BUREAU OF ECONOMIC GEOLOGY

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INTRODUCTION

Since production of fluorspar began in northern Coahuila, Mexico in 1950-51, thousands of tons of high-grade ore have been mined from numerous deposits situated 5 to 75 miles south of the Rio Grande. A large part of the fluorspar mined from these deposits has moved northward through Boquillas, Stillwell Crossing, and Heath Crossing to the railhead at Marathon, Texas. Consequently, Marathon has become one of the principal fluorspar shipping points in the world. Even though none of the nearly two million tons of fluorspar shipped from Marathon during the last 15 years came from a deposit in Texas, several occurrences of fluorite are known in southern Brewster County, Texas (fig. 1); the northern Mexico fluorspar province does not terminate abruptly at the Rio Grande.

Deposits in Mariscal Mountain in Big Bend National Park are possibly equal in size and grade to deposits 5 to 10 miles southward across the Rio Grande in the San Vicente district. Potentially commercial deposits are known at several places in and around the Christmas Mountains (just outside the northwestern boundary of Big Bend National Park), and fluorite mineralization is widespread throughout the Terlingua quicksilver district (fig. 1).

Cretaceous limestone formations which serve as host rocks for fluorspar deposits in northern Coahuila crop out extensively in Brewster County, Texas in the following areas: the Dove Mountain--Maravillas and Reagan Canyon country, on the flanks of the Marathon Dome, in the Sierra del Carmen--Santiago--Del Norte Range, in the Christmas Mountains--Corazones Peaks area, in the Terlingua quicksilver district, and in Mariscal Mountain in Big Bend National Park. But in Brewster County, as in Coahuila, fluorspar deposits are found only in close proximity to rhyolite intrusions. The intrusive rocks in southeastern Brewster County are dominantly syenodioritic in composition and most of the intrusions north of the Christmas Mountains--Corazones Peaks area are trachytes and microsyenites.

ACKNOWLEDGMENTS

This paper is based on work done by the writer and others with whom he was associated over a period of several years. A thorough search for fluorspar occurrences in the Big Bend area of Texas was made during the summer of 1952 under the sponsorship of The Dow Chemical Company. The Dow project of 1952 was directed by the writer and Dr. S. E. Clabaugh, and the following students of geology were employed: Robert J. Brod, John C. Darst, Andrew E. Kurie, Floyd F. Sabins, and David L. Amsbury. Several of the occurrences mentioned in this paper were found by this group in 1952. Later, Don R. Atkinson and Stan R. Williams, working for Dow under the writer's direction, found other deposits. Annual assessment work on claims owned by Dow gave information on several of the deposits. This paper is published with the consent of The Dow Chemical Company, Midland, Michigan.

