitumen and contains small pieces of dolomite and, invariably, pyrite and native quicksilver. The content of mercury in this variety runs to 67.77 per cent. The second variety has a steel-gray lustre on a fresh surface and is very pure, the content of metal running to 80.81 per cent. It contains cinnabar mixed with bitumen. Idrialite is sometimes found in this variety as a bituminous, earthy mineral of liver color (quecksilberlebererz) Where this is noted the ore is of the third class.

The fourth class is known as coral ore from the occurrence of coral and other fossils, which are found in the slate beds. This coral-ore is remarkable in containing 56 to 57 per cent. of phosphate of lime, and 4 to 5 per cent. of fluorspar. In addition it contains bitumen and a compound of phosphate of lime and iron. In this connection it is interesting to note that corals have been found in association with the Texas cinnabar and that fluorspar is one of the minerals found in the ore-veins. The recent discovery, by the writer, of beds of cream colored limestone, closely resembling sandstone, and dolomitic conglomerates carrying phosphate of lime north of the Terlingua quicksilver district and south of Agua Fria, Brewster county, Texas, would tend to bring the Texas deposits into some correllation with the deposits at Idria. Add to these the further facts that bituminous shales are abundant in the Terlingua district and that pieces of asphalt have been found in the sandstones along Terlingua creek and the correllation becomes closer. Pyrite occurs also in the bituminous shales near Terlingua and is not infrequently associated with the cinnabar.

At Idria native quicksilver has been found near the surface, but not in depth.

In this connection, although the locality is not in Austria, but in the Pfalz, Germany, may be mentioned the occurrence of quicksilver ore in Permian slates, sandstones, flints and conglomerates, through which there have been eruptions of melaphyr and porphyry. The mercury compounds present are native mercury, amalgam, calomel, metacinnabarite, and gray copper ore (mercurial). The following other minerals have also been found: pyrite (sometimes silver-bearing), limonite, hematite, siderite, galena, gray copper ore, chalcopyrite, stibnite, pyrolusite and psilomelane, calcspar, barite, quartz, flint, chalcedony. Especially worthy of mention is the occurrence of asphalt.

A peculiar feature of the deposits near Moschel is that the ore occurs not only in the sandstone, but in the porphyhy as well, a notable instance of an eruptive rock carrying ores of quicksilver. In this connection, compare the occurrence of cinnabar at the Study mine, Sec. 216, Block G4, Brewster county, Texas.

CANADA.

At Kamloop's Lake, east of the Fraser river, British Columbia, cinnabar occurs with calcspar and quartz in zones traversing a gray feldspathic and dolomitic rock. The country rock, through which the ore-bearing zones run, is a dark greenish-black acidic eruptive rock of Tertiary age and contains pyroxene and olivine. It has been called picrite. Through this there are small fisures of dolomitic material carrying cinnabar. The larger fissures carry a rock shading from tufa to rhyolite, containing, at times, disseminated crystals of cinnabar, another instance of the ocurrence of cinnabar in eruptive rock.

It is possible that some of the dark red earth used as a pigment by the former inhabitants of that region, mentioned by the Jesup Archœological Expedition in its recent reports, contains cinnabar, although nothing has been said on this point. The Indians in Brewster county, Texas, used cinnabar as a pigment.

The quicksilver industry in Canada has not yet assumed much commercial importance.

ITALY.

The principal deposits are at Monte Amiata, in Tuscany, and occur in the Tertiary (Eocene). They were worked as far back as 1000-1200 A. D.

Between 1890 and 1897 the Siele works treated 48,353 tons of ore, the content in quicksilver varying from 20 per cent. in 1890 to 1.20 per cent. in 1897. The Monte Amiata works, between 1893 and 1897, treated

73,177 tons of ore, the content in quicksilver varying from 1.90 per cent. to 1 per cent. The average content of the Monte Amiata ore in quicksilver is from 0.30 per cent. to 0.8 per cent., and by the use of the Cermak-Spirek furnaces and condensers ore of 0.30 per cent. can be profitably treated. This represents an ore carrying but 6 pounds of quicksilver per ton of 2,000 pounds, and is probably the lowest limit of economical working. The most complete returns, however, are from the furnaces using an ore of 1.20 per cent. It is stated by Vincente Spirek that a plant costing $30,000 will successfully treat 45 tons of ore of this grade every day, with a loss of 4 to 5 per cent. of metal, after the condensers have become impregnated with the mercurial vapors. The cost of producing a flask of quicksilver, excluding general charges, is placed at $30.

MEXICO.

Near Arichuivo, Chihuahua, there is cinnabar in porphyry. Near Guadalcazar, San Luis Potosi, there is cinnabar in gypsum and limestone, with calcspar and fluorspar, the content of metal varying from 2 to 3.5 per cent. A mile to the east is porphyry and granite. In 1893 the ore carried 4.05 per cent. of quicksilver, and the extraction was 83.56 per cent. In 1894 the ore carried 1.95 per cent. of quicksilver and the extraction fell to 81.87 per cent.

The principal producing mines are near Huitzuco, Guerro, where there are pockets and veins of cinnabar in disturbed and metamorphosed limestones and slates. The ore, which also carries silver and antimony, is found at or near the tops of small hills and occurs as a soft, sandy, claylike filling in crevices that often radiate from a common center. The average content of the ore in quicksilver is about 1.70 per cent., but the extraction is very low, about 50 per cent, although ore of 0.62 per cent. has been worked.

The Nueva Potosi deposits, San Luis Potosi, were worked 25 years ago and have been reopened. The ore carries less than 1 per cent. of quicksilver, but is said to exist in large bodies easily mined. The Montezuma district, in San Luis Potosi, may also be mentioned, especially the Dulces Nombres mines, where ore of 30 to 70 per cent. quicksilver has been found in a ferruginous gangue.

RUSSIA.

The deposits of cinnabar near Nikitovka, Government of Ekaterinoslav, were discovered by A. Minenkov in 1879 and opened in 1886. They occur in a carboniferous sandstone, in folds in the main anticlinal of the Donetz coal basin. The ore is found not only in the sandstone proper, but also in a quartzite, which has been much fractured. The quartzite is the richer material and the ore occurs in its crevices. Stibnite and pyrite are present, as also a bituminous, or other carbonaceous substance, which encloses crystals of cinnabar of imperfect development. The average yield of the ore, between 1888 and 1897, was 0.65 per cent. (13 pounds per ton), the production during this period being 19,192 flasks. The furnaces used are of the Spirek-Schernia design, improved by Auerbach, and it is claimed on what appears to be good authority, that ore of 0.40 per cent (8 pounds per ton) can be profitably treated.

SPAIN.

The quicksilver deposits at the Almaden mines, Ciudad Real, are the most famous in the world, not only on account of the length of time they have been worked (before the Christian era), but also and particularly on account of their extent and richness, and the amount of metal taken from them. They occur in clay slates of upper Silurian and Devonian age, with interstratified beds of limestone and sandstone. The slates themselves seldom contain cinnabar, and when it is found in them it occurs on the bedding planes and in very small veins. The wall rock for the most part is composed of bituminous slates and quartzites, which alternate with schists, fine grained sandstones and limestones. There are two kind of sandstone, white and black, the former being the richer. In the black sandstone the cinnabar is distributed in an irregular manner in particles and as a coating. The white sandstone is sometimes so full of cinnabar that it is difficult to say just where the cementing material begins. The limestone also carries ore and thin veins of calcspar, carrying ore, penetrate the otherwise barren slates.

The most important deposits are those of San Francisco and San Nicholas, where the thickness of the ore-body is about 20 feet. These beds, or veins, are separated from each other sometimes by a soft slate, two or three feet thick, but at a depth of 810 feet they are worked as one, the distance across being 67 feet. The deposits carry a great deal of quartz and the cinnabar is found penetrating this, or else concentrated into pockets. There are cavities containing native quicksilver. Geodes of calcspar occur and in them pyrite and galena. Yellowish-red cinnabar of stalactitic form, and probably of recent origin, has been found at the Concepcion Nueva mine, at Almadenejos. Fragments of diorite (an eruptive rock occurring in the vicinity) have been found in the deposits and LePlay thought that there was an intimate connection between the occurrence of the ore and the existence of the eruptive rock. The controversy over the exact nature of these deposits, whether they are true veins or beds, has never been settled. The wasteful methods of mining and treating the ore, described by C. E. Hawley (*American Journal of Science,* Vol. XLV, Second Series, pp. 9-13), in 1868, have been superseded by modern appliances. The Almaden ores carry from 7 to 8 per cent. of quicksilver, although in the district ore of much smaller content of metal is worked, as, for instance, by El Porvenir Company, which has treated ore of 1.20 per cent. But even allowing that lean ores do occur and are treated, the fact remains that the Almaden deposits are probably the richest now worked, and they have been operated for about 2600 years, the earliest records dating from 700 B. C.

