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Fluorspar In New Mexico

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Bulletin No. 1. The Mineral Resources of New Mexico, Fayette A. Jones, 1915.

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Bulletin No. 3. Oil and Gas Possibilities of the Puertecito District, Socorro and Valencia Counties, New Mexico, E. H. Wells, 1919.

Bulletin No. 4. Fluorspar in New Mexico, W. D. Johnston, Jr., 1928. (Price 60 cents.)

[1]Bulletins 1, 2 and 3 were issued by the Mineral Resources Survey of the New Mexico School of Mines. They arc no longer available for distribution.

FLUORSPAR IN NEW MEXICO

PART I. MINERALOGY, GEOLOGY AND UTILIZATION

By WILLIAM DRUMM JOHNSTON, Jr.[1]

INTRODUCTION

PREVIOUS INVESTIGATIONS AND FIELD WORK

Since 1909 New Mexico has annually produced a small quantity of fluorspar, and in past years it has challenged Colorado's position as the principal producing state of the west.

In 1911 Darton and Burchard[2] published a description of the Sadler property near Deming. Ladoo, in 1922, visited a number of New Mexico properties which he described in a recent bulletin[3] of the Bureau of Mines.

In the summer of 1927 the writer undertook the field examination of all reported fluorspar deposits in the state. As the investigation progressed other occurrences were brought to his attention and by the spring of 1928 some 40 deposits had been visited. These deposits are described in Part II of this bulletin.

ACKNOWLEDGMENTS

In a limited field time a long list of examinations of properties scattered over as great an area as the state of New Mexico could have been accomplished only with the assistance of many men.

The writer gratefully acknowledges his indebtedness to all those who have facilitated his field work, and especially to Roy Beal of Heathdon, J. E. Connor of Redrock, L. H. Duriez of Fierro, C. B. Hanson and Blanchard Hanson of Hot Springs, F. M. Hayner of Las Cruces, H. D. Hill of Hatch, W. D. Howard of Deming, Benjamin Luchini of Derry, Leon Martin of Hatch and Octoviano Salcido of Percha Dam.

Most of the drawings were prepared by Sydney Helprin of the School of Mines.

All analyses listed, unless otherwise noted, were made by Harold Olsen of the School of Mines.

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[2] Darton, N. H., and Burchard, G. F., Fluorspar Deposits near Deming, New Mexico: U. S. Geol. Survey Bull. 470, pp. 533.545, 1911.

[3] Ladoo, Raymond B., Fluorspar. Its mining, milling and utilization, with a chapter on cryolite: U. S. Bureau of Mines Bull. 244, 1927.

THE NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

The New Mexico Bureau of Mines and Mineral Resources was established by the New Mexico Legislature of 1927. It was made a department of the New Mexico School of Mines, and hence its activities are supervised by the board of regents of that institution. The chief objects and duties of the bureau, as provided for in the law, are as follows:

To collect, to compile and to publish statistics relative to New Mexico geology, mining, milling, metallurgy and oil and natural gas and the refining thereof.

To collect typical geological and mineral specimens and samples of products; to collect photographs, models and drawings of appliances used in the mines, mills, smelters, oil wells, natural gas wells and the refineries of oil and natural gas in New Mexico.

To collect a library and bibliography of literature pertaining to the progress of geology, mining, milling, smelting and the production of oil and natural gas and refining the same in New Mexico.

To study the geological formations of the State with special reference to their economic mineral resources, both metallic and non-metallic.

To examine the topography and physical features of the State with reference to their practical bearing upon the occupation of the people.

To study the mining, milling, smelting operations and oil and natural gas production and the refining of the same carried on in the State with special reference to their improvements.

To prepare and publish bulletins and reports with *the* necessary illustrations and maps, which shall embrace both a general and detailed description of the natural resources and geology, mines, mineral deposits, both metallic and non-metallic, oil wells, natural gas wells, reduction plants, smelters, mills, oil refineries and natural gas refineries.

To make qualitative examinations of rocks and mineral samples and specimens.

To assist in the education of miners and prospectors through lectures and publications.

To consider such other kindred, scientific and economic problems and questions as in the judgment of the Board shall be deemed of value to the people of the State.

To communicate special information on New Mexico geology, mining, both metallic and non-metallic, oil and natural gas and to serve as a Bureau of Exchange and Information on the mineral, oil and natural gas resources of New Mexico.

To co-operate with the University of New Mexico, with the State Mine Inspector and with other departments of State Government as may be mutually beneficial and to co-operate with the United States Geological Survey and with the United States Bureau of Mines in accordance with the regulations of those institutions.

The bureau began to function officially with the opening of the 16th fiscal year, July 1, 1927.

MINERALOGY OF THE FLUORSPAR DEPOSITS

The minerals of importance in the fluorspar deposits of New Mexico are few in number and simple in chemical composition. Fluorite, calcite, barite, and quartz are the chief primary minerals of the veins. Galena is present in a few of the deposits. Gypsum occurs as a later mineral. Rarely some oxidized copper minerals are found in the outcrops, and in one instance vanadium minerals occur. Specularite was observed at one deposit. Fluorite is found as a gangue mineral in a wide variety of metallic deposits in New Mexico, but only such minerals as are associated with deposits in which fluorite is the principal economic mineral are here considered.

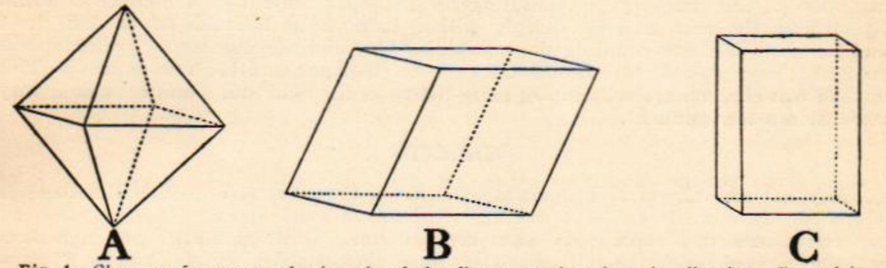

Fig. 1.—Cleavage fragments of minerals of the fluorspar deposits. A, fluorite; B, calcite; C, barite.

Detailed descriptions of the physical and chemical properties of the minerals of fluorspar deposits can be found in any text book on mineralogy.[1]

FLUORITE

Physical and Chemical Properties.—Fluorite, also called fluorspar or spar, is fluoride of calcium with the formula CaF,. Contains 4S.9 per cent fluorine and 51.1 per cent calcium when pure. Usually transparent to translucent, but dark-colored varieties may be nearly opaque. Isometric crystallization. Brittle, breaking with well-defined cleavage in four directions (planes). This cleavage gives fragments their characteristic octahedral shape as shown in fig. la. Each face of a cleavage fragment of fluorite usually forms an equilateral triangle. Crystals which grew in open spaces are cubical (fig. 2a). Color may be green, blue, rose, claret, purple, or white. It fades upon long exposure to light, and material which has been exposed in an outcrop for some time is invariably colorless or white. Hardness 4. Can be scratched by a knife but will not scratch window glass, (differing from quartz which will scratch window glass). Specific gravity ranges from 3.01 to 3.25.

When heated, fluorite decrepitates, breaking into fragments with a sound similar to popping corn. This test can be made in a shovel over a fire or on a hot stove. A number of blowpipe tests give distinctive reactions. In a closed tube at low heat some specimens become phosphorescent. When fluxed on charcoal it melts to a white opaque glass and colors the flame red. When heated with potassium acid sulfate or sulfuric acid, fumes are liberated which corrode or etch glass. The corrosion test is probably the most valuable of all the blowpipe reactions of fluorite.

[1]Butler. G. M., Mineralogy, Blowpipe Analysis, and Crystallography: John Wiley & Sons.
Ford, W. E.. Dana's Textbook of Mineralogy: John Wiley & Sons.
Kraus and Hunt, Mineralogy: McGraw-Hill Book Company, Inc.
Moses and Parsons, Elements of Mineralogy, Crystallography and Blowpipe Analysis: **D.** Van Nostrand Company.

Local Occurrences.—In the New Mexico deposits fluorite normally is associated with variable amounts of quartz and calcite and usually with barite. In veins in limestone the calcite content is always higher than in veins in calcite-free rocks. The quartz content is independent of the nature of the wall rock.

In most of the deposits the fluorite is green or light shades of purple or violet. Wel-formed, deep violet crystals occur at the Galena King mine. On the Bowman and Holt claims the fluorite is green, rose, deep claret, and blue. In the green and blue varieties the color is constant throughout the crystal, .but in the claret- and rose-colored fluorite the color is in zones parallel with one pair of cube faces.

Good cleavage **is** exhibited by fluorite from all of the deposits described except the Great Eagle mine in the Telegraph Mountains where some specimens were noted which broke with a conchoidal fracture. Subsequent microscopic examinations of this ore showed 12 to 14 per cent of quartz in minute crystals intimately intergrown with the fluorspar.

Fluorite when struck with steel in the dark emits blue sparks which contrast sharply with the yellow sparks emitted by material associated with it. The writer made use of this property in estimating the fluorspar content of a number of veins. By striking the vein material sharply with a hammer at intervals of one-half to **1** inch across a vein and counting the number of blue and the number of yellow sparks emitted it was possible to estimate the ratio of fluorspar to other vein minerals. This method was checked against detailed examination in the light and found to seldom vary more than a few per cent.

CALCITE

Physical and Chemical Properties.—Calcite is the mineral of which limestone is composed. It is a carbonate of calcium with the formula CaCO, and contains 44 per cent of carbon dioxide and 56 per cent of lime. Small quantities of magnesium are often present with the calcium. Hexagonal rhombohedral crystallization. Transparent to opaque. Brittle. Has excellent cleavage in three directions (planes) which give cleavage fragments in the shape of rhombs illustrated in fig. lb. The sides of such fragments of calcite are parallelograms which serve to distinguish it from fluorite with triangular sides and barite with oblong or square sides. Crystals which grew in open cavities and were free to develop symmetrically have the form of scalenohedra (fig. 2d) or rhombohedra similar to the cleavage forms (fig. lb). Usually white or colorless, although pale shades of red, blue, green, brown, and yellow sometimes occur. A dark brown calcite, whose color is due to clayey impurities, is often found in the New Mexico fluorite veins. Hardness 3. Can be scratched by a copper coin which distinguishes it from fluorite which cannot be scratched. Specific gravity 2.71.

Calcite is infusible. Upon heating in the open flame it becomes opaque and colors the flame red. Soluble in cold dilute acids, including strong vinegar, with vigorous effervescense and the liberation of carbon dioxide. Effervescence with acid serves to distinguish it from all other minerals occurring in the fluorspar veins of New Mexico.

Local Occurrences.—Some calcite always accompanies fluorite in deposits in limestone. It may occur as crystallized calcite deposited with the fluorspar, as the lining of vugs, or as limestone inclusions in the veins. Often it is present in veins in rocks other than limestone.

When crystallized with fluorspar it is usually white. A brown calcite replaces limestone on the Bonanza claim of the New Mexico Fluorspar Corporation properties in Woolfer Canyon in the Sierra de los Caballos. A similar occurrence was noted on the Lava Gap property in the San Andreas Range. It retains the laminae present in the original limestone.

GYPSUM

Physical and Chemical Properties.—Gypsum is a hydrous sulfate of calcium with the formula CaSO4. 2H20. Transparent to opaque. Silky or pearly luster. Monoclinic crystal system. Cleavage laminae are flexible but not elastic. Granular varieties are brittle. Breaks in flat plates similar to mica and is frequently mistaken for that mineral. Occasionally rhombs suggestive of calcite are found, but gypsum is readily distinguished by its softness. Usually white, but colored varieties of light

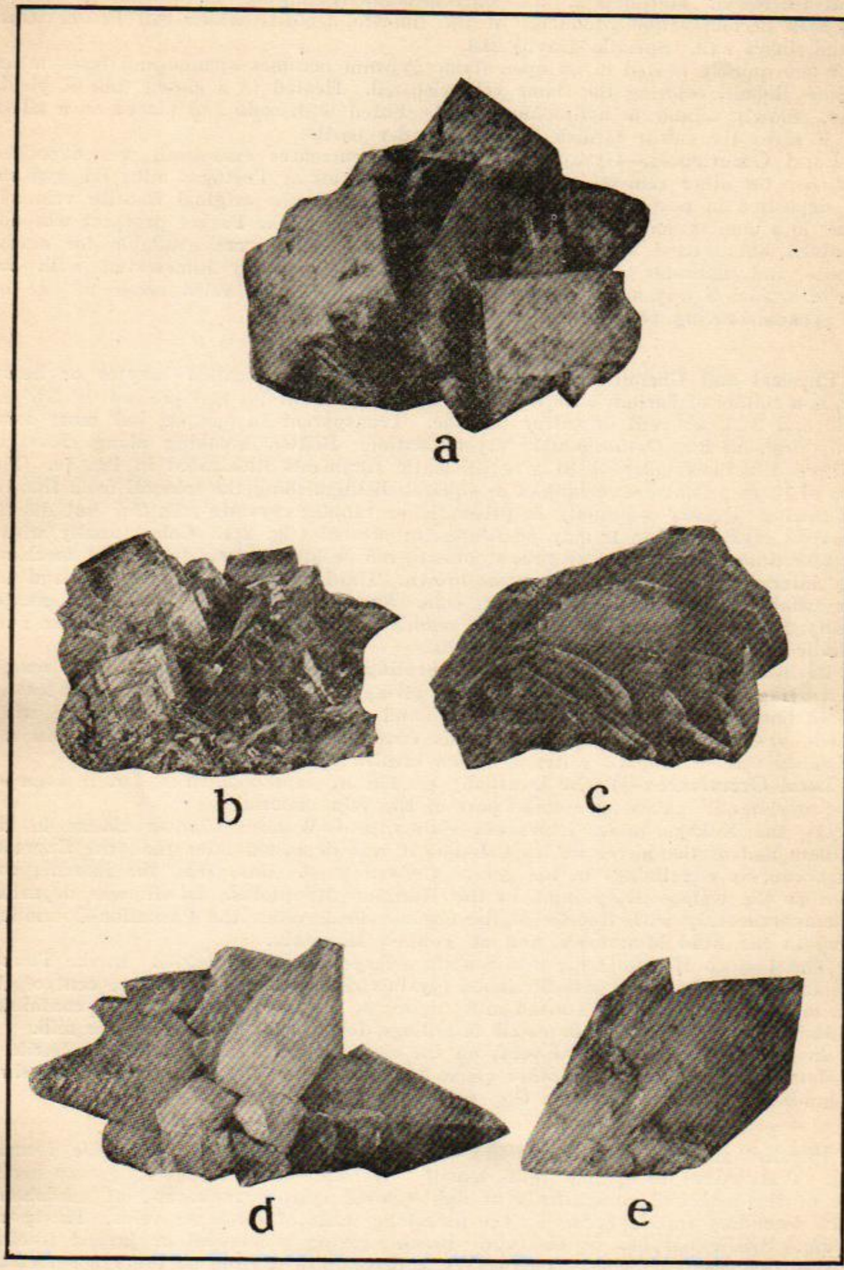

Figure 2.—Crystal forms of minerals of the fluorspar deposits. a, fluorite; b, barite; c, crested barite; d, calcite; and e, quartz.

shades are found. Hardness 2. The only mineral (excepting kaolin and associated wall rock decomposition products) of the fluorite deposits which can be scratched by the finger nail. Specific gravity 2.3.