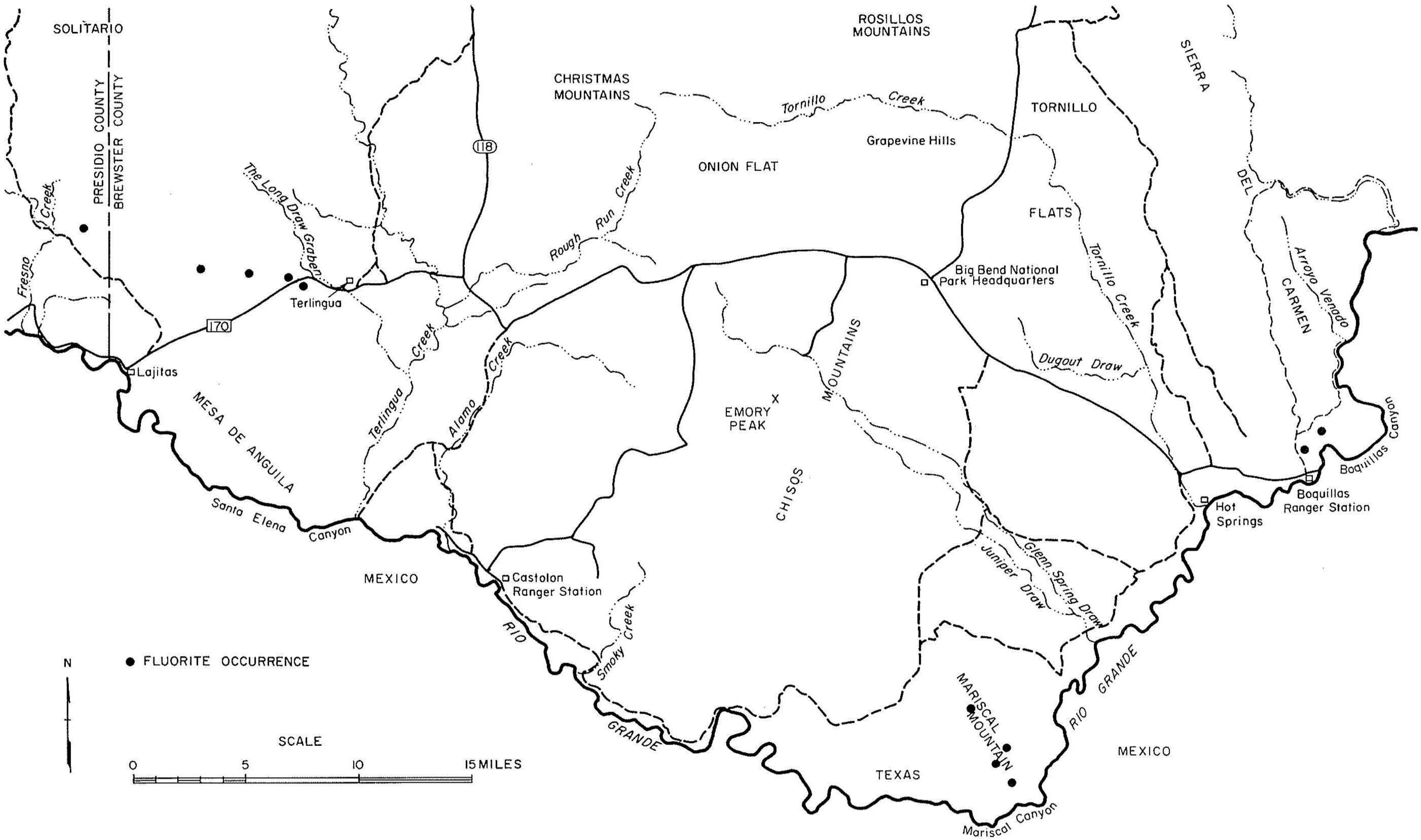

FIG. 1. Fluorite occurrences in Brewster County, Texas.

FLUORSPAR DEPOSITS IN THE CHRISTMAS MOUNTAINS--CORAZONES PEAKS DISTRICT

General Geology

Outside Big Bend National Park, potentially commercial deposits of fluorspar in Brewster County are known only in and around the Christmas Mountains, in the Christmas Mountains--Corazones Peaks district. This district embraces approximately 40 square miles of mountainous terrain located immediately north of the northwest boundary of Big Bend National Park. It lies within parts of the Paint Gap, Nine Point Mesa, Agua Fria, and Terlingua quadrangles. The central part of the district is about 85 miles south of Alpine, Texas.

The rugged topography of this district is the result of differential erosion and a rather complex history of vulcanism and diastrophism. The Christmas Mountains are developed on a faulted and intruded domical structure composed of Cretaceous sedimentary rocks and a variety of igneous rocks. Erosional truncation of the apical portion, and canyons cut into the flanks of the dome, reveal the structure, stratigraphic sequence, and many intrusive bodies.