In speaking of these deposits Von Cotta says*: "The uncommon breadth or massiveness of this quicksilver occurrence is very remarkable. It is not very strange to find ores, which occur as frequently in the earth's crust, as those of iron, copper, lead, or zinc, locally aggregated in massive deposits; but in the case of a metal such as mercury and its ores, which relatively occur so rarely, and in so few localities, such a massive aggregation is certainly astonishing."

The minerals associated with the cinnabar at Almaden are calcspar, pyrite, galena, quartz, barite, calomel and arsenical pyrite.

*Treatise on Ore Deposits, Prime's Translation, pp. 400-401.

UNITED STATES.

Quicksilver ores have been mined in California, Oregon and Texas, by far the largest producer being California.

The California deposits have been most carefully studied by Dr. Geo. F. Becker, and the results of his observations were published in Monograph XIII, United States Geological Survey. The Thirteenth Annual Report of the State Mineralogist, 1896, also has much interesting matter, and Arthur Lakes, in *Mines and Minerals,* March and April, 1899, has two good articles on the New Almaden mines, and R. B. Symington, in *The Mineral Industry,* Vol. VII, 1898.

The California deposits occur principally in metamorphosed Mesozoic beds, either of early Cretaceous or late Jurassic age, although there are deposits in the Miocene, and to some extent in alluvium of the Quarternary. Becker calls the deposits "chambered veins," and they occur in zones which have been much fisured and fractured. The early Cretaceous or late Jurassic rocks, which hold the ore, appear to be composed to a great extent of granitic detritus. The volcanic rocks of the vicinity, such as rhyolite, andesite and basalt, are related to the ore-system, and at New Almaden there is a long rhyolite dike near and almost parallel to the general fissure system carrying the ore.

In Colusa county cinnabar occurs in an altered serpentine; in Lake county, in seams in shale near contact with serpentine, as also in hard opaline serpentine and in a greenish-gray sandstone with seams of serpentine. In Napa county, cinnabar occurs in sandstone at a contact of argillite (clay-slate), and in black chalcedony. In Santa Clara county, New Almaden, "the ore occurs in shoots and bunches in a brecciated zone along a contact of serpentine and shale, the vein matter being chiefly serpentine, generally richer near the hanging wall, and becoming poorer in depth as the vein matter becomes harder."*

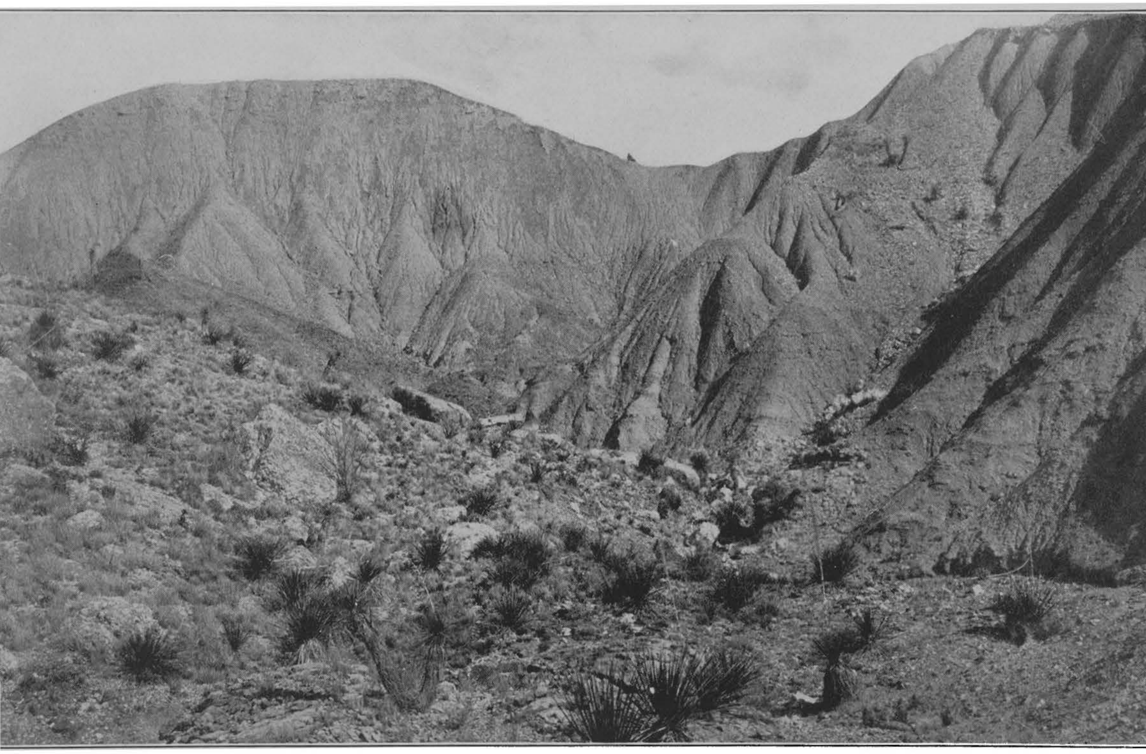
The New Almaden mines have been developed to a depth exceeding 2,500 feet.

In *The Mineral Industry,* Vol. I, 1892, there appeared a table giving the quicksilver production of California from 1850 to the close of 1892. From this it appears that the yield of metal during this period varied from 36.74 per cent., in 1850, to 1.22 per cent., in 1892. The cost per flask varied from $11.98, in 1881, to $46.57, in 1892, the cost per flask being given from 1871 to 1892, but not previous to the former year. In 1897, 28,650 tons of ore gave 474,300 pounds of metal, an average yield of 0.83 per cent. In 1898 the Napa Consolidated Quicksilver Mining Company treated 32,489 tons of ore, the average yield of which was 0.80 per cent. The average receipts were $35.89 per flask and the average cost $21.33. During the same year the New Idria Quicksilver Mining Company treated 18,627 tons of ore, with an average yield of 1.03 per cent. The average receipts were $35.86 per flask and the average expense $17.48. The Aetna Consolidated Quicksilver Mining Company, in 1898, treated 18,394 tons of ore, which yielded 0.72 per cent. of metal. The average cost was $26.55 per flask.

In 1900 the Aetna Consolidated treated 11,888 tons of ore and obtained 1,945 flasks, a yield of 0.63 per cent., while the New Idria Company

*Abstract in The Mineral Industry, Vol. V, p. 464, of article in 13th Annual Report of the State Mineralogist of California, 1896.

STUDY BUTTE, SECTION 216, BLOCK G4.



CLAY MOUNTAIN FROM THE SOUTH.

treated 20,638 tons and produced 3,990 flasks, a yield of 0.74 per cent. The practice in California now seems to be to treat all material that carries more than 0.50 per cent of metal, or 10 pounds of quicksilver per ton of rock, this being worth about $6.

The minerals associated with the quicksilver deposits of California are: bitumen, free sulphur, stibnite, and other ores of antimony, mispickel, gold and silver ores, chalcopyrite, pyrite, marcasite, millerite, quartz, calcite, barite, and borax.

OREGON.

A deposit of cinnabar was opened in Lane county in 1899, and a 40 ton furnace erected. There is said to be a large amount of low grade ore, averaging, perhaps, 0.50 per cent. There are deposits also in Douglas county. The production, however, has been small, 233 flasks during the year 1900. No description of the deposits is available.

TEXAS.

The deposits of cinnabar at and near Terlingua, Brewster county, are described by Mr. B. F. Hill in this Bulletin. They were first noticed by Prof. Wm. P. Blake in the *Transactions of the American Institute of Mining Engineers,* Vol. XXV, 1895, pp. 68-76. A notice of the discovery had previously appeared in *The Bullion,* Los Angeles, Cal., August 14, 1894. The El Paso papers also noticed the discovery, as also *The Manufacturers' Record,* Baltimore, Md. Since that time the deposits have been described by H. W. Turner, in the Twenty-first Annual Report of the United States Geological Survey; by E. P. Spalding in the *Engineering and Mining Journal,* Vol. LXXI, No. 24, June 15, 1901, and by Robt. T. Hill, in the same journal, Vol. LXIV, No. 10, September 6, 1902.