When quickly heated in an open flame gypsum becomes opaque and fuses to an alkaline globule, coloring the flame yellowish-red. Heated in a closed tube it yields water. Slowly soluble in hydrochloric acid. Fused with soda and placed on a silver coin it gives the sulfur tarnish described under barite.

Local Occurrences.—Gypsum, in all field occurrences examined, was deposited later than the other vein minerals. In the upper levels of Tortugas mine the gypsum was deposited in post-fluorite fractures on pinches in the original fluorite vein. It occurs in a similar manner at the Lava Gap property. The Parker prospect was not examined but several specimens of ore from the veins were available for study. Selenite and alabaster varieties of gypsum were intimately interwoven with the fluorite in such a way as to suggest strongly that the Parker veins occur in one of the gypsum-bearing beds of the Chupadera formation.

BARITE

Physical and Chemical Properties.—Barite, sometimes called barytes or heavy spar, is a sulfate of barium with the formula $BaSO_4$. Contains 65.7 per cent of barium oxide and 34.3 per cent of sulfur trioxide. Transparent to opaque, but most commonly translucent. Orthorhombic crystallization. Brittle, breaking along cleavages in three directions (planes) to give prismatic fragments illustrated in fig. 1c. The faces of these prisms are rectangles or squares distinguishing, the mineral from fluorite and calcite. Occurs commonly in prismatic or tabular crystals (fig. 2b) but due to imperfect crystallization it may be fibrous or crested (fig. 2c). Color usually white, but sometimes light shades of yellow, brown, red or blue occur. Impurities mechanically intergrown may color it gray or brown. Hardness ranges between 2.5 and 3.5. Can usually be scratched by a copper coin. Specific gravity 4.3 to 4.6. Its greater density (hence the name, heavy spar) readily distinguishes it from the other nonmetallic minerals of the fluorspar deposits.

Barite, like fluorite, decrepitates upon heating. Insoluble in acids. Can be readily fused with charcoal or in platinum forceps, giving a yellowish-green flame and leaving an alkaline residue. If mixed with soda and fused on charcoal an opaque white globule or crust will be formed. If this crust is scraped upon a silver coin and moistened with a drop of water a brown tarnish will form on the silver.

Local Occurrences.—Barite is usually present in small quantities, but in some of the properties it makes up a large part of the vein material.

At the Nakaye mine, Esperanza claims, and Woolfer Canyon claims in the southern end of the Sierra de los Caballos it was deposited later than the fluorspar and occurs as vug linings in the veins. Crested barite, later than the fluorite, was noted at the Galena King mine in the Manzano Mountains. Barite was deposited contemporaneously with fluorite in the Capulin Peak veins, the Carnation-Columbine group in the Zuni Mountains, and at Tonuco Mountain.

The Tonuco Mountain deposits contain a large amount of barite. In the Tonuco vein it is in large platy, well-developed crystals comprising 20 to 40 per cent of the vein material. By the old Tonuco mill there is a pile of impure barite containing 200 tons or more which accumulated as tailings during the short run of the mill.

In some parts of the Beal veins on the east side of Tonuco Mountain barite is the dominant mineral, and in other places fluorite is the chief vein mineral. A similar gradation occurs in the Lava Gap vein.

QUARTZ

Physical and Chemical Properties.—Quartz is silicon dioxide with the formula SiO,. Transparent to opaque but usually translucent. Vitreous to greasy luster. One of the principal constituents of light-colored igneous rocks and of sandstones. Much secondary quartz occurs in the limestone walls of fluorspar veins. Hexagonal system. Brittle but has no cleavage. Breaks giving conchoidal or jagged fracture surfaces that are not planes. This serves to distinguish it from all other non-metallic minerals in the fluorspar veins. When free to develop crystals it forms six-sided prisms capped by pyramids (fig. 2e). Hardness 7. Will scratch all other minerals found in fluorspar deposits. Specific gravity 2.65. Usually white or colorless.

Colored varieties are smoky quartz, which is gray-brown to black; rose quartz; amethyst, the purple variety; and citrine, which is yellow. Chert is an amorphous silica, white to light gray in color. When dark it is known as flint. Jasper is a red to red •brown amorphous form. Chert having a pink to light red cast is often called jasperoid.

Quartz is insoluble in all acids except hydrofluoric. With soda it fuses to a clear opaque bead with marked effervescence.

Local Occurrences.—Quartz occurs in all of the fluorspar deposits as vug linings, crystals interwoven with the fluorspar, or as silicification of the wall rock. Jasperoid and chert are of common occurrence.

Often the quartz was deposited in a number of generations. At least three are recognizable in the Universal vein of the Fluorspar Mines of America at the north end of the Sierra de los Caballos.

At the Great Eagle mine in the Telegraph Mountains in Grant County quartz and fluorspar are intimately mixed. Specimens examined microscopically showed a complete transition from cherty material containing minute spherules of fluorite to fluorspar containing less than 1 per cent of quartz.

The siliceous ore of the northern end of the Sierra de los Caballos and of the Lida-K vein demand special milling treatment. Milling difficulty increases in direct proportion to the intimacy of the fluorspar-quartz intergrowth.

GALENA

Physical and Chemical Properties.—Galena is a sulfide of lead having the formula PbS. Contains 86.6 per cent lead and 13.4 per cent sulfur. Occurs in lead-gray cubical crystals often disseminated in limestones and vein material. Has a metallic luster and lead-gray streak. Isometric system. Brittle, •breaking along three cleavage planes to give cubic fragments. Hardness 2.5, easily scratched by a copper coin. Specific gravity 7.5.

When heated on charcoal with soda a malleable bead of lead is formed. Soluble in hot hydrochloric and strong nitric acids with the separation of a precipitate in each case.

Local Occurrences.—Galena is the chief ore mineral of lead deposits. It is found in many of the fluorspar deposits, some having been worked originally for the galena content. It was deposited contemporaneously with the fluorspar.

A number of fluorspar deposits have galena in amounts which may warrant its recovery. The White Star vein of the Fluorspar Mines of America, the Harding group, the Lida-K vein, the Esperanza group, the Capulin Peak vein, and the Dewey mine vein can be so regarded. The Dewey mine and the Galena-King mine were originally developed as lead deposits.

MINOR MINERALS

Anglesite.—Anglesite, lead sulfate, (PbS0,) is common in the oxidized zone of lead-bearing veins as an alteration product of galena. Good anglesite specimens were obtained at the Galena King mine in the Manzano Mountains. The mineral was also observed at the Capulin Peak prospect in the Sandia Mountains, in the White Star vein of the Fluorspar Mines of America, the Lida-K vein, and in the Esperanza group near Derry, all in the Sierra de los Caballos.

Copper Carbonates.--Malachite and azurite, both copper carbonates, occur **as** stains in the outcrops of a number of fluorspar veins. The White Star vein of the Fluorspar Mines of America, the veins of the Harding prospects, Juan Torres prospect in the Ladrone Mountains, and the Tyrone prospect, all show some copper stains. Primary copper minerals were not observed in any of the copper carbonate occurrences.

Chalcocite.—Chalcocite (Cu,S) occurs as a secondary mineral in the fluorspar-quartz veins at the Juan Torres prospect in the Ladrone Mountains and at the east end of the Dewey vein in the Joyita Hills. In the Dewey vein chalcopyrite was the primary copper mineral.

Vanadium Minerals.—Vanadinite and cuprodesdoizite are reported by Hess, from the veins of the Harding prospects. They are associated with barite, calcite, fluorite, quatz, galena, cerussite, malachite and azurite.

[1]Hess, F. L., U. S. Geol. Survey Bull. 530, pp. 157.160; 1910..

Specularite.—A small amount of the variety of hematite (Fe_2O_3) known as specularite occurs in the Juan Torres vein in the Ladrone Mountains adjacent to an andesite dike.

Secondary Minerals Formed by Wall-rock Alteration.—Kaolin, sericite and chlorites are commonly developed in the wall rock of the fluorite veins and in horses and inclusions of wall rock which have been included in, the vein material. Scricitization of the granites is extensive adjacent to the Lida-K vein and kaolin and chlorite are developed in the schists on the footwall of the Tonuco vein.

GEOLOGY OF THE FLUORSPAR DEPOSITS

FORM AND CHARACTER OF THE DEPOSITS

Fluorspar in New Mexico occurs as vein fillings in igneous and sedimentary rocks and as replacements in limestone. Veins in limestone are usually accompanied by some replacement of the wall rock.

VEINS

The veins are variable in form and character. Without exception they appear to be fillings of pre-existing fractures, and no direct evidence of injection of vein-depositing solutions under pressure was observed. While clean-walled fissures are most abundant, breccia cemented veins are common. Occasionally, as at the White Star and Oakland veins of the Fluorspar Mines of America near Hot Springs, simple veins pass horizontally into sheeted zones. Banding is not always conspicuous, but where barite or calcite is present in large amounts as a primary vein mineral a rough banding is usually present. In some of the siliceous ores, as at the 2 de Abril claim in Woolfer Canyon near. Garfield, delicate banding in the smaller veins is common. The veins occur in many types of country rock, including granites, schists, monzonites, rhyolites, latites, shales and limestones.

REPLACEMENTS

While a few veins have fresh sharp walls, some replacement by fluorite of the wall rock and included fragments and horses occurs in most of the veins in limestone. The Nakaye mine near Derry is essentially a replacement deposit. There, on the borders of fracture zones, certain favorable limestone beds capped by impervious clayey limestones are completely replaced by fluorite. As the main fractures are filled with gouge and impervious to ore-depositing solutions no veins were formed.

Much secondary quartz sometimes accompanies the replacement of limestone by fluorspar. Thin sections of the Nakaye ore on the outer edge of the replacement usually show a narrow band of quartz advancing into the limestone just ahead of the fluorspar. This quartz band appears to be later replaced by fluorite. A similar sequence of replacement was observed at the Esperanza claim of the New Mexico Fluorspar Corporation near Derry (fig. 15). An analogous case in which granite breccia fragments were replaced by quartz deposited from fluorite-bearing solutions was observed at the Tonuco mine and is elsewhere described.

TENOR IN DEPTH

The greatest depths to which New Mexico fluorite veins have been followed is 320 feet at the Galena King mine and 286 feet at the Tortugas mine. In both instances no change in tenor of the ore occurred.

As the fluorspar veins are simple fissure fillings their shape and extent is determined by the shape and extent of the pre-existing fractures. There is no reason to expect a consistent pinching of such fissures at depths less than 1000 feet and mineralization can be expected to be fairly continuous to that depth at least.

LATERAL VARIATION

A number of New Mexico fluorspar veins shcw conspicuous lateral variation in the vein material. This is particularly true for the Lava Gap property of the Fluorspar Mines of America (fig. 38) where fluorite grades laterally into barite. In a number of the veins on Tonuco Mountain the lateral variation from fluorite to barite is conspicuous. It is to be expected that this variation will occur vertically as well as horizontally, but development of the two properties mentioned is insufficient to expose such vertical variation.

The change in the character of the vein material can readily be explained by assuming that the ore-depositing solutions were moving and varied somewhat from time to time in composition.

CHARACTER OF THE OUTCROPS

Fluorspar outcrops are seldom conspicuous. Exceptions are the siliceous ores such as occur at the Lida-K property of the Southwestern Flourspar Corporation where the vein stands as a dikelike ridge as much as 20 feet above the weathered country rock (fig. 10). Usually, however, the outcrop is marked by residual fragments of white fluorspar, sometimes iron stained, which are mixed with fragments of country rock. Fluorspar at the outcrop is always white, as sunlight bleaches the color from the mineral. Loose fragments of fluorite on hillsides and in ravines may lead to the discovery of new deposits. Such occurrences should be traced to the outcrop as any other float mineral would be.

ORIGIN OF THE DEPOSITS

The table at the end of the report summarizes the geological occurrence of the New Mexico fluorspar deposits.

TERTIARY HISTORY OF NEW MEXICO

All of the fluorspar deposits are in mountainous areas in which volcanic activity occurred during the Tertiary and they owe their origin to that activity.