The first (?) doming intrusion, a core of gabbro, is exposed in the central area. It is surrounded by a large mass of rhyolite which probably produced further doming as it was emplaced. Sills and dikes of basalt and gabbro cut the sedimentary beds for considerable distances away from the central core. Emplacement of the centrally exposed masses of gabbro and rhyolite effected doming of the overlying Cretaceous sediments, producing dips up to 45 degrees. Concurrently and/or subsequently, the Cretaceous strata were invaded by numerous smaller bodies of acidic magma, in the form of dikes, sills, and irregularly shaped plutons, which solidified to form rhyolite, soda rhyolite, trachyte, and soda trachyte rocks. Scattered erosional remnants of lavas, tuffs, and conglomerates are evidence of extrusive vulcanism in the area.

The symmetry of the dome is broken by a great normal fault, downthrown to the southwest; the Christmas Mountains are bounded on the southwest by a steep, northwest-trending faultline scarp reflective of this fault. Numerous faults of lesser displacement occur in the area.

Except for thin deposits of alluvium in the valleys and along principal arroyos, all sedimentary rocks in the district are Cretaceous in age. The exposed section includes the Santa Elena Limestone, Del Rio Clay, Buda Limestone, Boquillas Formation, Pen Formation, and Aguja Formation. Commonly, the stratigraphic position of the Del Rio Clay is occupied by more or less concordant intrusive bodies of rhyolitic composition. Tabular intrusive bodies of igneous rocks are numerous in the Santa Elena, Buda, and Boquillas Formations along faults and fractured zones.

The stratified rocks in the area bordering the Christmas Mountains on the north and west are cut by many dikes, sills, and plutons of rhyolitic and trachytic composition. Several of the larger intrusions produced considerable local deformation and faulting. East and West Corazones Peaks, plug-like intrusions of soda rhyolite, are among the most prominent topographic features in the bordering area.

Location and Description of the Fluorspar Deposits

The first fluorspar deposits discovered in the Christmas Mountains--Corazones Peaks district are located in section 94, block G-4, D & W. Ry. survey, in an area covered by the Paint Gap Quadrangle, Corps of Engineers, U. S. Army Tactical Map--in the southwest quadrant of the rectangle bounded by the following grid lines: on the south, 660,000; on the north, 665,000; on the west, 1165,000; and on the east, 1170,000 (fig. 2). Two 20-acre mineral claims, Christmas Mountains No. 1 and No. 2, Award Numbers A39570 and M39571, embrace the deposits. These claims are owned by The Dow Chemical Company. The discovery was made in 1952 by Floyd F. Sabins and Robert J. Brod. The fine-grained, pink to purplish-gray mineral was identified as fluorite by Dr. S. E. Clabaugh.

The fluoritization occurs in the Santa Elena Limestone along and near the contact with a slightly discordant tabular body of fine-grained rhyolite. The fluorite was formed by replacement of the limestone by fluorine-bearing fluids moving through the broken contact zone following emplacement of the rhyolite. Replacement was more effective in brecciated areas. Several small pods of fluorspar occur at intervals in the narrow contact zone. The largest known deposit crops out in a topographic saddle for a distance of approximately 500 feet. Trenches across this deposit show that it is a replaced limestone xenolith or roof pendant. A similar fluoritized "xenolith" occurs in the western part of the mineralized area. Fluorite occurs intermittently along and a short distance away from the limestone-rhyolite contact in a swath about 600 yards in length. Veinlets of fluorite extend into the limestone for several feet, and veins up to

4 feet in width are present in the limestone in one small area. Test pits and trenches (maximum depth, 20 feet) on the principal mineralized outcrops revealed that the fluoritization is erratic. No large orebodies have been found, but a systematic exploration program has not been conducted, and this area appears to be geologically favorable for sizeable deposits of commercial-grade fluorspar.