As Prof. Blake's article was the first to appear and contains the results of his observations when the district had not been prospected much, a full abstract of it will be given. It is as follows:

"The elevation of the camp is shown by the aneroid barometer to be 3,250 feet above tide. The valley of the Rio Grande, marked by its fringing groves of cottonwood trees, is in full view for several miles. The mountains across the border in Mexico are also clearly seen, as well as the high range on the southeast, known as Los Chisos, culminating in Emory Peak, and the peculiarly shaped peaks known as the 'Mule Ears,' all noted landmarks.

From Marfa to the Tres Lenguas the direction is nearly southeast, following a widely erroded valley in table-lands, which are generally capped with a hard layer of basaltic lava, seen to the best advantage at the Alamitos rancho, and in the Church mountains, near Collinson's rancho. An isolated conical mountain, rising from the broadly eroded country to the eastward of the Church mountains, has a flat top and is evidently a remnant of former mesa, left standing as a monument, as if to show what an enormous amount of material has been swept away to the Gulf by erosion and degradation. The edges of the horizontal beds can be seen from a distance, and the mountain known as San Diego Peak doubtless affords a very complete and interesting section of the entire series of beds from the lava cap to the lower strata of the Cretaceous.

"The beds of which this peak and the mesas along the Alamitos and the upper branches of the Tres Lenguas are chiefly formed, are remarkable for their whiteness and homogeneity, and appear to consist chiefly of an indurated volcanic mud. It is an amorphous mass, in which there is a large amount of clay and silica; but it is without well-defined structure or stratification. It is remarkable for the general absence of oxide of iron. It is fusible and would appear to be a mass resulting from the breaking up of feldspathic rocks. The thickness is probably not less than 500 feet, and it extends over a wide area, east and west, as far as the edges of the high mesas can be seen. The general uniformity of composition of this deposit is broken toward the top of the mesas by a bed of conglomerate and breccia, 10 feet or more in thickness, made up chiefly of red and brown porphyritic rocks. The masses being, in part, well rounded, show the action of currents of considerable force and extent. This stratum contrasts strongly with the white sediments above and below, and makes a dark-colored belt or band through the hills visible for miles on either side.

"In descending the valley of the Tres Lenguas, there is a marked transition from the volcanic beds to those of unquestionable Cretaceous age. At first, thick masses of finely bedded blue and yellow shales are encountered, and in the broad, flat surfaces countless casts of Inoceramus reveal their proper horizon. The strata, at first lying apparently horizontal, are found to be cleft in various directions by faulting planes, with large blocks partly upturned and evidences of extreme lateral pressure, by which the shales along the faults are buckled upward and crushed. The shales are succeeded by limestones, massive, light colored, nodular, and rugose in structure.

"The cinnabar occurs both in massive limestone and in a siliceous shale and a white, earthy, clay-like rock, and in part in a true breccia of grayish-white siliceous shale, dense and compact, embedded and cemented in a red and chocolate-colored ferruginous mass, also dense and hard. The white blocks or included fragments of the shale exhibit a concentric arrangement of coloring by oxide of iron disposed in bands and thin sheets, deposited in the substance of the shale by the absorption of ferruginous solutions, penetrating from without inwards along the surfaces of the fragments. These deposited coatings or layers conform in general to the exterior forms of the masses, and succeed each other like the concentric layers seen in agates and chalcedony. The colored depositions may also be seen surrounding tube-like or thread-like channels, which have permitted the inflow of solutions bearing not only iron salts, but also those of quicksilver, and leaving behind, in the substance of the rock, layers of iron oxide and of cinnabar concentrically disposed.

"While the genesis of the cinnabar is here shown to be essentially like that of the iron oxide, it is smaller in quantity, and is so far separated from the ferruginous bands as to show a great difference in the conditions of deposition. The cinnabar is more generally crystalline than amorphous; it is not found in such continuous coatings or layers in the white shale as the iron oxide, but is in distinctly separate grains and small but brilliant rhomboidal crystals, having the brilliant red color characteristic of vermilion. There are also considerable masses of snow-white argillaceous rock, in which cinnabar is found in minute crystalline grains spread in bunches here and there through the mass, and often not observable until the mass is rubbed or bruised with a pick or hammer, when the red color of vermilion appears. In such masses there is apparently a complete absence of ferruginous matter. The soft, white, chalk-like masses of rock do not appear to be so favorable to the crystallization of the cinnabar as the more dense and siliceous portions of the rock, resembling chert, or flint, where the cinnabar is in distinctly formed crystals sprinkled through the rock, much like the occurrence of cinnabar in the siliceous gangue of the deposits of Buckeye Rancho, California.

"In addition to these disseminated crystalline granules in the brecciated shale and in the more massive white rock, there are amorphous bunches of cinnabar found in the shales and in the limestones and the breccia. This cinnabar is not, however, in the hard masses like those of the New Almaden mine in California, nor is it in veinlets, as there found, traversing the rocks, but it is soft and friable and has a light vermilion color. Calcite is associated with it, but, so far as observed, no petroleum or bituminous exudations. Some of the larger masses of cinnabar bunches, weighing 2 or 3 pounds of nearly pure mineral, were taken out of an open cut where the shale appears to be the parent rock; but I noted also some small bunches of the cinnabar in the compact blue limestone.

"There are several points on the line of about 1,000 feet in length, along a shallow ravine, where open cuts have been made to a depth of a foot or two, revealing the presence of cinnabar in each and in the soil mixed with the croppings. This linear distribution of the cinnabar is indicative of a vein-like occurrence, or it may be the result of a cropping of a certain bed or stratum. The openings which had been made were not deep enough to show conclusively the real conditions of occurrence. In some places the appearance favored the conclusion that the ore is interstratified or bedded; in others, it seems to occur along a fissure or fault plane, and it is most probable that both of these forms of occurrence will be found to exist.

"There is a second line of cropping a few rods north of the first and higher up the hill, and in the midst of the hard limestones. This is in the midst of a well-defined breccia of iron oxide, and the masses of cinnabar are closely associated with it. Masses of iron oxide, rock and cinnabar, weighing a hundredweight or more, can be broken out from the croppings here; but no work has been done to develop this ground in depth. The cinnabar croppings may be traced for a few feet each way, and the breadth does not exceed 18 inches or 2 feet. This occurrence does not appear to be connected with the series of croppings before described, and it has a more decided resemblance to a fissure deposit or impregnation.

"The existence of several outcrops of a ferruginous breccia, with and without cinnabar, is indicative of breaks in the beds in the nature of fissures (fault planes, probably), accompanied by rupturing and crushing of the rocks by violent movements under pressure. Other evidences of fissuring and of metalliferous impregnation through the fissures are visible in the neighborhood in the many vertical cracks in the limestone strata, marked by the lateral deposition of oxide of iron on both sides. Such deposits are extensive and show that there has been an abundant supply of iron-bearing solutions.