Lindgren, Graton, and Gordon[1] in summarizing the Tertiary and Quaternary events in New Mexico say:

At the close of Cretaceous time the long-maintained condition of quiescence and scarcely broken periods of deposition *ceased*. Here, as elsewhere in the Rocky Mountain region, the deposition of the Cretaceous beds was followed by an epoch of igneous activity and of mountain building, during which the most important of the mineral deposits of the Territory were formed. Intrusions of large masses of monzonitic magmas seem to have constituted the first step; they were forced it underneath the pliable and tough mantle of Cretaceous sediments, bulging it in laccolithic fashion. Their distribution corresponds with the zone of orogenic disturbance and with the belt of mineral deposits extending across the Territory in a north-northeast and south-southwest direction. The marine conditions ceased, but during the Eocene lake basins were probably established in the northwestern part of New Mexico, possibly also elsewhere.

Mountain building accompanied and succeeded intrusion. 'While conditions still remained quiescent in eastern and northwestern New Mexico, tremendous forces were at work in the southward extension of the Rocky Mountain region. The old pre-Cambrian core in the north seems to have been forced upward by faulting, or by warping followed by faulting. Farther south the sediments were broken along north-south lines and the characteristic New Mexican monoclinal ranges were created, the prototype of the "Great Basin structure," which in fact is far more characteristically developed in this region than in the area from which it receives its name. * * * * It is sufficient to say that the Sandia, Oscura, San Andreas, Caballos, Organ, and other ranges, which lie in the southern continuation of the Rocky Mountain uplift, clearly show this combination of a fault scarp, facing east or west, with a monocline sloping gently in the opposite direction. Folding is absent or only slightly developed.

During the same epoch the desert ranges of the southwestern part of New Mexico were outlined by intrusions and by faulting, though here the monoclines are far less conspicuous and erosion seems to have been the most active factor in producing the present mountain forms.

A general uplift of the plateau province, and to a less degree of the whole Territory, accompanied this orogenic disturbance, the major features of the present drainage system were outlined and, of course, erosion at once began its work of exposing the deeper strata and the intrusive rocks

A second epoch of igneous activity, distinctly separate from the first epoch of intrusion, began, prdbably in the middle Tertiary, and vast masses of andesitic and rhyolitic flows were extruded. The flows, which in places are 2,000 feet or more thick, rest on the old sedimentary rocks, beveled by erosion, on the earlier intrusive rocks, or on the pre-Cambrian granites and gneisses. * * There are several minor areas in the ranges of the extreme southwest, but the largest field of rhyolites, latites, and andesites is that extending from the vicinity of Socorro to the south end of the Mimbres Range and thence westward to Silver City, the Mogollon Mountains and over into Arizona. * * *

Toward the dose of the Tertiary there was a third outbreak of igneous activity. Basalts were erupted in large quantities and spread over vast areas, covering the Santa Fe marl, the eroded older sediments, or the intrusive rocks. Such basalt flows cover considerable areas in various parts of the Territory; for instance, at Raton, in the foothills east of the Mora uplift, along the northern course of the Rio Grande, and at many points farther south along the same river. * * *

Basaltic eruptions continued during the Quaternary period and such eruptions of minor extent have taken place very recently. During the early part of the Quaternary there was a heavy accumulation of land deposits, forming masses of coarse gravels (known as the Palomas gravel), which filled many of the structural troughs to a depth of about 1,000 feet. Basalt flows were poured out again after the deposition of these gravels, and smaller flows of recent age, possibly erupted only a few hundred years ago, are found in eastern Socorro and Otero counties, and westward Dona Ana and Valencia counties.

[1]Ore Deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 32-33, 1910.

AGE OF THE DEPOSITS

Flourspar deposition probably was concurrent with the intrusion of the larger masses of monozonite porphyry, and it may have occurred here and there throughout the whole of the volcanic cycle. The deposits of Tonuco Mountain in northern Dona Ana County antedate the thick pyroclastics and mud flows which make up the mountain. The Cooks Range deposits came after the monzonite intrusion, and Lindgren[1] described flourite veins at Ojo Caliente adjacent to a flouritebearing thermal spring which are of recent date.

In the table at the end of the report the distance between the fluorite deposits and the nearest outcrop of an igneous rock which may bear a genetic relationship to the fluorite is shown. In no instance is the relationship established beyond doubt, but the persistent association of flourite and igneous rocks appears to be significant. In the Sierra de los Caballos the distances to the nearest known outcrops of Tertiary igneous rocks are sometimes great. Detailed field examinations in the vicinity of the deposits, impossible for lack of time in the fluorspar studies, might reveal nearer outcrops. In the Manzano and Sandia Mountains igneous activity was probably deep seated and intrusive masses did not ascend through the pre-Cambrian rocks.

PRIMARY MINERALS OF THE FLUORSPAR DEPOSITS

The chief primary minerals of the fluorite deposits of New Mexico are fluorite, barite, calcite, quartz, galena, pyrite, chalcopyrite and specularite. With the exception of specularite, they are characteristic of mesothermal[2] to epithermal conditions. The occurrence of small amounts of specularite adjacent to a dike in one deposit is of little moment in the consideration of the general conditions of temperature and pressure under which the deposits of the state were formed. The list of secondary minerals includes limonite, manganese oxides, malachite, cerussite, chalcocite, vanadinite, cuprodescloizite, chrysocolla, anglesite and gypsum.

WALL ROCS ALTERATIONS

There is great variation in the character and extent of wall rock alteration adjacent to the fluorspar veins. Replacement by fluorspar

[1]Lindgren, Waldemar, The Hot Springs at Ojo Caliente: Econ. Geol. Vol. V, No. 1, pp. 22-27, 1910.

[2]In his textbook entitled "Mineral Deposits" (McGraw-Hill Book Co., Inc., New York City) Waldemar Lindgren classifies ore deposits whose origin is connected with igneous rocks as: (1) Liquid-magmatic, (2) pyrometasomatic, (3) pegmatites, (4) hydrothermal, (5) mesothermal, and (6) epithermal. Mesothermal ore deposits arc those formed at intermediate temperatures-175° to 300° C.— and at depths of 4000 to 12000 feet below the surface by ascending thermal waters connected genetically with igneous rocks. Epithermal deposits arc those formed less than 4000 feet from the surface and at temperatures of 50° to 200° C. by ascending thermal waters connected genetically with igneous rocks.

is common in limestone. Silicification occurs both in limestones and igneous rocks. Sometimes the silicified limestones take on the appearance of chert, and the original character of the rock can be determined only in thin sections. In such occurrences the quartz is colloidal. Silicification of granites, latite porphyries, and mica schists was observed. In the igneous rocks, particularly those with coarser textures, the secondary quartz is crystalline and first appears in the feldspars. Often a band of secondary quartz is present which seems to have advanced into the wall rock as a wave.

Sericitization is possibly the most prevalent type of wall rock alteration in the igneous rocks. It may be confined to the walls immediately adjoining the veins or it may extend into the country rock several hundred feet.

Some chloritization of the basic mineral of the metamorphic rocks adjacent to fluorspar veins was observed, but in the occurrences noted this alteration, like the development of kaolin in the wall rock, can be attributed to ordinary weathering processes as easily as to chemical activity at the time the veins were formed.

CONCLUSIONS

From a consideration of the geological evidence the following conclusions concerning the origin of the fluorspar deposits were derived:

1. Mineralization in all of the deposits was concurrent with the volcanic cycle which began in the early Tertiary, but in that sense only can they be considered to be contemporaneous.

2. The wall rock alterations and geological setting of the deposits point to a lack of uniformity in the temperature and pressure conditions under which they were formed. The mineral suite is characteristic of mesothermal to epithermal deposits. It is probable that some of the veins were formed under conditions of moderate temperature and pressure and some as near surface or even hot spring deposits..

LOCALITIES FAVORABLE FOR PROSPECTING

Most of the fluorspar deposits which have been discovered in New Mexico are located in the southern and southwestern part of the state. They occur in the Caballos Mountains, San Andreas Mountains, Oscura Mountains, Organ Mountains, Little Florida Mountains, Cooks Range, Little Burro Hills, Telegraph Mountains, Glenwood Mountains, Little Burro Mountains, and Mogollon Mountains. The Zuni Mountains in the northwestern part of the state and the Sandia Mountains and Manzano Mountains near Albuquerque have fluorspar deposits. These ranges may contain other deposits and additional prospecting in them is desirable. Fluorspar in important amounts may also occur in other places in New Mexico.

In the past some fluorspar, because of its resemblance to such rock-forming minerals as quartz and calcite, has doubtless been overlooked by those who sought metallic deposits. It is hoped that this bulletin will direct the attention of the prospectors of the state to fluorspar, and that any new deposits which they encounter will be recognized.

MINING, MILLING AND MARKETING

MINING

The mining of fluorspar in New Mexico presents no problems peculiar to the ore. In every case where development has passed the prospecting stages a vertical or inclined shaft was sunk on the vein, drifts were driven along the plane of mineralization, and the ore mined by overhead stoping.

The maximum depth attained in a single shaft is 286 feet at the Tortugas mine in Dona Ana County. Here ore is stoped from raises and run down chutes to the lower level from which it is hoisted to the surface.

At the Fluorspar Mines of America property near Hot Springs the vein material on the face of the hillside is mined in benches and dropped through chutes to the lower adit to be loaded into mine cars.

Because of the small size of most of the high-grade deposits, development work has been limited, and permanent installations in shafts and adits have been avoided. In the course of the field investigation many old workings could not be entered with safety because of inadequate timbering and poor mining methods.

MILLING

An excellent discussion of the milling methods used in the principal fluorspar producing districts of the United States is contained in a recent publication by Ladoo[1].

The beneficiation of fluorspar ores is accomplished by mechanical processes which take advantage of certain physical properties of fluorspar which differ in a greater or lesser degree from analogous physical properties of the associated minerals. Such properties of fluorspar upon which successful concentration processes have been based are (1) specific gravity, (2) size of crystals, and (3) disruption on heating.

Jigging, tabling, and air classification are dependent upon specific gravity, selective screening upon size of crystals and cleavage fragments, and decrepitation upon the disruption of fluorite on heating.

Gravity Separations.—Both jigs and tables are used in the New Mexico mills.

The specific gravity of the minerals of the New Mexico fluorspar deposits is as follows:

[1]Ladoo Raymond B. Fluorspar, its mining, milling and utilization. with a chapter on cryolite: U. S. Bureau of Mines Bull. 244, pp. 35-53, 1927. This publication, the price of which is 35 cents, can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Quartz	2.65—2.66
Calcite	2.71—2.72
Fluorite	3.01—3.25
Barite	4.3 —4.6
Galena	7.4 —7.6

The Tortugas mill at Mesilla Park employs 4 Hartz jigs each with 4 cells. The first jig handles —1/8 inch material, the second +1/8 to —¼, the third +¼ to —½, and the fourth +½ to —3/4. The head feed contains about *75* per cent fluorite.

ANALYSES OF JIG PRODUCTS, TORTUGAS MILL, AUG. 12, 1927.

	CaF_2	$CaCO_3$	SiO_2	$Al_2O_3+Fe_2O_3$
Head Bin	75.85	14.85	8.55	0.75
-⅛" jig, sieve product				
Cell 1	94.52	2.57	2.09	0.82
Cell 2	66.29	25.94	7.08	0.69
+⅛" to -¼" jig, sieve product				
Cell 1	93.37	2.88	2.87	0.88
Cell 2	73.63	16.42	8.29	1.66
+¼" to -½" jig, sieve product				
Cell 1	85.82	4.14	7.47	2.52
Cell 2	60.63	24.32	14.26	0.8
+½" to -¾" jig, sieve product				
Cell 1	75.23[1]	9.76	12.76	2.25
Cell 2	78.28[1]	11.38	8.21	2.13
Waste from dump	24.22	50.43	20.13	5.22
Ground product[2]	94.92	2.55	1.61	0.92

[1]Sieve product is hand picked.
[2]Enriched by addition of hand picked acid lump from sorting platform at mine.

More careful supervision and adjustment of the jigs would doubtless yield a higher grade product.

Jigs were also used at the Nakaye and the Tonuco mills but did not prove satisfactory. In milling the Tonuco ore, which is high in barite, much fluorite was lost in the barite concentrates.

The wet plant of the Fluorspar Mines of America at Hot Springs employs two double-deck Deister Plat-0 tables for cleaning the product of the decrepitation plant. Head feeds at the wet plant are ground to pass 100 mesh. The flow sheet of the mill is shown in fig. 8.

In speaking of the Hot Springs mill, Mr. B. J. Roberts[1] says:

> Concentrating tables on this material apparently have a very low capacity, but in reality such is not the case. The revenue derived from the operation of concentrating tables is of course based on the quantity of marketable minerals coming off as **a** concentrate, and not on the tonnage of raw feed coming to the table. Ore concentrating tables, and particularly those of the plateau type, will have a high capacity when considered from the feed or raw material standpoint. As a rule, however, 15

[1]Sales manager, Deister Machine Co. Personal communication to the writer.

to 20% mineral is very high, while the average will be more nearly around 4 or 5 per cent—these percentages representing the approximate quantity of marketable mineral products coming off of the concentrate discharge end of the table. The balance of the original feed comes off as a tail along the tailing discharge edge.

In the case of the fluorspar at Hot Springs, between 90 and 95 per cent of the feed is valuable and should be taken off as a concentrate. This means that the capacity of the table is the quantity of marketable fluorspar which it can remove on the concentrate discharge end, plus the 10 per cent or more of waste material the original feed contains. An increase in the quantity of waste material in the original feed would result in a higher "feed capacity," but would in no wise increase the monetary returns from the work of the table.

The results so far received on sampling which was taken of the work of the table on original feed, show that the feed carried 95 per cent CaF2, while the resultant concentrates had an average of 98 per cent CaF2, 1.2 per cent SiO, and 0.7 per cent $CaCO^3$.