The fine-grained, replacement-type (metasomatic) fluorspar in these and other deposits in the Christmas Mountains--Corazones Peaks district is similar in appearance and mode of occurrence to contact metasomatic deposits being exploited in several districts in Mexico, especially the Pico Etereo--Aguachile, San Luis Potosi, and Rio Verde districts. Grains of fluorite from 0.01 to 5 millimeters in diameter make a crystalline granular mosaic. The principal impurities are calcium carbonate and silica (largely in calcite and chert, respectively). The fluorspar ranges from light to dark purplish gray to purple. The average composition of four samples analyzed by the Central Laboratory of The Dow Chemical Company, Freeport, Texas, was as follows: CaF_2, 71.5%; $CaCO_3$, 14.16%; SiO_2, 9.13%; $CaSO_4$, 1.06%. The CaF_2 content ranged from 60.3% to 81.4%.

The relatively high calcium carbonate and silica content of the ore should not present a particularly difficult beneficiation problem and an acid-grade product probably could be made by flotation. However, the high silica content makes the ore unsuitable for the metallurgical-grade market because metallurgical-grade fluorspar is sold on an "effective unit" basis. Effective units are determined by subtracting 2.5 x the SiO_2 content from the CaF_2 content. For example, ore containing 71.5% CaF_2 and 9.13% SiO_2 has only 58.67 effective units (71.50-12.83 =

58.67). Most metallurgical-grade ore marketed today contains a minimum of 72.5 effective units and 60 effective unit ore is the lowest grade marketable.

Several fluorspar deposits occur in contact zones around two rhyolite plutons located about 1.5 and 5 miles, respectively, from the Christmas Mountains No. 1 and No. 2 claims, on section 131, block 4, H. E. and W. T. Ry. Co. survey; section 4, block 11, C. A. Adams, Grantee; and on a section which lies north of section 4. The area embracing these occurrences is shown on the Paint Gap Quadrangle in the rectangle bounded by the following grid lines: on the south by 660,000; on the north by 665,000; on the east by 1160,000; and on the west by 1165,000 (fig. 2). The plutons, Hills 5460 and 4933 on the Paint Gap Quadrangle, with which the fluoritization is associated, make prominent topographic features.

The base of Hill 5460 has a diameter of about one-half mile. The hill is composed of Cretaceous strata surrounding an intrusive core of rhyolite. The Buda Limestone crops out in a nearly continuous band near the base of the hill. There are scattered, erosional remnants of fault blocks of Boquillas Limestone on the slopes above the Buda outcrop. The largest fluorspar deposit known in this area crops out on the north side of the hill, along the Buda Limestone-rhyolite contact. At this locality, a block of the Buda Limestone about 1,200 feet long and 200 feet wide rests on rhyolite and dips about 20 degrees northward. The limestone has been fluoritized near the contact with the rhyolite and metasomatically changed into typical, fine-grained fluorspar. This fluorspar deposit has an average thickness of 5 feet along a length of 1,000 feet and, where arroyos cut into the limestone block, it can be seen to extend 40 feet down dip. Thus, the observable dimensions of this orebody are 1,000 feet x 40 feet x 5 feet. A sample taken from the weathered outcrop contained 57.5% CaF_2. This deposit is embraced by a patented 20-acre mineral claim, Christmas Mountains No. 6, on section 4, block G-11, C. A. Adams, Grantee; owned by The Dow Chemical Company.

About 1,000 feet from the deposit on Christmas No. 6 claim on section 131, block 4, H. E. and W. T. Ry. Co. survey, and higher on the slope of Hill 5460, fluorspar crops out along the contact between the Del Rio Clay and intrusive rhyolite. The outcrop is 60 feet long and 2.5 feet thick. It is covered by colluvium at either end. At this locality small "islands" of Del Rio Clay and Buda Limestone are surrounded by intrusive rhyolite, and the size of individual fluorspar deposits is restricted to the size of the Buda Limestone block. A composite sample of fluorspar taken over the outcrop contained 71.8% CaF_2.