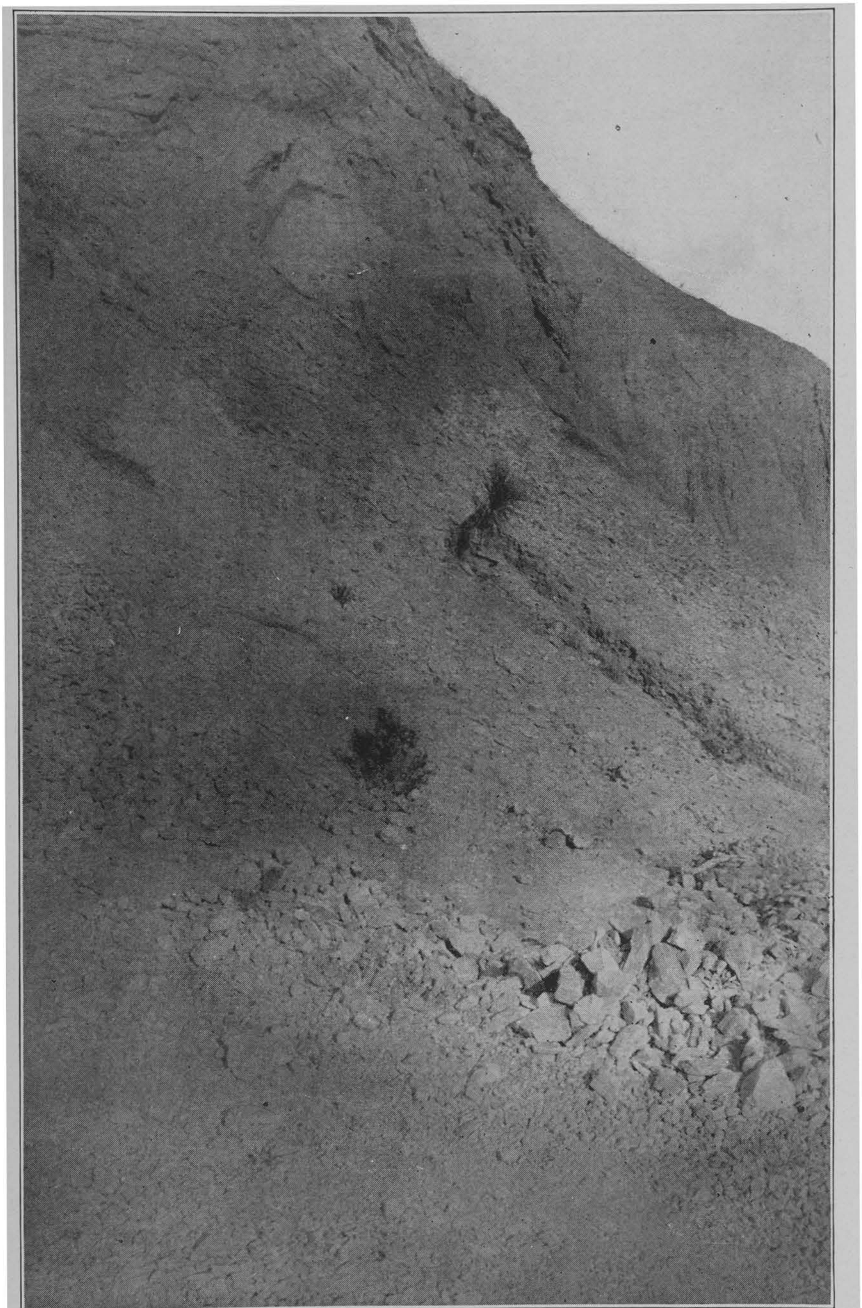
"The best place in which to sink for the better development of the ore in quantity would appear to be at the brecciated cropping on the hill in the limestone. This place seems the most promising, as limestone, being the more soluble rock, may contain large bunches below, where the ore has accumulated by replacement. The conditions for working these deposits of cinnabar are not as favorable as could be wished. The brilliant color of the ore would permit of its being utilized as vermilion; but there is no water near the place for concentrating it. Considerable ore could be taken out of the loose earth along the main croppings if water could be had to wash it. A supply of wood for fuel can be had along the Rio Grande, and could be delivered at the mines for probably \$5 or \$6 per cord. Although a considerable quantity of high-grade ore which would bear transportation could be selected by culling, there would remain a larger quantity of low-grade which would be practically useless. There has not yet been sufficient work done on the croppings to show satisfactorily what quantity of ore of a desirable average percentage can be expected."

Considering that Prof. Blake visited the district when there was almost no development, his remarks are certainly very much to the point. What he said in 1895 is true today, and the development of the district is now preceding in the direction he indicated, among the brecciated deposits in the limestone on the hills.

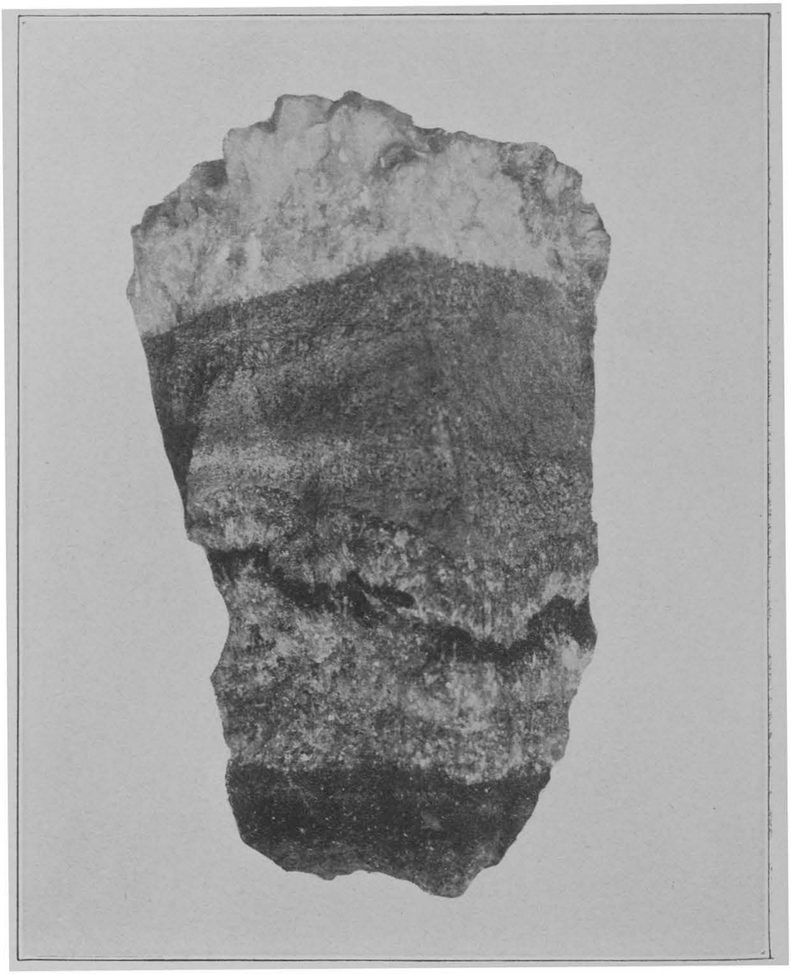
Mr. E. P. Spalding, in the article already alluded to, thought that the main belt of workable ore was about 6 miles from east to west and about 2 miles from north to south. The limits of the field have been considerably extended during the last 16 months, so that it is now thought that 15 miles from east to west and 4 miles from north to south, or 60 square miles, will be found to be ore-bearing at intervals. He noted the existence of very rich pockets and bunches of ore, some of them carrying from 40 to 82 per cent.of metal, and considered that the deposits generally were replacements due to ascending solutions. Without committing himself, which, considering the fact that the deepest shaft at the time of his visit was only 65 feet, he could hardly have been warranted in doing, he says that the deposits give one the impression of not being deep seated. At the same time, he also says that there are reasons for supposing that they are.

The question of the deep seatedness of the deposits must be left to the miner, and we shall have to await further development. The greater part of the evidence thus far to hand is in favor of the continuation of the deposits through the limestone holding them, about 1,700 feet.

In speaking of the occurrence of cinnabar in the district, Mr. Spalding says that he observed it in every class of rock found there, even as a coating on basalt, an eruptive rock. While he was there he witnessed the opening of a pocket of cinnabar, from which two men in half a day took about 20 tons of ore assaying from 40 to 75 per cent. of metal and worth from \$12,000 to \$15,000. From the same locality there were obtained several hundred tons of ore carrying from 1 to 2 per cent. of metal. This rich pocket was found within two feet of a place that had been pronounced barren. Other instances might be given of the close segregation of these pockets, for while there may be, and often is, a visible connection between two or more pockets in the form of stringers (hilos), or other evidences of like nature, yet the pockets stand for themselves and can often be so completely stripped of ore as to leave but scanty evidence of its former existence. In this way they remind one of the pockets of zinc ore in the Joplin district, Mo., or of the pockets of limonite (brown ore) in the Silurian clays of Alabama.



CINNIBAR-BEARING CRETACEOUS CLAYS, M'KINNEY AND PARKER'S.



BANDED STRUCTURE IN CINNABAR ORE.

Prof. Robt. T. Hill, in the article already alluded to, considers the region, as a whole, to be made up of marine Cretaceous sedimentary rocks, tilted, faulted, fissured and metamorphosed.