As a further test a truck load of tailings from previous operations was run over the table. The analytic results on this work showed a concentrate product carrying 96.78 per cent CaF2, 2.8 per cent SiO', and .35 per cent CaCO'. This tailing material was in bad shape, having become mixed with sand and dust blowing across the country, and also had considerable oversize particles.

According to Mr. W. H. Coghill[1], close and accurate sizing is essential for successful gravity separation of fluorspar. Jigging is efficient on sizes between five-eighths of an inch and 2 mm., and tabling on smaller material. The concentration of fluorspar has its own technique which must be mastered in order to obtain satisfactory results.

Decrepitation.—Certain minerals including fluorite and barite are mechanically disrupted by heat. The decrepitation process takes advantage of this property.

The first-described mill for the decrepitation of fluorspar is on the Rock Candy group of the Consolidated Mining and Smelting Company at Trail, British Columbia. In describing the mill, Freeland[2] says:

The fluorite is brought approximately two miles from the mine to the mill over an aerial tram, and then dumped in bins of 250 tons capacity. From thence it Is distributed by apron feeds through a 20 by 10 inch Blake crusher and elevated to a trommel screen of one-fourth inch mesh, the oversize passing through two sets of rolls set to three-eigths inch and one-fourth inch respectively. All products then pass through a rotary dryer 14 feet long and 3 feet 2 inches in diameter, which is heated by the waste gases from the kilns. This product is again elevated and passed over three sets of impact screens, the feed for No. 1 kiln being plus one-fourth inch, No. 2 kiln being minus one-fourth inch or plus No. 8, and No. 3 kiln being minus No. 8 or plus No. 15.

The minus No. 15 makes up the middling product. The smalls from No. 2 screen *give* the best results for decrepitation, making a product containing about 2 per cent silica. The rotary kilns are 14 feet long and 3 feet 2 inches wide and make 3 revolutions a minute. About 1,200° Fahr. is the necessary temperature for decrepitation. The middling product contains about 5 per cent. silica and is used locally for making acid, and also for adjusting the concentrates to meet specifications. After decrepitation takes place the product is slowly elevated to permit cooling •before being finally screened and stored ready for shipment.

Decrepitation is used in two mills in New Mexico, the Fluorspar Mines of America (flow sheet shown in fig. 8) and the Southwestern

[1]Coghill, W. H., Metallurgist, U. S. Bureau of Mines, Rolla, Mo. Verbal communicaiton to B. H. Wells.

[2]Annual report of the Minister of Mines, British Columbia, p. 165, 1919.

Fluorspar Corporation (flow sheet shown in fig 11). In both instances the ore is free from barite, and fluorspar is the only decrepitating mineral present.

The kiln at the Fluorspar Mines of America is small and will probably prove inadequate for handling a profitable tonnage of ore. That at the Southwestern Fluorspar Corporation's mill, which is 36 feet long and 31 inches in diameter, was designed by Leon Martin, superintendent of the Lida-K property.

During decrepitation the fluorspar flies to pieces, freeing itself from the larger quartz and calcite masses. Screening following decrepitation effects a partial separation of fluorspar and the impurities. n optimum mesh for most efficient concentration exists for each ore and kiln and must be determined by experiment. The Fluorspar Mines of America employ a 40-mesh screen which results in large ore losses. The Southwestern Fluorspar Corporation have tentatively selected a 16-mesh screen.

Decrepitation will doubtless play an important role in the milling of New Mexican ores, particularly those which are too siliceous to be successfully handled by gravity methods. Fluorspar losses are heavy, but at the present stage of milling development a marketable product cannot otherwise be obtained.

Selective Screening.—In the past a number of unsystematic attempts have been made to screen New Mexico ore for the separation of fluorspar from its associated minerals. The attempts have been unsuccessful due to random efforts rather than unsoundness in the method. In some ore the fluorite breaks in the course of mining into finer particles than does the quartz and calcite associated with it. Proper screening of the gravel grade often results in an increase of the fluorspar content.

UTILIZATION OF FLUORSPAR

The steel industry is the principal consumer of fluorspar. It is used as a flux in the furnace charge in the manufacture of basic open-hearth steel, 7 or 8 pounds being required for each ton of steel produced. The amount so used in the United States during 1926 was 91,760 short tons. Lesser amounts are used by foundries in cupola charges and in the manufacture of ferro-alloys and electric furnace steel. Small amounts of higher grade spar are required for special metallurgical processes as the manufacture of nickel and the reduction of aluminum.

In the ceramic industries fluorspar finds use in the manufacture of opal glass and of enamels for coating steel and other metals. A small amount is occasionally used in burning cement mixtures.

Fluorspar with a high CaF_2 content is the basic material for the manufacture of hydrofluoric acid. Small amounts have other chemical uses as a flux or catalyst. Artificial cryolite for use in the reduction of bauxite is prepared from fluorite.

Occasionally lumps of colorless and flawless fluorspar can be sold for optical use. Such material commands an excellent price. Pogue[1], in a bulletin of the Illinois State Geological Survey, has described in detail the properties, uses and value of optical fluorite.

MARKETING[2]

The marketing of fluorspar from western localities follows the practice established in the Kentucky-Illinois fields. Minor departures from this practice are occasionally feasible, and it is to be hoped that western fluorspar producers will in time be in a position to make such alterations of specifications and sales terms as are justified by the quality of their product and their remoteness from the eastern markets.

SPECIFICATIONS

Grading of commercial fluorite is based upon its content of calcium fluoride and various impurities into acid, ceramic, and metallurgical spar. Further division is based upon the size of the particles; lump, gravel, and ground spar being recognized. This dual classification gives nine grades, not all of which, however, have a market demand.

Acid Grade.—Fluorspar containing 98 per cent or more of CaF_2 and less than 1½ per cent of silica is of acid grade. Some consumers specify 99 per cent CaF_2 and less than 1 per cent of silica, but such specifications are met with difficulty by western ore. Calcium carbonate should be less than 1 per cent and the ore should be free from metallic sulfides. Lump, gravel, and ground grades are purchased, but most acid manufacturers prefer to buy the lump and grind it at the plant. A lower grade fluorspar can be used for acid making, but manufacturers naturally prefer to purchase the higher grade material.

A sample of acid-grade spar[3] from the Kentucky-Illinois field contained 99.07 per cent CaF_2, 0.23 per cent CaO, 0.24 per cent SiO_2, 0.29 per cent $Al_2O_3+Fe_2O_3$, 0.15 per cent CO_2, and 0.18 per cent S.

Acid grade is also required for the production of nickel and monel metal and the reduction of aluminum.

Ceramic Grade.—Davis[4] quotes the following specifications of a large consumer of fluorspar in the glass industry as follows:

[1]Pogue, J. E., Optical Fluorite in Southern Illinois: Illinois State Geological Survey Bull. 38, pp. 1-7, 1918.

[2]Good discussions of the marketing of fluorspar are contained in the following books: Spurr and Wormser, Marketing of Metals and Minerals: McGraw•Hill Book Co., Inc. Ladoo, Fluorspar, its mining, milling and utilization: U. S. Bureau of Mines Bull. 244. Ladoo, Non-Metallic Minerals: McGraw-Hill Book Co., Inc.

The latest number of Mineral Resources of the United States, published by the Bureau of Mines. should also be consulted.

[3]Davis, H. W., Fluorspar and Cryolite in 1926: Mineral Resources of the U. S., pt. II, p. 34.

[4]Davis, H. W., op. cit., p. 33.

Our specifications call for a limit of 0.12 per cent iron oxide content. Really we would object strongly if we obtained much fluorspar with that much iron in it, as it colors the glass, and we have been receiving fluorspar from responsible sources around 0.06 per cent.

Calcium fluoride content has been placed at a minimum of 90 per cent. However, we received most of it well above 95 per cent, and our price is based on that. If the diluting material is something such as silica which is used in the glass, it would not interfere with the process, but would with the price.

Calcium carbonate content must not vary too much as it affects the formula used in the *glass* batch. We do not want lead, zinc, or sulphur, so this specification is not a usual one in the glass trade. We do this because we neutralize these materials rather accurately, and too much of them will give us an off shade in color.

All our material is bought in bulk and is finely ground, generally nearly 100 mesh. We can stand considerable variation in this.

Enamel manufacturers specify either 90 or 95 per cent fluorspar, but upon previous arrangement they sometimes accept slightly lower grade. Although they buy all sizes, they prefer material ground so that 80 per cent passes through a 100 mesh screen. Iron, lead, zinc, and sulfur are objectionable impurities.

ANALYSES OF FLUORSPAR USED IN THE MANUFACTURE OF GLASS AND ENAMEL[1]

CaF_2	SiO_2	Fe_2O_3	Al_2O_3	$CaCO_3$	$MgCO_3$	S
Per Cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
97.86	0.72	0.06	0.08	1.01	0.26	Trace
97.403	1.55	0.14	0.26	0.54	—	0.027
96.92	1.24	0.88	—	1.28	—	—
97.15	1.60	0.08	—	0.90	—	—

Metallurgical Grade.—Metallurgical spar should contain at least 85 per cent CaF_2 and not more than 5 per cent SiO_2 to meet existing market specifications. Occasionally a lower percentage of fluorspar is acceptable in purchased ore. Although some steel manufacturers use spar from their own mines with CaF_2 content as low as 75 to 78 per cent, they object strongly if purchased ore does not meet the 85-5 specification, even though adjustment will be allowed by the shipper.

In discussing the silica-fluorspar ratio Davis[2] says:

As generally computed, one part of silica requires 2% parts of fluorspar to flux it; a fluorspar containing 85 per cent of calcium fluoride and 5 per cent of silica would be equivalent to 72% units of net calcium fluoride. With some manufacturers a sliding scale is acceptable, and for each 21/2 unite of calcium fluoride above 85 per cent the silica is allowed to go up 1 per cent. In other words, a fluorspar containing 87% per cent of calcium fluoride and 6 per cent of silica is equivalent to one containing 85 per cent of calcium fluoride and 5 per cent of silica. As a rule, there are no guarantees on the other elements, but the consumer prefers the absolute minimum of the lead and zinc. However, fluorspar carrying as little as 80 per cent of calcium fluoride and 6 to 7 per cent of silica is occasionally used. Furthermore, some consumers do not object to a larger amount of sulphur.

The following tables[3] show the effect of a variable silica content upon the percentage of effective fluorspar in the ore.

[1]Davis, H. W., op. cit., p. 33. [2]Davis, H. W., op. cit.. p. 31.
[3]Engineering and Mining Journal. July 30, 1927.

Calcium Fluoride Per Cent	Silica Per Cent	Equal to a net Calcium Fluoride Content of, Per Cent
85	1	82½
85	2	80
85	3	77½
85	4	75
85	6	70
85	8	65

Calcium Fluoride (Ignoring Silica) Per Cent	Cost at Mine, per Unit Based on Fluorspar at $20 per Short Ton at Mine, Cents
80	25.00
82	24.40
84	23.80
85	23.53
86	23.26
88	22.73
90	22.22

Silica Per Cent	Reduction in Calcium Fluoride, Points
0	0
1	2½
2	5
4	10
6	15
8	20

Both gravel and lump are sold in the metallurgical grade.

FLUORSPAR BUYERS

Transportation charges do not permit New Mexico fluorspar to compete in the east with the product of the Kentucky-Illinois fields. The market is thus limited to consumers west of the Mississippi River, particularly in the mountain states and on the Pacific Coast.

The following tables of fluorspar buyers in the Western United States are taken from Mineral Resources of the United States in 1926.[1]

[1] pp. 38-45. Davis' report contains complete tables for the whole of the United States.

CONSUMERS OF FLUORSPAR IN BASIC OPEN-HEARTH STEEL PLANTS IN THE WESTERN UNITED STATES.