Three small outcrops of fluorspar are known on the western slope of Hill 5460 (fig. 2), the largest of which (180 square feet) is exposed in a gulley along a Buda Limestone-rhyolite contact. A sample from this deposit contained 83.8% CaF_2. Farther up the slope of the hill, about 300 feet northeastward, are several small outcrops surrounded by a heavy mantle of colluvium, and approximately 800 feet south of this area there is small exposure (2 feet thick and 10 feet long) of fluorspar in the Boquillas Limestone. A composite sample of ore from these outcrops contained 78.3% CaF_2.

The data available are insufficient to evaluate the reserve potential of the several deposits known on the slopes of Hill 5460. All fluoritization observed was in either Buda or Boquillas Limestones, neither of which is as susceptible to replacement as the underlying Santa Elena Limestone. The contact between the rhyolite and the Santa Elena Limestone is not exposed and should be the principal target for exploratory drilling and excavating.

Hill 4933, situated about 2 miles north of Hill 5460 (fig. 2), is also composed of deformed Cretaceous strata resting on an intrusive rhyolite plug. The limestone-rhyolite contact is exposed at only a few places where gullies have cut through colluvium. Fluorspar occurs at several places where the intrusive contact is exposed, in both Buda and Boquillas Limestones. All outcrops are small but there is appreciable fluorspar in the float on the slopes. A sample from one of the larger deposits contained 67.2% CaF_2.

Fluorspar also occurs on a laccolithic structure located about 1.5 miles northwest of West Corazones Peak. This area is shown on the Paint Gap Quadrangle in the rectangle bounded by the following grid lines: on the south by 665,000; on the east by 1160,000; on the west by 1165,000; and on the north by parallel 29°30' (fig. 2). At this locality a "slab" of Santa Elena Limestone about 50 feet thick resting on intrusive rhyolite has been elevated and tilted 25 degrees. The limestone is cut by numerous apophyses of rhyolite. The principal limestone-rhyolite contact is fluoritized discontinuously over a distance of nearly 3,000 feet. Small pods and narrow veins of fluorspar can be seen over the surface of the limestone. The fluoritized limestone varies from light gray to pink and is fine grained. Aggregates of small euhedral crystals of fluorite occur randomly in small pockets and along small veins, but it is doubtful that commercial deposits occur in this area.

Several small outcrops of fluorspar were found in the relatively high and rugged southeastern part of the Christmas Mountains. There are no roads into this area, and it can be reached on foot only with considerable effort. The area embracing these outcrops is shown on the Paint Gap Quadrangle, in the rectangle bounded by the following guidelines: on the south, 655,000; on the east, 1170,000; on the north, 660,000; and on the west, 1165,000 (fig. 2).

Small pods and irregular-shaped bodies of fluorspar were observed in the upper part of the Santa Elena Limestone near contacts with small acidic dikes, near the upper end of the canyon which drains the East Basin. A composite sample of fluorspar from these outcrops contained 58.2% CaF_2; SiO_2 in the form of chert is the principal impurity.

Three outcrops of fluorspar in the upper part of the Santa Elena Limestone, near the contact between the limestone and an intrusive body of rhyolite, are present about 1 mile southwest of the occurrences mentioned above, near a prominent fault line scarp (fig. 2). The limestone-rhyolite contact is covered by alluvium in the immediate vicinity of the fluorspar outcrops. Pods of fluorspar appear to be clustered around irregular apophyses of the intrusive rock in the contact zone. The southernmost outcrop, located near a fence at the head of a small gully, is 80 feet long and 20 feet wide. The fluorspar is fine grained, purple and white banded, and contains small cubes of fluorite in numerous small vugs. The limestone in the contact zone is very cherty and, consequently, the fluorspar is highly siliceous. A composite chip sample from this outcrop contained 79.6% CaF_2. It is estimated that the combined reserves of these three deposits is of the order of 10,000 ± tons.