In the Upper Cretaceous, the Montana division (Eagle Pass), with its seams of lignite and coal, lies in the valley of Terlingua creek and its tributaries between Terlingua and the Chisos mountains. In the Lower Cretaceous, the Georgetown (Fort Worth) and Edwards limestone of the Fredericksburg division are composed of about 1,700 feet of a massively bedded white limestone, in which flints, fossil Rudistes, Requienias and Gryphæa abound. These hard limestones have been of great influence upon the typography of the country, as they have resisted erosion and now stand out prominently. The Del Rio clays, carring the fossil Nodosaria, have, on the contrary, yielded to erosion. The Buda limestone of the Washita division of the Lower Cretaceous, has also been sufficiently hard to withstand the erosion, but as it is thin and underlaid by the friable Del Rio clays, it now appears as a cap rock.

The Cretaceous strata have not only been greatly deformed and disturbed, with a resulting fault system in monoclinal blocks, they have also been cut through by numerous dikes and necks of igneous rock, some of them of rare types.

Prof. Hill says: "While no igneous rocks are encountered immediately within the mineralized ground, the surrounding country is the site of some of the most remarkable igneous phenomena in America. About two miles north of the mines there is a conspicuous volcanic neck. Some ten miles to the west the eastern edge of the great Bofecillos fissure eruption and flows are encountered. Twenty-five miles to the east are the remarkable volcanic necks of the Chisos mountains rising some 5,000 feet above the plain, while between them and the quicksilver country are many later necks, stocks, and monticules of more basic igneous rocks."

But there are igneous rocks in very close association with the Cretaceous limestone carrying cinnabar, as, for instance, at California Hill, where a notable neck of what was at first thought to be andesite, but now proves to be phonolite, intrudes itself. At Study Butte, also, east of Terlingua creek, cinnabar has been found in rhyolite and its decomposition products. These localities are described by Mr. B. F. Hill in his report. In the light of our present knowledge, it must be held that there is, in some localities within the Terlingua district, a very intimate connection between the mineralization of the limestone (and clays) and the intrusions of igneous rock.

Such phenomena have been seen during the last few months and were not commented on by earlier observers owing to the lack of development. New discoveries have been made and new data gathered within the last year.

Prof. Robt. T. Hill regards the deposits as replacements due probably to ascending vapors, and refers them to the Mexican rather than to the American type, inasmuch as they are irregular bodies of ore in pipes, stringers, mantillas and pockets. He thinks it probable that the ore will be found in depth almost, if not entirely, throughout the entire thickness of the limestones, 1,700 feet. As remarked in the report of Mr. B. F. Hill, the greatest depth now attained in mining operations is less than 100 feet, good ore being found at the botton of the shaft. The ore near the surface having yielded good returns, the miners have felt under no necessity of sinking. This state of affairs can not continue indefinitely, and the ore will have to be proved in depth if the district is to become of greater importance as a source of quicksilver.

For the information of these who may wish to know more about the actual conditions in the quicksilver districts of Brewster county it may be as well to add a special part dealing with the region as it is today in respect of transportation, living, etc.

Terlingua, the center of the industry, may be reached from any one of three stations on the Southern Pacific Railroad and by way of San Antonio or El Paso. From southeast to northwest these stations are Marathon, Alpine and Marfa, distant from San Antonio 379, 411 and 438 miles, respectively. The distances from El Paso are as follows: Marfa, 196 miles; Alpine, 223 miles; Marahon, 254 miles.

Up to this time most of the business with the quicksilver districts has been carried on through Marfa, the county seat of Presidio county. From this point to Terlingua there is a stage line, carrying the mail and making two trips a week, going down by way of Alamito (Dysart Postoffice was at Alamito, but has been discontinued), McGuirk's Ranch and Fresno Cañon. According to the United States Postal Map of Texas, March, 1901, the distance from Marfa to Terlingua is 100 miles. The run down is made in one and one-half to two days, and the return fare is $13.50. Marfa will soon be in telephone connection with Terlingua, the charge being $1.00 per conversation of moderate length.

Freight rates, by wagon, from Marfa to Terlingua are 60 cents per 100 pounds, with a half rate back on quicksilver. Houshold furniture, being bulky, is at a special rate and arrangements have to be made with the freighters in each case. At Marfa, the price of lumber varies from $22 to $30 per thousand, and in freighting it down an allowance of 3 to 4 pounds per foot is made.

The elevation at Marfa is 4689 feet and at Terlingua 3274 feet, so that in the distance of 100 miles the decrease in altitude is 1415 feet, or a trifle over 14 feet per mile. The road is fair, considering all the circumstances of the case, although it could be greatly improved from the Fresno Cañon to Terlingua. A saving of 20 or 25 miles could be made by the construction of a road from McGuirk's Ranch direct to Terlingua, and thus avoid the long detour into and through the Fresno Cañon, but the cost would be in excess of the present requirements of the district.

Along the road from Marfa to Terlingua water is to be found at Bogel's Ranch, 12 miles; Alamito, 30 miles, and to the east of the road between Bogel's and Alamito, in Alamito creek; at the two wind mills near San Jacinto Peak, 10 miles below Alamito; at an earth tank 15 miles below San Jacinto Peak and in some tinajas (natural rock tanks) between San Jacinto and the earth tank; at McGuirk's Ranch, 20 miles below San Jacinto, and for several miles in Fresno Cañon. After leaving Fresno Cañon there is no more water until one reaches Terlingua creek, 20 miles, or the Rio Grande, 12 miles.

From Alpine to Terlingua is about 85 miles, the road going down to the west of Elephant Mesa and by way of Butcher Knife and Adobe Walls. The road is fair and water can be obtained along it at intervals.

There is regular freighting from Alpine to Terlingua at 50 cents per 100 pounds. The price of lumber varies from $17.50 to $27.50 per thousand. Elevation of Alpine, 4485 feet.

From Marathon to Terlingua it is 83 miles, the air-line distance being taken at 66 miles. The return trip for wagons is made in about a week.

The freight rate is 50 cents per 100 pounds on merchandise, machinery, lumber and all classes of goods either way, except when full freight is secured each way, the rate in this case being 40 cents per 100 pounds. The price of lumber at Marathon varies from $18 to $30 per thousand. The elevation at Marathon is 4043 feet. The road to Terlingua passes by the old government post at Peña Colorado and thence across the Maravillas creek to Del Norte Gap at easy grades. Through this gap there is a good road 20 feet in width, and it proceeds by easy grades into Green Valley. It follows this valley for about 45 miles and then crosses the divide below Adobe Walls into the valley of Terlingua creek. There are same steep grades along this divide, but they are not long. Loads of 6000 and 7000 pounds have been hauled from Marathon to Terlingua by six Spanish mules. The watering places between Marathon and Terlingua are as follows: Peña Colorado, 4 miles; Peña Colorado to Maravillas creek, 12 miles; Maravillas creek to Jackson's first tank, 14 miles; Jackson's first tank to Jackson's second tank, 8 miles; Jackson's second tank to Adobe Walls, 23 miles; Adobe Walls to Terlingua creek at Mrs. Reed's, 6 miles; Mrs. Reed's to Cigar Springs, 8 miles. After leaving Cigar Springs there is no more water, the supply for the quicksilver district at Terlingua being obtained principally from this place, distance 9 miles.