Name of Consumer	Address of purchasing agent	Location of Plant
California:		
Southern California Iron & Steel Co.	Huntington Park	Huntington Park
Judson Manufacturing Co.	San Francisco	Oakland
Columbia Steel Corporation	San Francisco	Pittsburg, Torrance
Pacific Coast Steel Co.	San Francisco	South San Francisco
Colorado:		
Colorado Fuel & Iron Co.	Denver	Pueblo
Iowa:		
Bettendorf Co.	Bettendorf	Bettendorf
Zimmerman Steel Co.	Bettendorf	Bettendorf
Missouri:		
Sheffield Steel Corp.	Kansas City	Kansas City
Scullin Steel Co.	St. Louis	St. Louis
Utah:		
Utah Steel Corporation	Midvale	Midvale
Washington:		
Pacific Coast Steel Co.	Seattle	Youngstown

CONSUMERS OF FLUORSPAR IN ELECTRIC-FURNACE STEEL PLANTS IN THE WESTERN UNITED STATES

Name of Consumer	Address of purchasing agent	Location of Plant
California:		
Best Steel Casting Co.	Oakland	Elmhurst
Alloy Steel & Metals Co.	Los Angeles	Los Angeles
American Manganese Steel Co.	Chicago, Ill.	Los Angeles, Oakland
Southern Pacific Railroad Co.	San Francisco	Sacramento
Columbia Steel Corporation	San Francisco	Torrance
Union Tool Co.	Torrance	Torrance
Colorado:		
American Manganese Steel Co.	Chicago, Ill.	Denver
Kansas:		
Locomotive Finished Material Co.	Atchison	Atchison
Missouri:		
Southern Manganese Steel Co.	Chicago, Ill.	St. Louis
Nebraska:		
Omaha Steel Works	Omaha	Omaha
Texas:		
Hughes Tool Co.	Houston	Houston
Washington:		
Puget Sounds Navy Yard	Bremerton	Bremerton
Pacific Car & Foundry Co.	Renton	Renton
Washington Iron Works	Seattle	Seattle

CONSUMERS OF FLUORSPAR IN FOUNDRIES AND OTHER METALLURGICAL PLANTS IN THE WESTERN UNITED STATES

Name of Consumer	Address of Purchasing Agent	Location of Plant
Arkansas:		
Standard Brake Shoe & Foundry Co.	Pine Bluff	Pine Bluff
California:		
P. J. Fasullo Foundry	Hanford	Hanford
Kinney Iron Works	Los Angeles	Los Angeles
Barth Foundry & Machine Co.	San Diego	San Diego
Amalgamated Metals Corp.	San Francisco	San Francisco
Colorado:		
C. S. Card Iron Works Co.	Denver	Denver
Iowa:		
Keokuk Electro-Metals Co.	Keokuk	Keokuk
Maytag Co.	Chicago, Ill.	Newton
Missouri:		
St. Mary's Oil Engine Co.	St. Charles	St. Charles
McQuay-Norris Manufacturing Co.	St. Louis	St. Louis
South Dakota:		
Homestake Mining Co.	Lead	Lead
Washington:		
Salmon Bay Foundry Co.	Seattle	Seattle

CONSUMERS OF FLUORSPAR IN THE MANUFACTURE OF GLASS IN THE WESTERN UNITED STATES

Name of Consumer	Address of Purchasing Agent	Location of Plant
Oklahoma:		
Okla. Glass Co.	Ada	Ada
A. K. Kerr & Co.	Sand Springs	Sand Springs
Kerr, Hubbard & Kelly	Sand Springs	Sand Springs
Texas:		
Ball Bros. Glass Manufacturing Co.	Muncie, Ind.	Wichita Falls

CONSUMERS OF FLUORSPAR IN THE MANUFACTURE OF ENAMEL, VITROLITE, AND GLAZES IN THE WESTERN UNITED STATES

Name of Consumer	Address of Purchasing Agent	Location of Plant
California:		
Smoot-Holman Co.	Inglewood	Inglewood
California Metal Enameling Co.	Los Angeles	Los Angeles
Washington Iron Works	Los Angeles	Los Angeles
Whiting-Mead Co.	Los Angeles	Los Angeles
Standard Sanitary Manufacturing Co.	Pittsburg, Pa.	Richmond
Missouri:		
Bridge & Beach Manufacturing Co.	St. Louis	St. Louis
Buck Stove & Range Co.	St. Louis	St. Louis

CONSUMERS OF FLUORSPAR IN THE MANUFACTURE OF CHEMICALS IN THE UNITED STATES.

Name of Consumer	Address of Purchasing Agent	Location of Plant
Delaware:		
General Chemical Co.	New York, N. Y.	Clayton
Illinois:		
Aluminum Ore Co.	Pittsburgh, Pa.	East St. Louis
Indiana:		
U. S. S. Lead Refinery	New York, N. Y.	East Chicago
Nebraska:		
American Smelting & Refining Co.	New York, N. Y.	Omaha
New York:		
John C. Wiarda & Co.	Brooklyn	Brooklyn
Ohio:		
Harshaw Fuller & Goodwin Co.	Cleveland	Cleveland
Pennsylvania:		
General Chemical Co.	New York, N. Y.	Newell

MARKETING NEW MEXICO FLUORSPAR

Fluorspar of all grades is usually sold on contracts of 3 to 6 months duration. This practice was established in the Kentucky-Illinois fields and has been continued in the west. The eastern production in most cases is handled by mineral brokers who contract for the entire output of a mine. Thus it is difficult for a small producer to sell a single carload of ore directly to the consumer. Usually the occasional producer sells his ore to one of the larger companies which disposes of it through its broker. Small outputs are sometimes so handled in New Mexico.

Sales directly to manufacturers are sometimes made. Such sales occasionally lead to short contracts for the periodic shipments of specified quantities and grades of ore.

New Mexico has a number of deposits of sufficient size to warrant contracts between individual producers and manufacturers. This is particularly true of ceramic and acid-grade ground fluorspar. The profitable disposition of the production of the smaller properties is difficult. The ore may be sold to larger operators as is sometimes done; but the price so obtained is usually below the open market.

In times past contracts with consumers have been entered into by small producers who found themselves unable to meet their contracted shipments. This failure of the producers has inspired in the consumers some distrust of New Mexico's ability to steadily produce ore and has made new contracts difficult to secure. Failure of shipments to meet grade requirements has added to the distrust.

The problem of marketing the ore of the smaller producers appears to be capable of solution. A marketing association organized among the smaller operators gives promise of meeting the situation. Such an association could enter into long-time contracts with consumers which would be met by the occasional producer shipping through the association. Grades and specifications necessarily would have to be complied with strictly.

At the present, long-time contracts are to be desired, and whether entered into by a marketing association or one of the larger producers they would insure a steady market and stabilize the fluorspar industry in the state.

Certain large consumers of fluorspar may find it advisable to acquire New Mexico properties either for immediate development or to hold as reserves against depletion of eastern supplies.

PRODUCTION OF FLUORSPAR IN NEW MEXICO[1]

In 1927 New Mexico contributed slightly more than 2 per cent of the total fluorspar shipments from the mines in the United States. The Illinois-Kentucky field gave 92 per cent and Colorado 5½ per cent of the total shipments for the year.

The table on page 26 gives the shipments of fluorspar for New Mexico for the years 1909 to 1927 inclusive. During 1926 and 1927 statistics were furnished by but two New Mexico producers, and consequently the value of the shipments cannot be shown.

Maximum production in the state was concurrent with the increase

[1]For current production statistics see:

Mineral Resources of the United States: U. S. Bureau of Mines. The annual review of mineral statistics published by the Department of Commerce. A separate chapter on fluorspar and cryolite is published in advance of the complete volume.

The Mineral Industry: McGraw-Hill Book Company, Inc. This annual review of the mineral situation appears in about October of the year following that reviewed.

in steel production during the war years. During that period a number of properties were worked out.

FLUORSPAR MARKETED FROM NEW MEXICO DEPOSITS, 1909-1927[a]

Year	Gravel Short tons	Lump Short tons	Ground Short tons	Total Short tons	Total Value Total	Total Value Average Per ton
1909				710	$ 3,728	$ 5.25
1910				4,854	26,250	5.40
1911				4,307	22,612	5.25
1912				196	1,176	6.00
1913				5,372	42,976	7.95
1914				——	——	——
1915				485	3,880	8.00
1916				——	——	——
1917				——	——	——
1918				3,437	64,348	18.72
1919				2,346	37,643	16.05
1920	470	5,883	——	6,353	101,460	15.97
1921	1,650	991	866	3,507	60,186	17.16
1922	1,008	820	352	2,180	30,992	14.22
1923	3,540	738	50	4,328	50,861	11.75
1924	1,620	883	77	2,580	35,178	13.63
1925	1,487	939	213	2,639	40,325	15.28
1926	1,063	820	106	1,989	b	12.98[c]
1927	1,562	574	477	2,613	b	14.43[c]
Total				46,896	521,615[b]	

a. Mineral Resources of the United States, 1926. Figures for 1927 from Dept. of Commerce press statement, April 4, 1928.

b. Values for 1926 and 1927 for New Mexico are not available and the total value for New Mexico fluorspar does not include those years.

c. Colorado and New Mexico.

NEW MEXICO FLUORSPAR RESERVES

New Mexico has numerous and varied fluorspar deposits, but few of them compare favorably with the great deposits of the Kentucky-Illinois fluorspar area.

In the mining of fluorspar to date few attempts have been made to block out definite ore tonnages. At three properties in the state, however, the deposits are sufficiently well defined to justify an estimate of ore reserves. These are the Fluorspar Mines of America property, the Southwestern Fluorspar Coporation's Lida-K property, and the Tortugas mine. The total possible recoverable amount of fluorspar at these properties is estimated to be 400,000 tons. With additional development work, increased prices, more favorable contracts, and improved methods of treatment they may yield more than the above tonnage.

Although most of the deposits of the state have not passed the prospect stage and estimates of reserves are not feasible, it is probable that some of them will develop into important mines and

The production from the small deposits which can be operated to advantage by only a few men should attain a substantial figure.

A number of New Mexico deposits containing both galena and fluorspar are apparently not commercial when worked for only one of these minerals. The development of a successful milling process whereby both a lead concentrate and a fluorspar concentrate are obtained may make some of this type of ore workable.

PART II. THE FLUORSPAR DEPOSITS OF NEW MEXICO

DEPOSITS IN THE SIERRA DE LOS CA BALLOS

THE SIERRA DE LOS CABALLOS

LOCATION AND TOPOGRAPHY

The Sierra de los Caballos (Spanish: Horse Mountains) in Sierra and Dona Ana County begin in the neighborhood of Elephant Butte Dam in Sierra County and extend for 35 miles to the south where they flatten and disappear under the bolson gravels and Tertiary flows just north of Rincon. A maximum elevation of 10,000 feet is attained at Timber Hill. To the north is a structural continuation of the Caballos in the Fra Cristobal Range, to the west is the valley of the Rio Grande, and to the east the bolsons of the Jornada del Muerto stretch for 20 miles to the San Andreas Mountains.

STRUCTURE

The Sierra de los Caballos are a great fault block with its upthrown fault scarp forming the west face of the mountains. Faulting is not confined to the western scarp face, however, for a series of north-south fractures, apparently accessory to the major break, occur in the northern end of the mountains, and Darton has traced a north-striking fault paralleling the east side of the range.[1] The strata of the range have an easterly dip.

East of Hot Springs and north of the Fluorspar Mines of America property a conspicuous south-moving overthrust striking east is exposed in the mountain side. At Palomas Gap a north-striking fault zone extends along the mountain east of the present scarp face.

The southern end of the range is marked by numerous small block faults. Here the predominant direction of faulting parallels the range, but east-striking and diagonal fractures are of common occurrence.

In the vicinity of the Nakaye mine the Magdalena limestone has been thrust to the north, over-riding the Abo sandstone with a throw in excess of 800 feet.

Two types of faulting occur in the Sierra de los Caballos which apparently represent two distinct disturbances. The block faulting responsible for the range is post Montana, likely coinciding with Tertiary volcanic activity so widespread throughout New Mexico. The dominant strike of the normal faults is north. Cutting the beds from east to west are at least two thrust faults, one at the north and one at the south end of the range. The relative ages of the two systems were not determined.

[1]Darton. N. H.. Geologic Structure of Parts of New Mexico: U. S. Geol. Survey Bull. 726. p. 231.

STRATIGRAPHY

The basal rocks are pre-Cambrian schists intruded by granites and granite gneisses and in places cut by acid pegmatites. At the northern end of the range dioritic rocks and biotite schists are intruded along schistosity planes in a pseudo lit-par-lit fashion by granite, giving the appearance of bedding at a distance. At the southern end of the range mica schists occur as horses in granite gneiss.

Older Paleozoic Rocks.—Schrader[1] in describing the Caballos Mountains says:

> The most prominent feature of the mountains is the great limestone and quartzite series, 1200 to 1400 feet in thickness. It consists chiefly of heavy-bedded massive gray and blue limestone with some intercalated shale and has at its base about 100 feet of hard quartzite. Much of the limestone is semicrystalline, and some of it contains black flinty or cherty nodules or inclusions. Part of it is greatly crushed and recemented by calcite veins.
>
> The quartzite at the base of the limestone series ranges from 50 to perhaps 200 feet in thickness; it is massive or heavy bedded and consists of black and red beds resting on the granite. Its age is probably Cambrian.

The heavily bedded quartzite of Schrader's description corresponds with the Bliss sandstone described by Richardson[2] from the vicinity of El Paso on the east side of the Franklin Mountains.

Darton[3] in his map of the Jornada del Muerto shows a band of undifferentiated Paleozoic rocks including the Lake Valley limestone (Mississippian), Percha shale (Devonian), Fusselman limestone (Silurian), Montoya and El Paso limestones (Ordovician), and Bliss sandstone (Cambrian) as outcropping on the west side of the central part of the range. As no fluorite deposits are known in the neighborhood of the pre-Pennsylvanian formations, this part of the Sierra de los Caballos was not visited by the writer. On the northern and southern ends, however, no pre-Pennsylvanian sedimentary rocks were recognized.

Magdalena Limestone (Pennsylvanian).—The greater part of Schrader's "great limestone and quartzite series" belongs to the Magdalena group. In the northern end of the range the Magdalena formation has a measured thickness of 1,000 feet. Most of the formation is limestone, and shales are subordinate. The older Paleozoic sediments are not visible in this locality, and although pre-Cambrian igneous and metamorphic rocks were not observed in contact with the Magdalena formation, the adjacent position of limestone of Pennsylvanian age and the basal crystallines leaves little room for older Paleozoic rocks.

[1]Schrader, F. C., Ore Deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 284-285, 1910. [2]Richardson, G. B., El Paso folio, U. S. Geol. Survey Geol. Atlas, El Paso Folio (No. 166) p. 3, 1909.
[3]Darton, N. H., Geologic Structure of Parts of New Mexico: U. S. Geol. Survey Bull. 726, Plate XLII, 1922.

The upper half of the Magdalena, as exposed in the mountain side above the property of the Fluorspar Mines of America, consists of massive beds of dense gray to dark gray limestones and a few intercalated beds of shale usually less than 5 feet in thickness. Some chert is present but not in large amounts. The lower half of the limestone is generally thinner bedded and very cherty.

A bed of arkosic quartzite 20 feet in thickness occurs in the middle of the section at the northern end of the range and again above the Nakaye mine on the southern end.

Most of the fluorite deposits in the Sierra de los Caballos occur in the Magdalena limestone. They are mainly fissure fillings with replacement of subordinate importance.