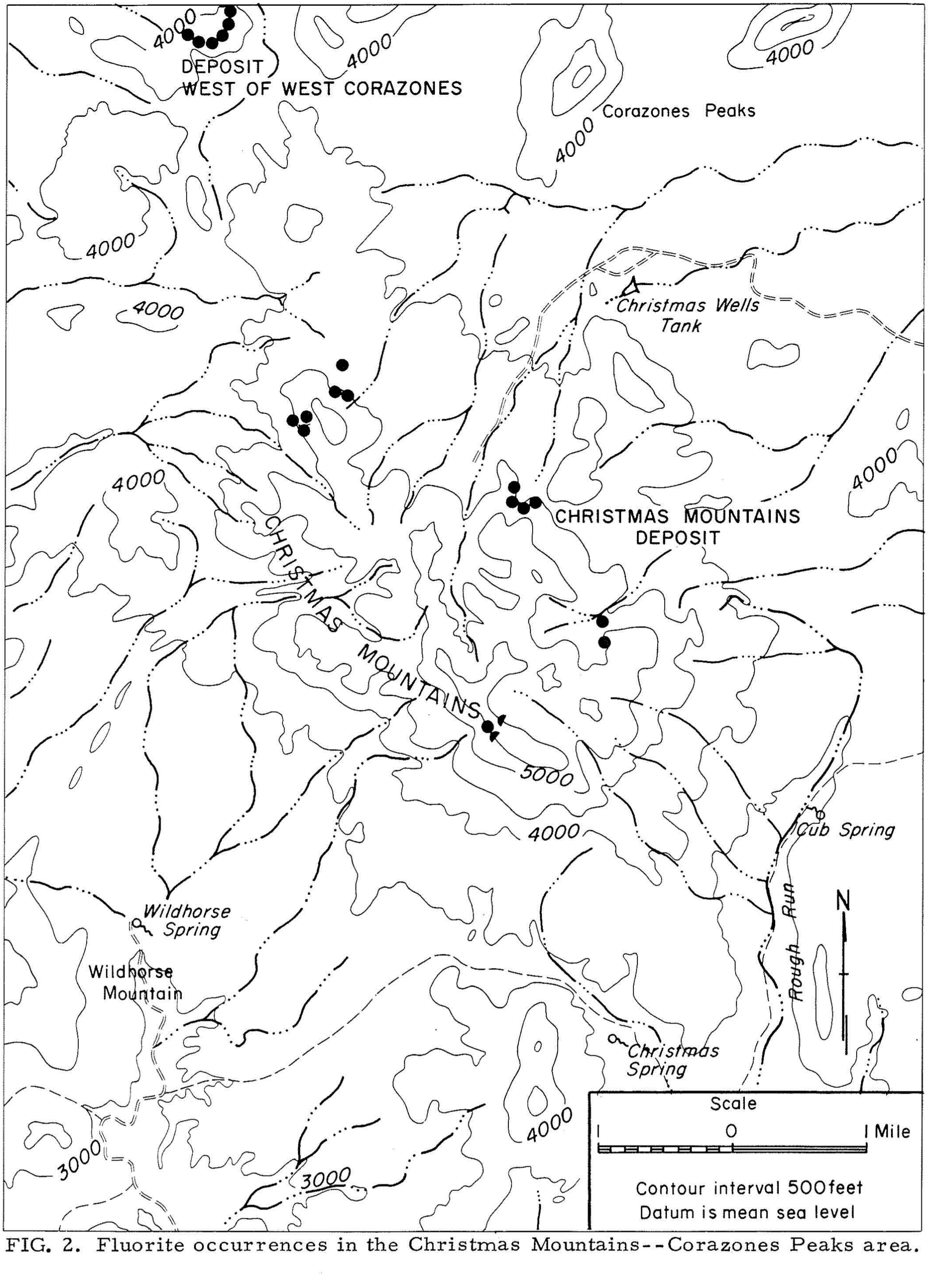

FIG. 2. Fluorite occurrences in the Christmas Mountains--Corazones Peaks area.