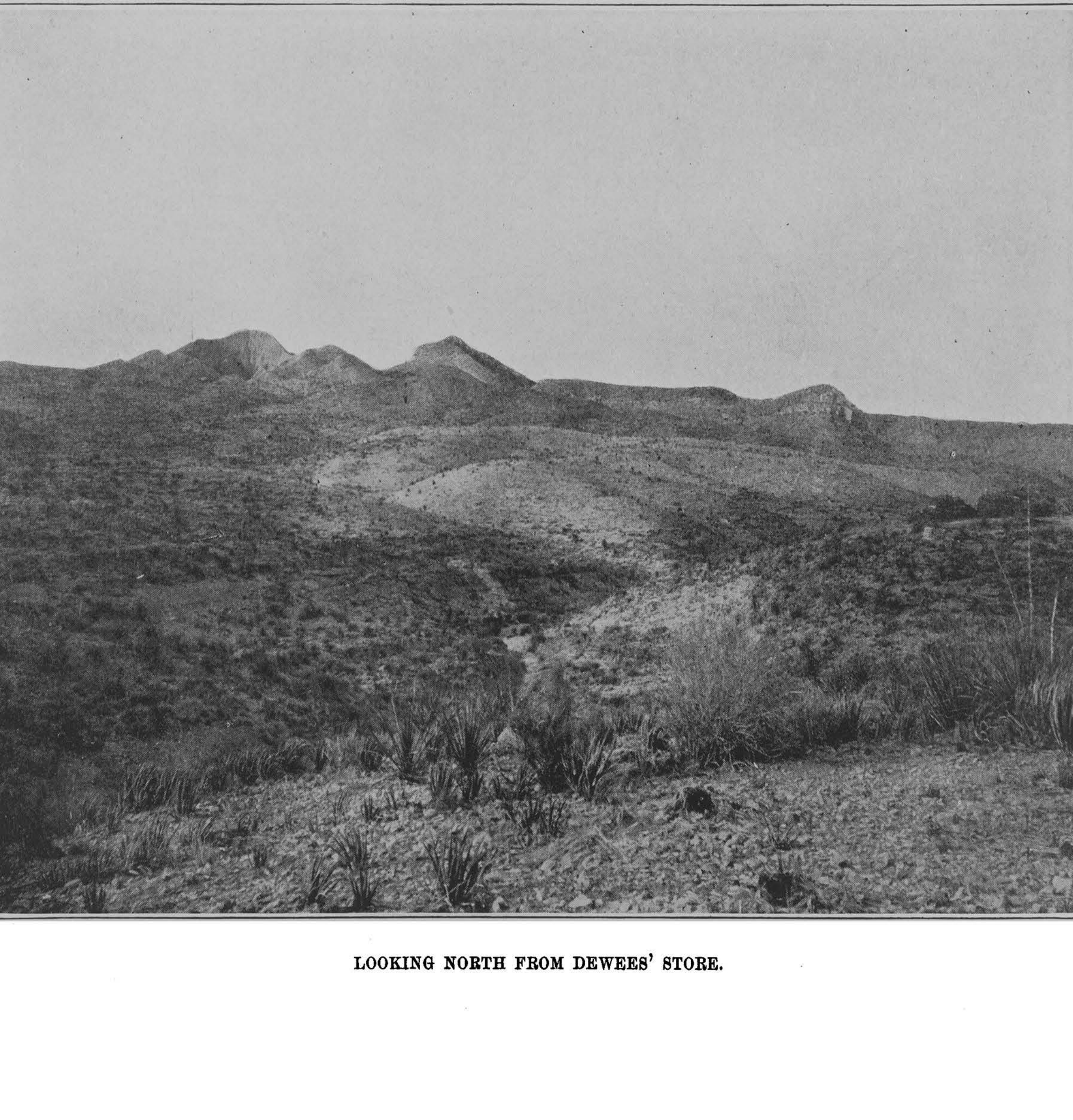
The road from Marathon to Terlingua joins the road from Alpine to Terlingua near Butcher Knife, 45 miles from Alpine, where water can be obtained the greater part of the year. With respect to water, there is not much to choose between the three routes, but with respect to distance Marathon has some advantage, with perhaps a better grade. The difference of elevation between Marathon and Terlingua is 769 feet, as against 1415 for Marfa and 1211 for Alpine.

With respect to facilities for outfitting, the three towns offer about the same inducements. There are excellent stores at each place and they carry large and varied assortments of goods needed in the country. There is scarcely anything that can not be obtained from these stores, and one finds the proprietors at all times ready to be of any assistance possible.

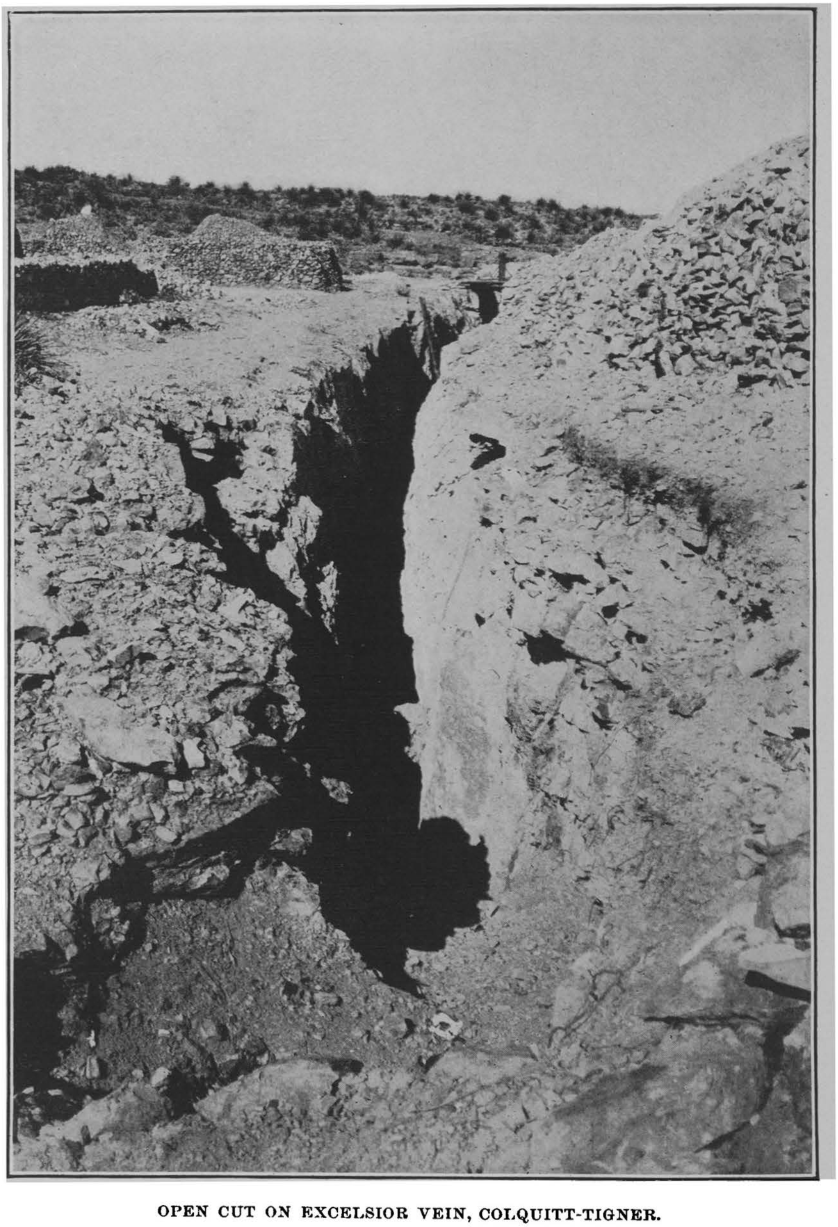
In going into the quicksilver country it is well to remember that there are no hotels, lodging houses, restaurants or other places of public entertainment. There are three good stores at Terlingua and one can buy everything necessary at any one of them, but it is necessary to provide one's own bedding, etc. During the greater part of the year out-door life in the southern part of Brewster county is pleasant enough, but during the early summer months and before the rains begin the temperature becomes excessive, at times, from 11 a. m. to 4 p. m. The nights are delightful, even when the extreme heat of the heat drives one out of the sun during the day. During the winter the cold is seldom severe enough to require the use of an overcoat. Ice forms at night over the little pools along the creeks and in the canteen, but seldom more than half an inch in thickness. Snow may fall occasionally, but it rarely lies on the ground longer than a day or two. Work in the open air can be carried on every day of the year without serious inconvenience except for the heat during the month preceding the summer rains. These rains begin sometimes in June, but generally not until July and August, and last until the middle of September. It seldom rains between the first of October and the first of May, so that it is necessary during these months to haul water for domestic purposes. After the rains begin and the natural and artificial tanks are filled it is not necessary, of course, to haul water so far. It may become necessary, as the district grows in population and importance, to install a pumping plant at some point on Terlingua creek, or the Rio Grande, and pump water into a storage reservoir above the camps, or to drill for water in the flats and along the "draws" at the foot of the hills. Water in the camps is now costing from 1 cent to 1½ cents per gallon in 350-gallon tanks, and it retails at prices varying from 2 to 2½ cents per gallon, these prices maintaining from about the first of October to the first of May. The question of obtaining water by boring has not yet been taken up by any of the companies, although it is probable that a great deal of water could be so secured and it is likely that it would be of as good quality as that now furnished by Cigar Springs and Terlingua creek. Larger storage reservoirs could also be constructed so as to hold more of the rain that falls during the summer. On the whole, the region is arid, but it does not deserve the name of desert that has been applied to it. A great deal of rain falls during the summer, and as the country is sparsely settled and will be so for some years, water collected in great reservoirs would be suitable for all purposes. There are many canyons and "draws" that could be thus utilized to great advantage.