Abo Sandstone (Permian).—The most conspicuous outcrops of the Abo sandstone occur on the east side of the range, where the formation rests upon the Magdalena and in places forms the cover dip slope surfaces. It is red to reddish brown and consists of interbedded clayey sandstones and sandy clays. The sandstones vary greatly in hardness.

Chupadera Formation (Permian).—The sandstones, limestones, and gypsum beds of the Chupadera formation resting upon the Abo formation are exposed on the east slope of the Caballos.

Cretaceous.—Faulted down against the Chupadera formation on the extreme eastern slope of the mountains is a series of shales and brown sandstones of Cretaceous age, likely assignable to the Mancos or Mesa Verde formation. Some thin coal seams have been noted.[1] Good Cretaceous exposures can be seen along the Elephant Butte Dam and Engle road on the northern end of the range.

THE FLUORITE DEPOSITS

The locations of the fluorite deposits of the Sierra de los Caballos are shown on fig. 3. They occur for the most part on the western slope of the range near the northern and southern ends.

The fluorite is found principally as fissure fillings in Magdalena limestones, although fissures carrying fluorite occur in the pre-Cambrian crystalline rocks as at the Lida-K property. In the limestones the amount of replacement varies. The Harding group of claims, to the north, has fluorite veins in which the walls are clean and show little or no replacement of the limestone, and at the Nakaye mine, on the south, certain limestone strata are so extensively replaced as to resemble blanket deposits.

The veins are probably coincident or immediately subsequent to the mountain-making and volcanic cycle which occurred during Tertiary times in New Mexico. The youngest country rock containing fluorite is the Chupadera formation of Permian age at the Parker property on

[1]Personal communication, Blanchard Hanson.

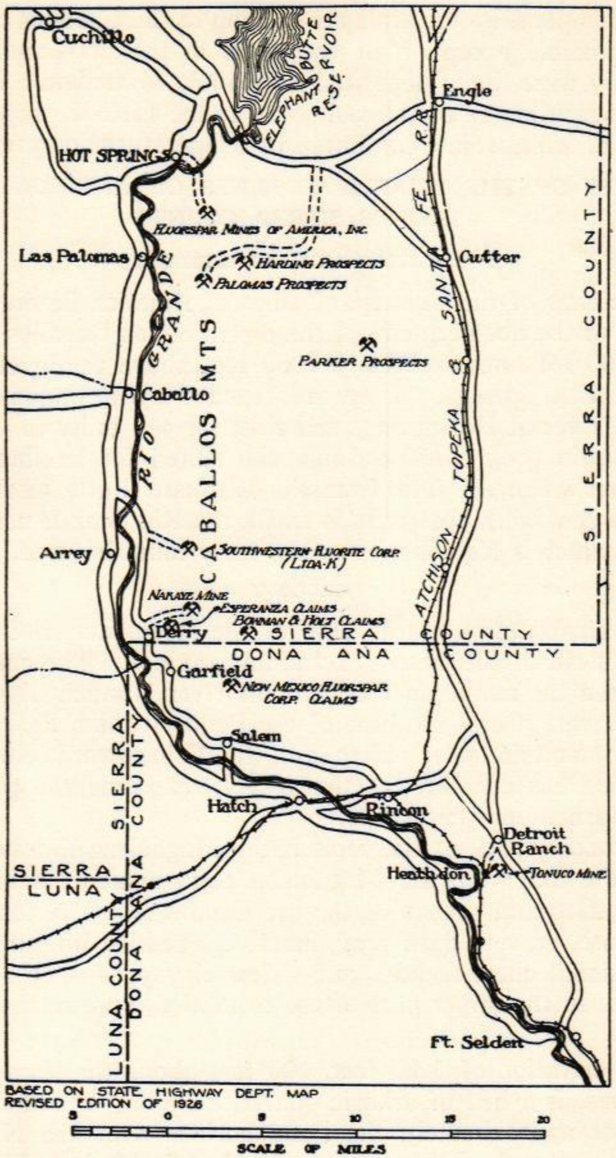

Figure 3.—Index map to the fluorspar deposits of the Sierra de los Caballos and Tonuco Mountain.

the eastern slope of the range.

High-temperature minerals are lacking in the Caballos deposits, and with the possible exception of the veins in the pre-Cambrian at the Lida-K they were likely deposited at shallow to moderate depth. The extensive sericitization of the wall rock at the Lida-K property is more suggestive of intermediate conditions of temperature and pressure.

PROPERTIES OF THE FLUORSPAR MINES OF AMERICA NEAR HOT SPRINGS, SIERRA COUNTY

LOCATION AND ACCESSIBILITY

The claims of the Fluorspar Mines of America lie on the western scarp face of the northern end of the Sierra de los Caballos at an elevation of 5200 feet, approximately 1000 feet above the level of the Rio Grande at Hot Springs. They are reached by a wagon road which crosses the river at Hot Springs and rises for 4½ miles to the property. The road is in good condition and well suited for hauling. In times of low water when the flow from the Elephant Butte reservoir, which is located a few miles upstream, is small, the Rio Grande can be forded. When the water is high, however, the ferry must be used.

GEOLOGY

The veins outcrop at the base of the steep face of the mountain and at the head of the westward-draining ravines. The country to the west between the mountain face and the river is much dissected. The Palomas gravels rise to the base of the Pennsylvanian limestones which form the mountain side. Here and there headward erosion of the present cycle has cut through the gravels, exposing the pre-Cambrian igneous and metamorphic rocks.

The country rock at the veins is the Magdalena limestone. North of the White Star vein the Magdalena rests unconformably upon the granite gneisses and schists of the pre-Cambrian. The formation consists of dense, gray to dark gray, massively bedded limestone. It contains occasional chert nodules and a few clayey beds up to three feet in thickness in the upper part of the formation, and much chert in the lower part.

At an elevation of 5400 feet, 200 feet above the shop at the Universal claims, is a bed of arkosic quartzite similar in character to that occurring at approximately the same horizon near the Nakaye mine in the southern end of the range. The bed is 20 feet thick and outcrcps above the Universal claim at an elevation of 5400 feet. It is composed of angular quartz and feldspar grains up to 2 mm. in diameter. The weathered surface is pitted due to the removal of the feldspar.

In the arroyo which is followed by the road to the mines the basement rocks are exposed. They consist of a biotite schist intruded by granite and granite gneiss. In places the schist occurs as horses in the granite, but a psuedo lit-per-lit structure is often presented in which the granite is intruded in the biotite schist along planes of schistosity. Usually the schist layers are broken and much contorted, but sometimes the alteration of rocks is so uniform as to resemble, at a distance, bedded deposits. The pegmatites which cut the basement rocks at the southern end of the range are here absent.

WORKINGS AND ORE DEPOSITS

The ore occurs in veins striking southeast. Three veins have been developed; the White Star at the northern end of the property, the Oakland in the center, and the Universal on the south. Five claims cover the outcrops, two each on the White Star and Universal, and one on the Oakland vein. A rapid sketch map of the property (fig. 4) shows the relationship of the outcrops.

The width of the veins varies from 5 to 15 feet of workable ore. In places there is a transition from the higher grade fissure deposit into more siliceous material on the walls of the vein. This transition is strongly suggestive of replacement of the limestone wall rock. Because of the extensive deposition of post-fluorite silica cutting the fissure material and extending into the country rock, the replacement relations are not clearly shown.

The White Star vein, the most northern on the property, strikes N. 75° to 85° W. It is traceable by surface float for a distance of 2000 feet up the hillside. In places it is a well-marked single fissure filling, but elsewhere it appears as a sheeted zone up to 60 feet wide containing much silica and calcite.

Near the upper end of the outcrop an old adit in calcareous shales shows 5 feet of siliceous fluorite carrying galena. At the lower end of the vein, just above where it disappears under the talus, an open cut and trenches expose 14 feet of siliceous ore, estimated to contain between 70 and 80 per cent fluorite and 15 to 25 per cent silica. Some galena occurs with the fluorite in the lower cut.

The Oakland vein is first exposed just above the chute and crusher southeast of the mill. Here an open cut 75 feet long follows the vein through a small downfaulted block of talus-covered limestone. Two feet of siliceous ore is exposed on the vein face.

Fluorite float can be traced up the hillside a distance of approximately 1200 feet with an occasional outcrop of the vein. Like the White Star, the Oakland vein sometimes merges into a sheeted zone.

Two hundred feet above the lower cut is an old adit driven as a lead prospect in about 1907. It enters with a course of S. 60° E. on a narrow galena-bearing vein in limestone, and 40 feet from the entry it turns east into a massive white siliceous fluorite.

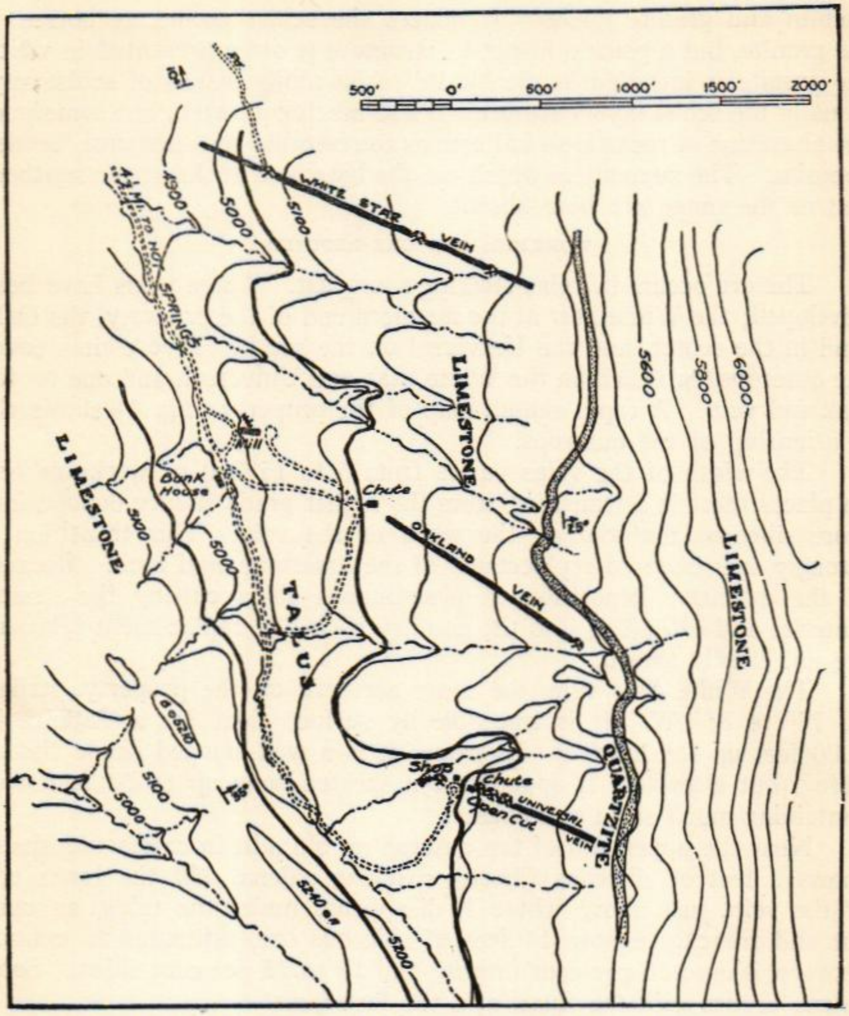

Figure 4.—Sketch map of the Hot Springs property of the Fluorspar Mines of America.

The Universal vein at the southern end of the group strikes S. 75° E. into the mountain face. It is traceable for a distance of 800 feet from the upper edge of the gravel and talus of the ravine below the shop.

Benches following the vein have been cut on four levels. The lower level below the shop enters in an open cut through 60 feet of talus. At the beginning of the vein material the cut continues as an adit in siliceous ore 8 to 10 feet in width. The breast, at the time of the writer's last visit, was approximately 40 feet from the beginning of the vein. The tramway is on this level and ore from the higher benches is brought down in chutes to be loaded into cars.

Figure 5.—Workings on the Universal vein, Fluorspar Mines of America, near Hot Springs.

The second bench, which is 20 feet above the shop, does not show the full width of the vein. The downthrow or hanging wall on the south is composed of white, gritty, calcareous clay, much foliated. Eight feet of fluorite intergrown with silica and a little calcite has been opened up, but the north wall is not exposed.

The third bench is 30 feet up the hill from the second bench. The face shows 10 feet of siliceous ore estimated to contain 70 per cent fluorite and 20 to 25 per cent silica. The hanging wall to the south is siliceous limestone. The north wall is not exposed, hence the total width of the fluorite is greater than 10 feet. The vein material shows a rough banding of silica and fluorite. Cutting the vein material are

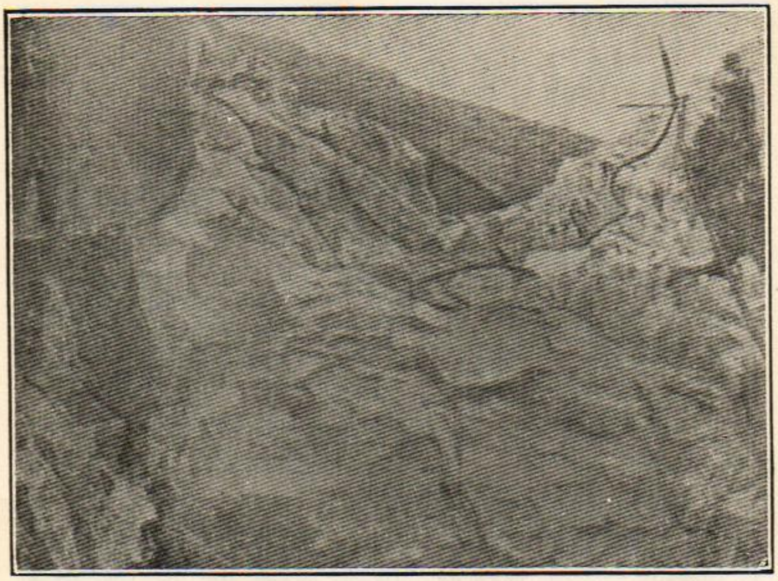

Figure 6.—Universal vein, Fluorspar Mines of America. The width of the vein is 10 feet.

later veinlets of jaspar and banded chert. Fig. 7 is a sketch of the face on this level. To the south there is an apparent transition into the siliceous limestone which forms the wall.