FLUORSPAR IN BIG BEND NATIONAL PARK

Big Bend National Park embraces more than 700,000 acres spread across the southern tip of the great bend of the Rio Grande in the extreme southern portion of Brewster County, Texas. Within this vast area is a great variety of geologic features, including rock types and structural conditions favorable for fluorspar deposits. Cretaceous limestones, which host commercial deposits of fluorspar in several districts in Mexico near by, crop out over large areas in the Park, and these formations are intruded by rhyolitic igneous bodies at many places.

Because mining is not permitted within Big Bend National Park, no great effort was made to locate fluorspar deposits within its boundaries. But for academic reasons certain areas which appeared to possess the principal requisites for deposits were reconnoitered, and several occurrences were found in the Mariscal and Del Carmen Mountains. This was not at all surprising in view of the fact that commercial deposits occur in the Mexican counterparts of these mountains.

A northwest-trending belt of Laramide deformation that extends from the Rio Grande through the Christmas Mountains includes Mariscal Mountain immediately north of the Rio Grande and Sierra San Vicente immediately south of the river in Mexico. Many high-grade deposits occur in Sierra San Vicente, some less than a mile from the Rio Grande. Mariscal Mountain is an asymmetrical anticline, about 3.5 miles wide at its widest point, which trends west of north and plunges out about 12 miles north of Mariscal Canyon on the Rio Grande (fig. 1). The Santa Elena Limestone crops out extensively over the axial portion and is well exposed in many arroyos cut in the limbs of the anticline. The Del Rio, Buda, and Boquillas Formations are present in succession on both limbs and around the plunging north end of the structure; older formations are exposed in the walls of Mariscal Canyon, which is about 1,600 feet deep. The major anticlinal structure is cut by several minor faults and fractures and by numerous small, sill-like and irregular-shaped intrusions. A sizeable area of fluoritized Boquillas Limestone, near an irregular-shaped rhyolitic intrusion, was observed on the plunge slope at the north end of the mountain, and small masses and stringers of high-grade, coarsely crystalline fluorite were seen along faults and fractures and in collapsed areas associated with small sinks at many places in the Santa Elena Limestone over the summital (axial) portion of the structure.

Less attention was given to that portion of Sierra del Carmen within the Park than to Mariscal Mountain, but a few small occurrences of fluorspar were observed in the Santa Elena Limestone on the west side of the range near Boquillas Canyon. However, intensive prospecting in the eastern part of the mountains, in areas outside the Park, failed to locate any shows of fluorspar. Commercial deposits occur at several places in the range 15 to 30 miles south of the international boundary.

FLUORSPAR IN THE TERLINGUA QUICKSILVER DISTRICT

The Terlingua quicksilver district extends southwestward across the Terlingua Monocline from Study Butte nearly to Lajitas and northwestward nearly to the Solitario. Most of the district is in southwestern Brewster County but a few mines are in southeastern Presidio County. Quicksilver (mercury) has been produced intermittently from several mines in the district since 1896. Many of the quicksilver deposits occur in and/or immediately below the Santa Elena Limestone. Faults, fractures, sinks, and intrusive igneous bodies are numerous in the area.

Fluorite is a minor gangue constituent in many of the quicksilver deposits and can be seen on dumps around several mines and prospects in the Mariposa--Black Mesa area, at the Fresno mine, and on Reed Plateau (fig. 3). Small, non-commercial occurrences are numerous in the district in small veinlets and veins, in irregular-shaped mineralized pods, and in mineralized collapse breccias associated with sinks in the Santa Elena Limestone. However, careful prospecting of the whole district failed to locate any commercial deposits.