The fuel problem is another thing that will have to be considered. At present the furnaces rely upon such wood as can be brought in by the Mexicans, and they gather it up wherever they can find it. In the course of time, however, the present sources of supply will be exhausted and it is likely that within two years the stringency of the fuel question will be felt. In the Chisos mountains, 25 miles to the east, there is much oak, piñon. cedar and juniper, and this supply may be drawn upon. But the cost of wood hauled 25 miles will become a serious item. There is also a fair supply of wood 15 to 20 miles west of north from Terlingua, and this may be used. The nearest coal is about 16 miles, but it has not been opened enough to allow one to express an opinion relative to its extent or quality. Between Lee Cartwright's and Rough Run there is a seam of lignitic coal, somewhat bituminous in places, but it has not been opened. At the Kimble coal pits, on Rough Run, about 20 miles from Terlingua, there is a fair coal, as also at Chisos Pen, 3 miles northwest of Gano Spring, which is in Section 1. Some work has been done at the Kimble pits and at Chisos Pen, but not enough to warrant one in pronouncing upon the workable nature of the coal. The country is badly broken by intrusions of igneous rock and it is likely that the continuity of the coal seams has been much disturbed. Still, it is likely that enough coal could be obtained for local purposes, and the attention of investors should be turned in this direction.

Some samples of coal were obtained by the writer from the seam near Cub Spring, Section 60, Block G4; from the Kimble pits in Section 44, Block G4; and from the Chisos Pen, Section 40, Block G4, in March, 1902. The old openings, made a year or so previous, had fallen in and it was not possible to get under cover. The samples, therefore, represent the coal that could be secured near the surface. It is possible that the coal from under good cover would be somewhat better. The analyses were made by Mr. O. H. Palm in the laboratory of the Survey.



LOOKING NORTH FROM DEWEES' STORE.



OPEN CUT ON EXCELSIOR VEIN, COLQUITT-TIGNER.

ANALYSES OF BREWSTER COUNTY COALS.

	Cub Spring.	Kimble Pits.	Chisos Pen.
Moisture	10.65	4.74	1.16
Volatile and combustible matter	50.91	29.84	32.79
Fixed carbon	19.52	49.84	44.53
Ash	18.92	15.58	21.52
	100.00	100.00	100.00
Sulphur	0.86	1.26	3.39
British Thermal Units	8,432	11,887	11,958

The Cub Spring coal is lignitic, but the coal from the Kimble Pits and from Chisos Pen is more bituminous, especially that from the latter locality. The Kimble Pits and Chisos Pen are about 20 miles from Terlingua and on the east side of Rough Run. Cub Spring is in the Christmas mountain district, 3 miles north of the Kimble Pits. Of the three localities the Kimble and Chisos Pen would appear to offer better inducements to the prospector than the other.

Locations for coal have been made on the eastern side of Block G4 in the even numbered sections from 36 to 66, inclusive, these being the public sections, but for the most part the claims have been allowed to lapse. Very little work has been done and that little of a desultory character. From the Kimble Pits some coal was taken out and hauled to Boquillas, where the Kansas City Smelting and Refining Company operated a silver-lead mine during the last few years. Some of the coal could be coked in a recovery oven, but it does not seem to be well adapted to the beehive oven. Without systematic prospecting no opinion can be given of the value of this coal field for commercial purposes, but there is enough coal for the quicksilver furnaces at Terlingua. The general situation is such as to militate against the existence of large bodies of coal, for the district has been greatly disturbed by intrusions of igneous rocks. At the Chisos Pen, for instance, the lava flow is almost in immediate connection with the coal and forms the capping to the sandstone roof of the coal. This condition exists south of the Christmas mountain all the way along Rough Run, a distance of 20 miles. At intervals along this section coal outcrops can be observed, but at no place was there more than 14 inches of coal to be seen, viz., at the Kimble Pits. It is the purpose of the Survey to examine the coal fields of Brewster county more in detail when the topographic maps now in preparation shall have been completed. A topographic corps of the United States Geological Survey is now at work in that part of the county and the maps will be ready during the spring of 1903.

PRESENT AND POSSIBLE RAILROAD FACILITIES.

As already remarked, the only railroad now within reach of the quicksilver districts is the Southern Pacific, the shortest distance to it being about 83 miles, viz., at Marathon. The Mexican & Orient, known locally as the Stillwell Road, may penetrate into the district, but the route which appears to commend itself would carry it some distance to the northwest of Terlingua. This road is building to a connection with the

Bay of Topolobampo, on the eastern side of the Gulf of California, through Chihuahua. In Texas the road has been located from Chilicothe, Hardeman county, near Red River, to San Angelo, Tom Green county, and is under construction from Chilicothe to Sweetwater, Nolan county.

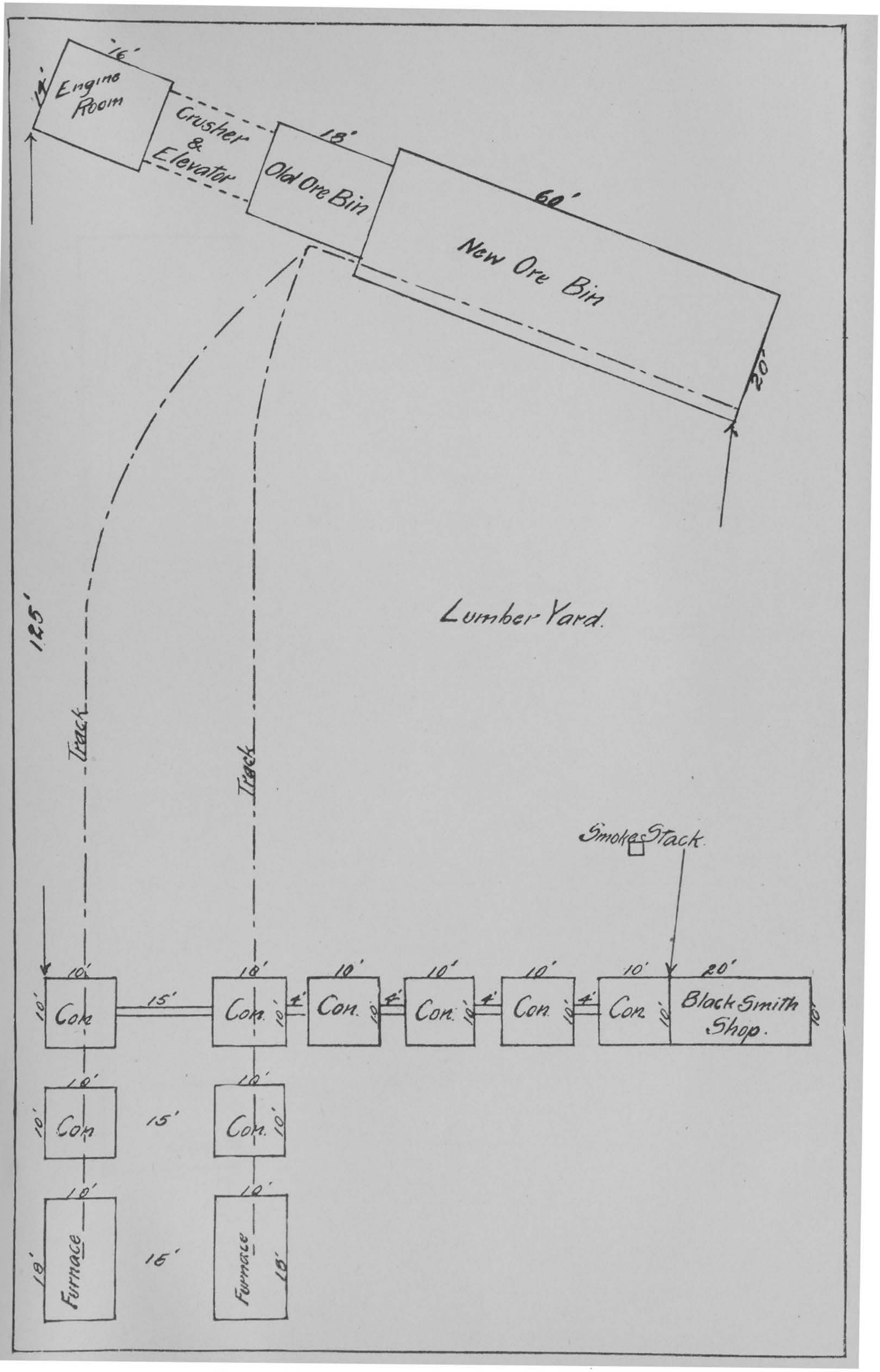
From San Angelo to Presidio, Presidio county, the location has not been made. If the road should cross the Southern Pacific at Paisano Pass, west of Alpine, it would probably follow the general course of Alamito creek to the vicinity of San Jacinto Peak and then strike for the mouth of the Concho river, at Presidio, and thence to Chihuahua. By this route the nearest available point to the quicksilver districts would be about 50 miles. If the crossing of the Southern Pacific is made at Marathon the road would probably pass through Del Norte Gap and into Green Valley.