The fourth level is 25 feet above the second bench. Here the ore, which is of the same character as that below, is 9 feet in width, but the north wall is not exposed. The south or hanging wall is again a foliated gouge similar to that on the second level. Cutting the face of the cut is a small nearly horizontal cross fault along which the vein has been displaced some 5 feet to the north. The vein can be traced some distance up the hillside above the upper bench, but is lost before it reaches the quartzite bed.

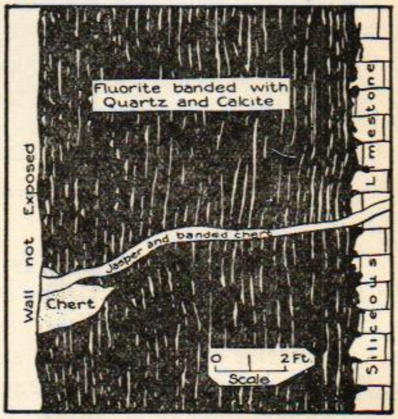

Fig. 7.—Sketch of the breast of the Universal vein, 3d bench. November, 1927.

Some 2000 feet north of the White Star vein, beyond the northern boundary of the area included in the accompanying sketch map, a small vein in granite gneiss carries quartz and fluorspar.

THE ORE

The ore of the fluorite deposits near Hot Springs is siliceous. Fluorite and quartz were deposited as the primary vein filling with considerable replacement of the limestone wall rock. There is a fair degree of uniformity in the ores from different veins. The best grade material will average 65 to 80 per cent fluorite and 15 to 25 per cent quartz. Calcite usually runs from 3 to 5 per cent.

The silica shows rough banding in the Universal vein, and some banding is present as chert veinlets younger than the main vein filling. On the third level there are large vugs 3 to 4 feet in diameter lined with druses of well-formed quartz crystals.

In the White Star vein, galena occurs in irregular disseminated pockets in the fluorite and will likely show considerable variation as the vein is followed.

PARAGENESIS

The veins are true fissure fillings with some replacement of the wall rock. The direction of the displacement was discernable only on the Universal vein where the downthrow was to the south.

In approximately parallel fissures and sheeted zones striking east-southeast was first deposited quartz, fluorite and small amounts of calcite with appreciable replacement of the limestone walls. To this generation of mineralization belongs the main fissure filling showing some vertical banding of quartz and fluorite paralleling the walls of the vein.

Following the main deposition came minor amounts of jasperoidal chert which cuts the vein as well as the wall rock in small veinlets.

A third generation is represented by fluorite and calcite in minor amounts consistently cutting both the jasper veinlets and the minerals of the first generation. Some wall rock replacement by fluorite may have occurred at this time.

The fourth generation is represented by quartz and calcite as vug linings in mineral material of all of the previous generations.

HISTORY

The fluorite deposits near Hot Springs were discovered by Blanchard Hanson in 1924. In April, 1926, the Fluorspar Mines of America, a Delaware corporation of which E. H. Wilson of New York City is president, was organized. A mill was built in the latter part of 1926 and the first ore was shipped in December of the same year.

Up to July, 1927, four carloads of ground spar had been shipped to a glass manufacturer in Indiana. Since then the wet plant has been improved by the installation of two double-deck Diester Plat-0 tables, and a contract with an eastern corporation for regular shipment of acid grade ground spar has been made. The first carload of ground acid grade spar on the new contract was shipped in February, 1928.

MILLING OPERATIONS

At the time of the writer's last visit in February, 1928, ore was mined at the Universal vein, trammed to the crusher, and trucked to the dry plant. The concentrates from the dry plant were hauled, again by truck, some 5 miles to the wet plant located on the Rio Grande at Hot Springs. Finally the finished product was hauled by truck 21 miles to Engle, a station on the Albuquerque-El Paso branch of the Atchison, Topeka & Santa Fe Railway, for. shipment.

The mill flow sheet as shown in fig. 8 was in use in January, 1928. It had not proved completely satisfactory and several possible changes in routing were under consideration.

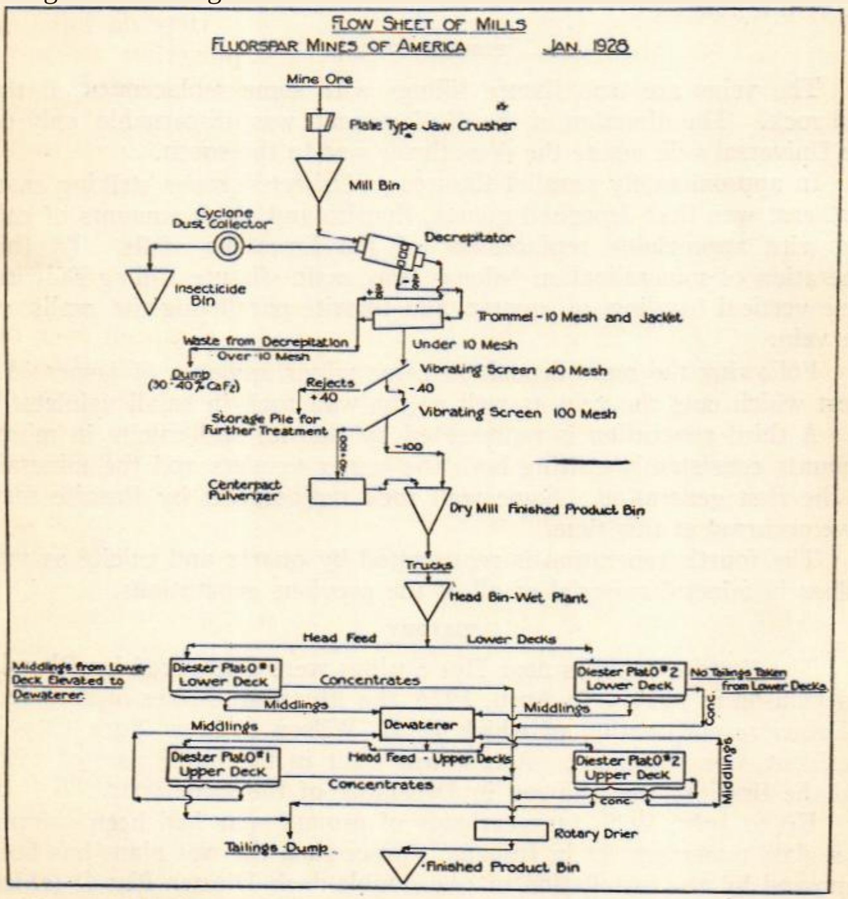

Figure 8.—Mill flow sheet, Fluorspar Mines of America, Hot Springs, Sierra County.

In the dry plant at the mines the ore is crushed and passed through a revolving steel drum at a temperature between 550° and 650° F., where decrepitation of the fluorspar is effected. Such silica as is not broken by the mechanical wear of the decrepitator retains the size to which it had been reduced by the crusher, but the fluorite and, to a lesser extent, the calcite is broken up by the heat of the cylinder. Oil is used as fuel.

Waste from the decrepitator consists of all material having a greater diameter than three-eighths of an inch. Material under three-eighths of an inch in diameter goes to a trommel and that in excess of 10 mesh is rejected and sent to the dump along with the oversize from the decrepitator.

A 40-mesh vibrating screen then separates the ore, material over 40 mesh going into a storage pile for further treatment and that under 40 mesh passing on to a 100-mesh vibrating screen. Here the minus-40 to plus-100 material is deflected into a centerpact pulverizer which discharges into the finished product bin. The minus-100 material passes directly to the bin.

A sample of the finished product of the dry mill obtained by the writer contained 95.80 per cent CaF_2 1.48 per cent $CaCo_3$ and 2.61 per cent $Si0_2$.

The fine dust from the decrepitator, which is largely calcium fluoride, is collected and stored for possible utilization as an insecticide.

From the dry mill the product is hauled by truck to the wet plant on the Rio Grande at Hot Springs. Here the ore is passed over two Diester Plat-0 tables and the tailings are discarded. The head feed is divided and goes to the lower decks of the two tables. Here concentrates are obtained and all middlings are pumped up to a dewaterer from which they are fed back to the upper decks. Products from these decks consist of concentrates and middlings which are returned to the dewaterer, and tailings which are rejected. The concentrates go to a rotary drier and thence to a storage bin for sacking and shipment.

This treatment has resulted in a product consistently carrying in excess of 97 per cent CaF_2. An analysis of the best grade of concentrates from the wet mill gave 98.13 per cent CaF_2, 1.00 per cent $CaCo_3$, and .64 per cent SiO_2.

ORE RESERVES

The writer's estimate of the possible recoverable ore occurring in the Universal, Oakland, and White Star veins within a vertical distance of 200 feet below the lowest outcrop on each vein is in the neighborhood of 300,000 tons. This is based of course upon the assumption that they retain their outcrop width to that depth.

FUTURE POSSIBILITIES

The existence of a large amount of fluorspar in the Hot Springs claims of the Fluorspar Mines of America is certain, but the treatment of the siliceous ore presents many difficulties. If a satisfactory milling process is achieved, these deposits will be an important factor in the fluorspar industry in the west. The fact that a concentrated ground spar is the only product seriously limits the market. It seems certain, however, that a sliding scale of prices for metallurgical spar will be applied to the western deposits in the next decade. In that case, it is possible that some of the crude ore may find a market. Some commercial ore which will yield both lead and fluorspar concentrates may be developed.

PALOMAS PROSPECTS

LOCATION AND ACCESSIBILITY

Two fluorspar deposits outcrop near the crest and on the west side of the Caballos Mountains. They are near the road between Engle and the copper property of the Monument Mines Corporation, about midway between Palomas Gap and the Marian tunnel.

GEOLOGY AND ORE DEPOSITS

The lower deposit is a mass of fine-grained, highly siliceous fluorite exposed on the east side of the lower road approximately 750 feet above the Rio Grande. The outcrop, which is 24 feet across, appears to be on a vein filling in much-disturbed Magdalena limestone. As no development work has been done and the small spur in which the fluorite is exposed is covered by talus from the adjacent mountain face, the vein relations are not clear.

East of and 200 feet above the lower exposure a body of similar siliceous fluorite occurs in an irregular vein striking northeast. The vein as exposed in two shallow cuts is 2 to 3 feet in width and is siliceous throughout. Some replacement of the limestone walls has taken place.

The fluorite in both exposures is estimated to contain silica, in excess of 25 to 30 per cent. In general appearance and in apparent habit it resembles very closely the veins of the Fluorspar Mines of America some miles to the north. Further development is necessary to clarify the relationship of the veins.

A mile or more south of the above veins fluorspar is found at the Marian tunnel of the Mounment Mines Corporation. The fluorspar **is** reported by Mr. Blanchard Hanson[1] to occur as a fine sand in a vein 6 feet wide at the bottom of a winze 150 feet below the level of the main adit. Movement along the vein subsequent to the deposition of the

[1] Oral communication. The winze was not entered.

fluorite is believed to account for the sandy nature of the material. The Marian copper property has not been worked for some years.

HARDING PROSPECTS

LOCATION AND HISTORY

The Harding group of claims is southeast of Palomas Gap and on the east slope of the northern end of the Sierra de los Caballos. They are on the wagon road between Cutter and the Marian copper mine which crosses to the west side of the range through Palomas Gap.

In 1910 and 1911 extensive prospecting for vanadium was done on the east slope of the northern end of the mountains', and although some fluorite was found at that time, the ground now covered by the Harding group of claims was originally located as a vanadium property. A number of the old workings are no longer safe to enter, but in others, as well as in more recent openings, the character of the fluorite occurrences is well shown.

The Harding claim on the east and the Canutillo claim adjoining on the west were relocated by Blanchard Hanson of Hot Springs, New Mexico. They are reached from Cutter, a distance of 14 miles, by a wagon road which is in good condition with the exception of a few short stretches.

GEOLOGY, ORE DEPOSITS AND WORKINGS

A group of fissure veins in Magdalena limestone striking N. 35° to 45° E. carry fluorite, calcite and some galena. At least three veins are present on the two claims.

In an old prospect on the Harding claim, reopened within recent years, a shaft is sunk approximately 90 feet on a vein striking N. 45° E. A drift on the 50-foot level follows two veins composed of fluorite, calcite, and galena and 2½ feet wide. They are separated by 10 to 12 inches of gouge, and the wall rock on either side, so far as exposed in the breast of the drift, is gouge. The larger of the veins is markedly banded, suggesting an opening in a gouge zone with subsequent fissure filling.

A sample across the face of the larger vein contained 92.85 per cent CaF_2, 3.46 per cent CaCo3, 3.00 per cent SiO2, and 0.75 per cent $A12O_3 \pm Fe_2O3$.

From the bottom of the shaft an incline 30 feet in length opens into a natural cave 30 by 60 feet which is said to be cut by three smaller veins bearing galena and fluorite.[1]

[1]Frank L. Hess has described the vanadium deposits in Bulletin 503, pages 158-160, U. S. Geological Survey. He lists the following minerals as occurring in the veins: fluorite, barite, calcite, quartz, galena, cerussite, malachite, azurite, vanadinite, and zinc-bearing cuprodescloizite. Pyromorphite and wulfenite are reported by others.

[2]Personal communication, Blanchard Hanson. The cave was not entered.