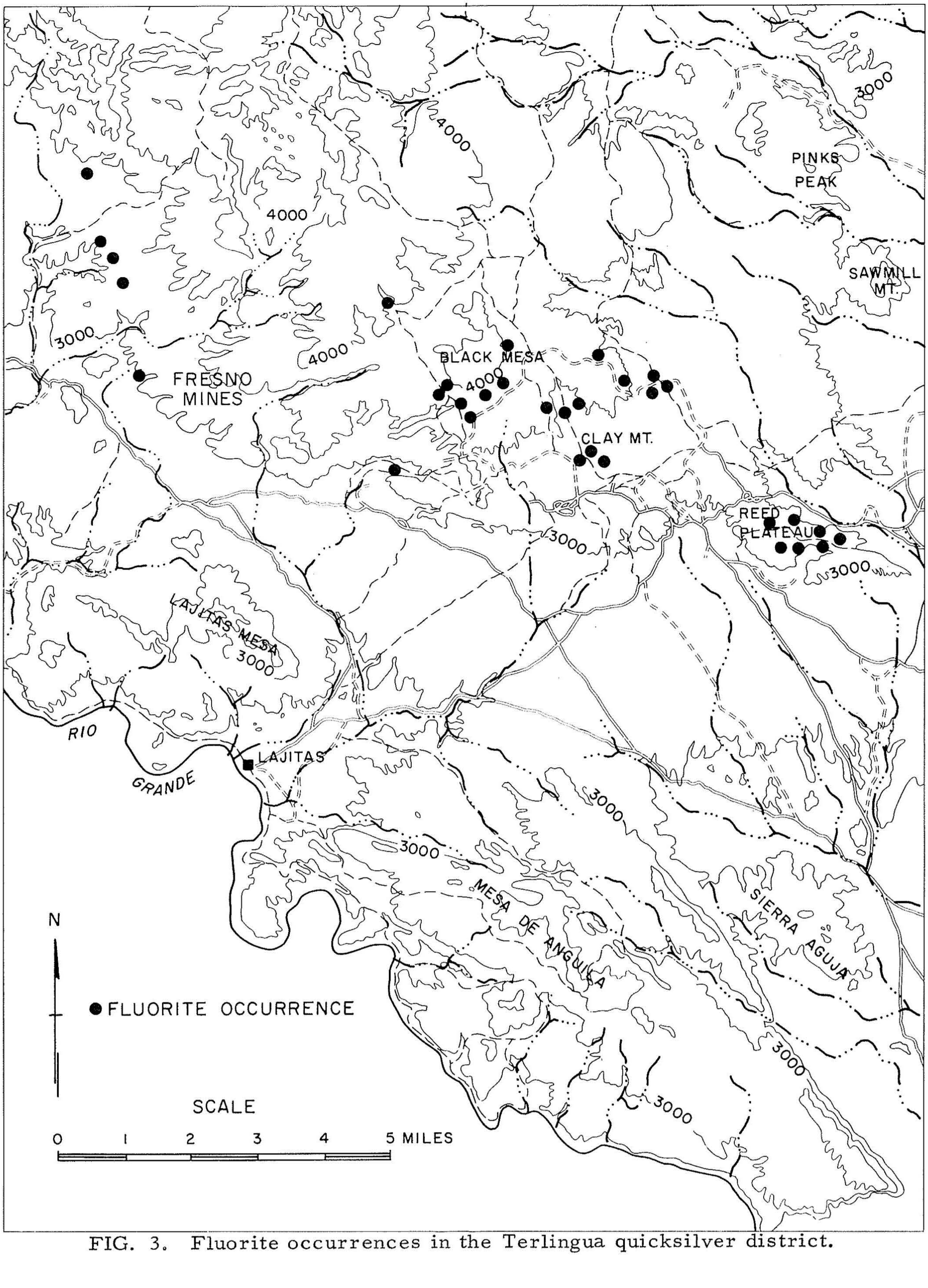

FIG. 3. Fluorite occurrences in the Terlingua quicksilver district.