Considering Presidio as the objective point, the most feasible route from Green Valley would appear to be by way of San Jacinto Peak and to the northward of it, for the country to the south soon becomes very rough and the rugged mountains that fringe the Frenso Cañon would entail costly construction. In either case, therefore, whether the road crosses at Paisano Pass or at Marathon it is not likely that the quicksilver districts would be brought nearer than 50 miles to rail. This, however, would be a considerable saving as against 83 miles to Marathon, 85 miles to Alpine and 100 miles to Marfa.

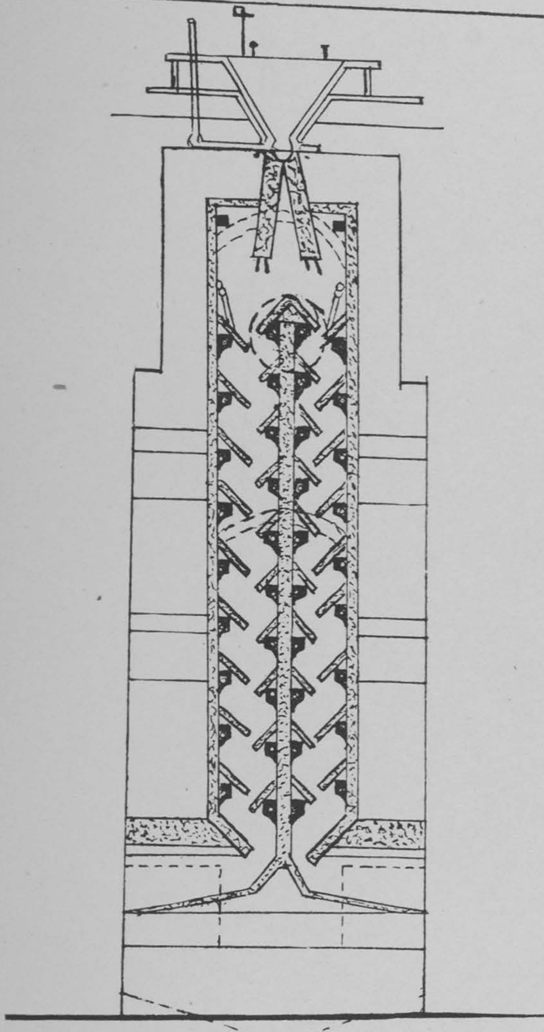
But for some time to come it is likely that the Southern Pacific will supply all of the transportation required in the development of the district, notwithstanding the fact that all merchandise has to be hauled from 80 to 100 miles after leaving the railroad. A metallurgical product that sells for 60 cents a pound will stand a good deal of hauling.

The development of the district will proceed along the economic lines indicated by the nature of the deposits. While rich pockets of ore are often met with, yet the chief reliance will have to be upon au ore yielding about 1 per cent. of quicksilver. Such ore can be profitably treated under the conditions that exist at present and that are likely to maintain for several years. It is, of course, somewhat to the disadvantage of the district that the deposits have not been explored in depth. Until this is done the importance of the district as a permanent producer of quicksilver will be open to question. The deposits that lie near the surface will be worked out within a comparatively short time, although they are now sufficient for the demands made upon them. The furnaces now built and under construction can use 75 tons of ore per day, which, at an average yield of 1 per cent., would represent about 570 flasks a month. Rich pockets of ore may increase the capacity to 800 flasks a month. The production during the year 1902 is likely to be about 5000 flasks, all drawn from surface deposits or those that may fairly be considered as such.

It is probable that new finds will be made, for there is much activity in the district. The construction of a custom furnace would do much towards development, but this is not to be recommended unless sufficient ore is controlled by the operator to enable him to run independently. But a custom furnace would secure the richer ores that are being taken out by prospectors and for which there is now no market. A 10-ton Scott furnace can be built for $15,000 and with a yield of 1 per cent. of quicksilver would produce $120 worth of metal a day.

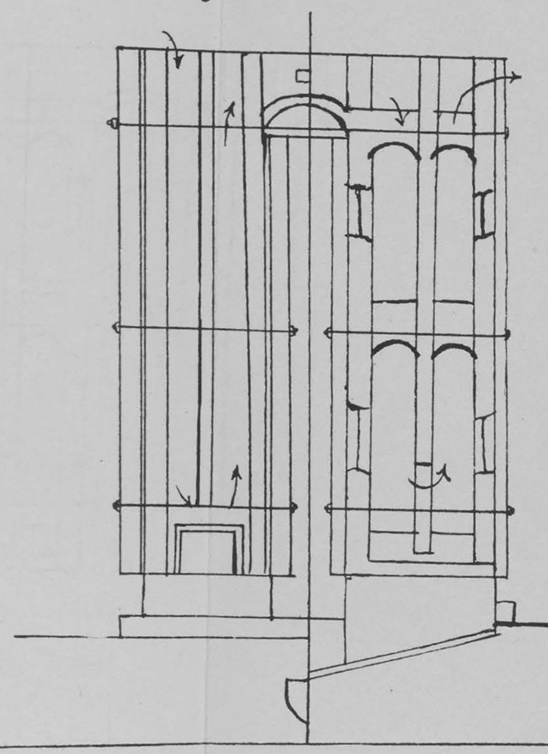


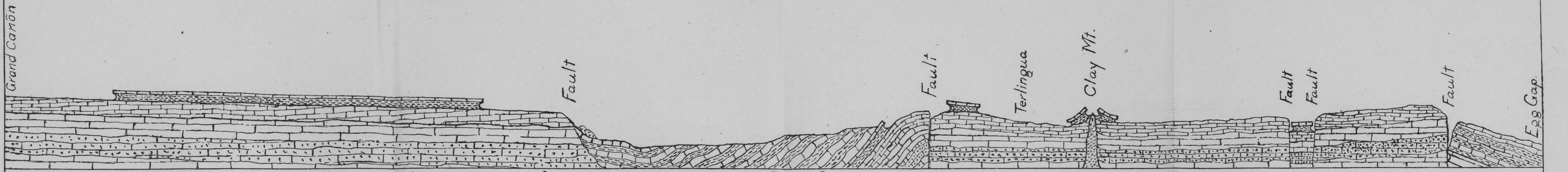
Ground Plan of Marfa and Mariposa Furnace Plant.



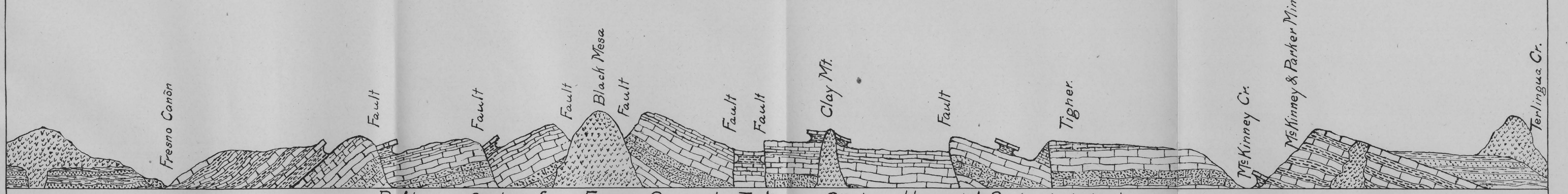
Section of the Granzita Furnace.

Section of Brick Condenser.





Profile and Section from Rio Grande River to Egg Gap. ∴ Horizontal Scale: 1 mi. = 1 inch.



Profile and Section from Fresno Cañon to Terlingua Creek. ∴ Horizontal Scale: 1 mi = 1 inch.


MAP OF THE
TERLINGUA
MINING DISTRICT
BREWSTER CO., TEXAS.
SCALE – 1 MILE
W. O. Washington, Del.
Block G.5.
Block G.12.
Block G.4.
Block 341.
Road to Alpine and Marathon
Road to Marfa