An open cut on the strike of the vein some 200 feet S. 45° W. from the main shaft shows a single vein 1½ to 2 feet in width containing fluorite and calcite.

Approximately 500 feet southwest along the same strike are two of the old vanadium prospect shafts said to be 150 feet in depth. Some fluorite with copper stains was found on the dump.

Approximately 200 feet southwest of the reopened prospect is a shaft on a parallel vein. Here the wall rock is fresh limestone free from gouge. The vein, which is followed to a depth of 20 feet, is between 2 and 21/2 feet wide and is composed of fluorite with a little calcite and some galena. At the bottom of the shaft the vein widens and there is some increase in the galena content.

On the Canutillo claim are a number of open cuts. Near its junction with the Harding claim is a trench following a vein 11/2 to 2 feet in width composed of fluorite, some calcite, and a little galena and barite.

FUTURE POSSIBILITIES

The vicinity of the Harding group can only be regarded as favorable prospecting ground for fluorite. All of the veins exposed in working up to the present time are too small to be of economic value. Some of the veins, however, show enough galena to warrant further development with the expectation of opening up ore which could be economically milled to yield both galena and fluorite concentrates.

PARKER PROSPECT

Some fluorite has been mined on a group of 3 or 4 claims located approximately 12 miles southwest of Cutter. These claims, known as the Parker property, are owned by Paul Larsh of Silver City, New Mexico.

The property was not visited by the writer but some of the ore was examined.

The fluorite is in large green crystals, many having well-developed faces up to 1½ inches across. Associated with the fluorite is much gypsum, suggesting that the country rock may be the Yeso or Chupadera formation.

PROPERTIES OF THE SOUTHWESTERN FLUORSPAR CORPORATION

LOCATION AND ACCESSIBILITY

The Lida-K claims of the Southwestern Fluorspar Corporation are located on the west face of the southern end of the Sierra de los Caballos, 23 miles by road from Hot Springs, at an elevation of approximately 450 feet above the Rio Grande. The highway south from Hot Springs is a Federal Aid project, well maintained. The private road begins

8 miles north of Salcido's store at Percha Dam and continues east across the Palomas gravels 2.3 miles to the claims.

The properties of the Southwestern Fluorspar Corporation comprise two claims, the Lida-K Nos. 1 and 2, which cover the entire outcrop of the fluorspar vein.

GEOLOGY

The fluorspar occurs associated with quartz and galena as a fissure

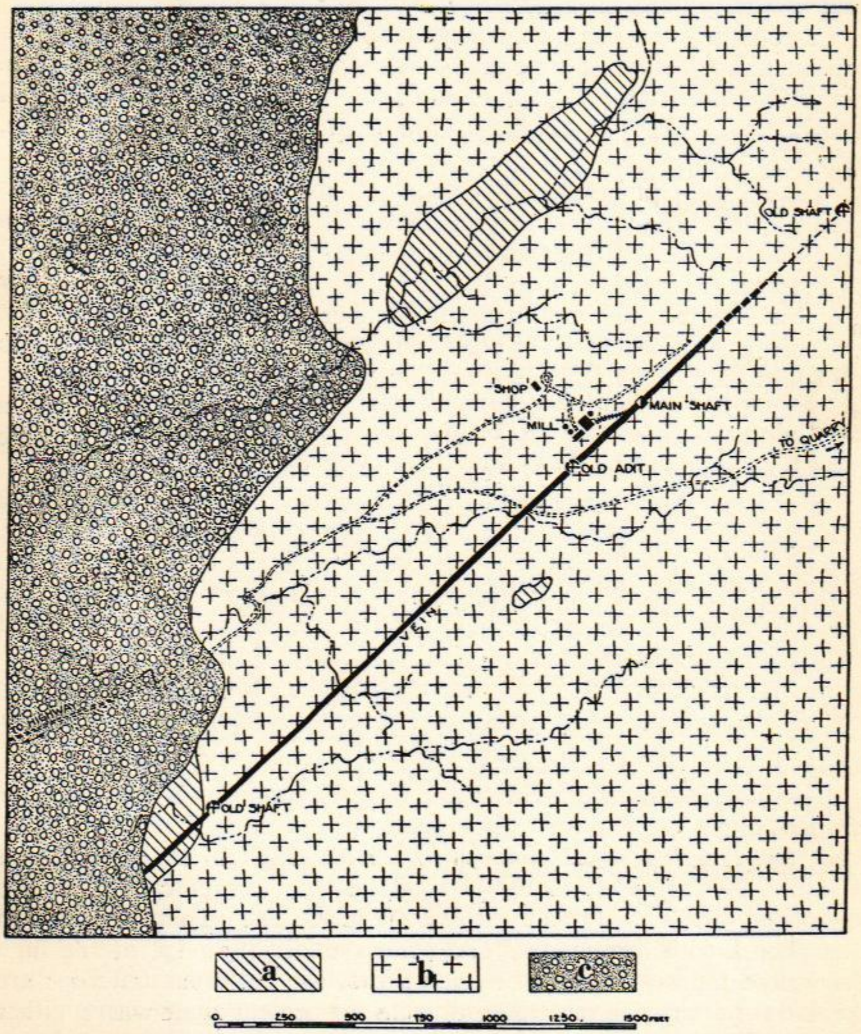

Figure 9.—Geological sketch map of the vicinity of the Lida-K vein of the Southwestern Fluorspar Corporation, near Derry. a, mica schist; b, granite; and c, bolson gravels.

filling 3 to 5 feet wide in the basal pre-Cambrian complex of the Caballos Range. The pre-Cambrian consists of a muscovite schist which has been intruded by granite gneiss and later cut by pegmatites consisting of feldspar and quartz. Fig. 9 is a geological sketch map of the area.

The schist outcrops in small islands surrounded by granite gneiss. It is dark gray to greenish black in color and, where exposed, it is badly weathered. Thin sections show it to be composed essentially of muscovite and quartz in a matrix of sericite and kaolinized feldspar.

Surrounding the islands of muscovite schist is granite gneiss, the most extensively exposed rock in the neighborhood of the Lida-K vein. It is pink when fresh but loses color upon weathering. The essential constituents of the granite gneiss are quartz, orthoclase, microcline, and biotite.

Cutting the granite gneiss in intricate fashion are many hundreds of feldspar-rich pegmatites varying in width from 6 inches or less to several feet. These are composed of orthoclase in crystals up to 4 inches across, microcline in crystals less, than one-half inch in diameter and a little quartz. So great is the number of these pegmatites that the granite gneiss, which is the principal country, rock, is in many places completely hidden. Pegmatites cutting the schists are rare.

In addition to the feldspar pegmatites there are a number of quartz veins a few inches wide which cut the feldspar pegmatites. These quartz veins are not known to carry mineral values.

A differentiation phase of the granite gneiss is found in the vicinity of the Lida-K in which the biotite is poorly developed or missing. From the field examination the relations of this biotite-free gneiss and the pegmatite, consisting of microcline, orthoclase, and quartz, is not clear. Possibly the pegmatite represents a last differentiation product of the granite-gneiss magma.

In the neighborhood of the main shaft the granite gneiss forming the wall rock of the veins shows conspicuous development of sericite.

ORE DEPOSITS

The fluorspar-quartz vein of the Lida-K property is traceable for 4000 feet along the outcrop. The southwestern part of the vein is exposed in a dikelike ridge as much as 20 feet high in the ravine near the mill. On the northeastern part of the vein, the outcrop is not so pronounced, and it is lost as the vein pinches out. To the southwest it disappears with the gneisses and schists under the edge of the high level Palomas gravels, and to the northeast the fluorspar outcrops are traceable for approximately 750 feet from the present shaft where, either the mineralization ends, or the fluorite contains less silica and, being softer than the gneisses and schists which constitute the country rock, has been eroded. The first of these two possibilities is more likely, as 250 feet farther northeast along the projection of the vein an old shaft 25 feet deep shows a clay selvage in gneiss 10 to 12 inches wide with no fluorite. Beyond the old shaft no fluorite has been found.

The outcrop of the fluorspar vein in a dikelike ridge (fig. 10) is unusual. The silica content, which is estimated at between 20 and 25 per cent, is high, and because of its intimate intergrowth with the fluorspar the rate of weathering of the vein material is slower than that of the country rock. In places, particularly just southwest of the mill where the vein stands highest above the country rock, it is protected by a coating of fine-grained quartz occurring on the outside of the fluorite in a relationship which suggests that a lining of quartz in the fissure preceded the main vein deposition of quartz and fluorite. This "case hardening" is best developed in the southeast side of the vein down the hillside 300 feet southwest of the mill.

A number of small offsets with horizontal displacements of 2 to 6 feet occur along the outcrop. The main shaft crosses one such displacement which has an offset of 8 feet at the bottom of the shaft 72

Figure 10.—Outcrop of the Lida-K vein. The dikelike outcrop rises 20 feet above the country rock of granite and schist.

feet below the surface. At these cross fractures the fluorite is re-cemented by silica.

The vein strikes N. 43° E., is nearly vertical, and is 3 to 5 feet wide. Departures from verticality are in the nature of a slight warping of the plane of fracture. The relation existing between the pinch and swell of the vein and these departures from verticality was not determined. From the outcrop pattern of the schist-gneiss contacts, the displacement of the original fissure was not great.

The siliceous fluorspar at the main shaft contains an average of 3 per cent PbS.

Half a mile east and 200 feet above the mill, sedimentary rocks can be seen resting upon the gneisses and schists.

THE ORE

At the main shaft most of the vein material contains between 72 and 77 per cent calcium fluoride and between 15 and 25 per cent silica. The remainder is calcium carbonate and galena. Galena seems to be confined to the northeast portion of the vein. At the collar of the shaft the vein material is 4 feet wide. The shaft cuts through a minor cross fault and at the bottom, 72 feet down, the ore is picked up about 8 feet to the south. At the time of the writer's visit only a few feet of drifting had been done. Along the cross fracture the vein material was brecciated and recemented by silica. The drift had, however, passed out of the brecciated zone into galena-bearing siliceous fluorite.

The fluorite occurs as interlocking crystals up to 3 inches across and is mainly green in color. The silica occurs in three forms; (a) as a fine grained white to gray chert-like material which appears to have been deposited contemporaneously with the fluorite, (b) as veinlets of jasper-like silica cutting the fluorspar and chert-like silica, and (c) druses of minute quartz crystals occurring in vugs and fine grained white sugary quartz cementing the brecciated ore along the small cross fractures. The last type often cuts the jasper-like material.

The galena occurs in well-developed crystals contemporaneous with the fluorite and chertlike silica. Calcite, likewise, is contemporaneous with the fluorite and is intergrown with it. The extent of the galena along the vein will be determined when development is further advanced.

The old adit 300 feet southwest of the main shaft extends approximately 45 feet into the hillside. The vein material is similar to that encountered in the shaft except that the galena content is much lower. A few very small barite crystals were noted on the adit face. The "case hardening" of the vein material is shown here by a layer of silica on the southeast wall 2 to 3 inches in thickness. This is better shown, however, in the bottom of the ravine where the vein crosses.

The old shaft at the southwestern end of the vein is in a material more siliceous than is encountered in the main shaft. There is little or no change in width. Doubtless the vein continues to the southwest under the gravels.

The following is a sampling report of the Lida-K property.[1]

Description of sample	Width of vein	SiO_2	CaF_2	$CaCO_3$	Pb
Cut across vein W. of shaft	4.0 ft.	19.38	74.98	1.48	—
Dump from bottom of shaft	4.0	23.72	67.38	1.30	0.16
600 ft. NE. of shaft	4.5	11.86	83.58	0.68	0.60
Open cut 50 ft. SW. from shaft	5.0	22.06	71.60	1.56	0.02
Dump from adit 300 ft. SW. from shaft	4.0	22.24	72.92	1.40	
Dump sample farthest SW.	4.0	25.40	70.88	0.62	—
Average		20.78	73.50	1.17	—

A sample of the ore pile at the mouth of the shaft taken July 25, 1927, showed 84.53 per cent CaF_2, 7.04 per cent PbS, and 7.64 per cent $Si0_2$. This is selected ore with a much higher lead content than the average vein material.

MILLING OPERATIONS

The character of the ore, which averages 75 per cent fluorite, makes the successful operation of this property largely a milling problem.

The flow sheet of the mill, so far as completed in November, 1927, is shown in fig. 11. Trial runs are said to have demonstrated the success of the process up to the air classification stage. Further experimental work upon the ore treatment from that point is being done by the owners.

The ore taken from the mine passes through a 9 by 5 inch Blake crusher where it is reduced to 2 inches or less and thence through rolls set at three-fourths inch. From the rolls it is elevated into a tumbling barrel with screen for the removal of dust material under 2 mm. in diameter, and edges and corners which might be knocked off in passing through the decrepitator. The function of the tumbling barrel is to furnish the decrepitator with a feed which will be disrupted only by heat and upon which a minimum of mechanical abrasion will be effected.

The decrepitator was designed by Mr. Leon Martin who had charge of the design and construction of the mill. It is 3 feet in diameter and 36 feet long and is fired with oil burners at the lower end which maintain a dull red heat. Material under 16 mesh from the discharge end of the decrepitator is received into the air classification system, material over 16 mesh dropping through the draft to the dump.

At present two settling tanks are provided. The first is set to collect fluorite over 100 mesh and the second all finer material. Experimental runs indicate that the galena present will accumulate in the plus 60 to minus 100 range, and a screen for separating this size from the material collected in the first settling tank has been installed.

[1]Released by courtesy of H. D. Hill of the New Mexico Fluorspar Corporation, former owners of the property. Report from U. S. Smelting. Refining & Mining Exploration Company, Boston, Mass., File K-347. Examination by Mr. L. M. Kniffin. manager, Hanover Bessemer Iron & Copper Co., Pietro, N. Mex.

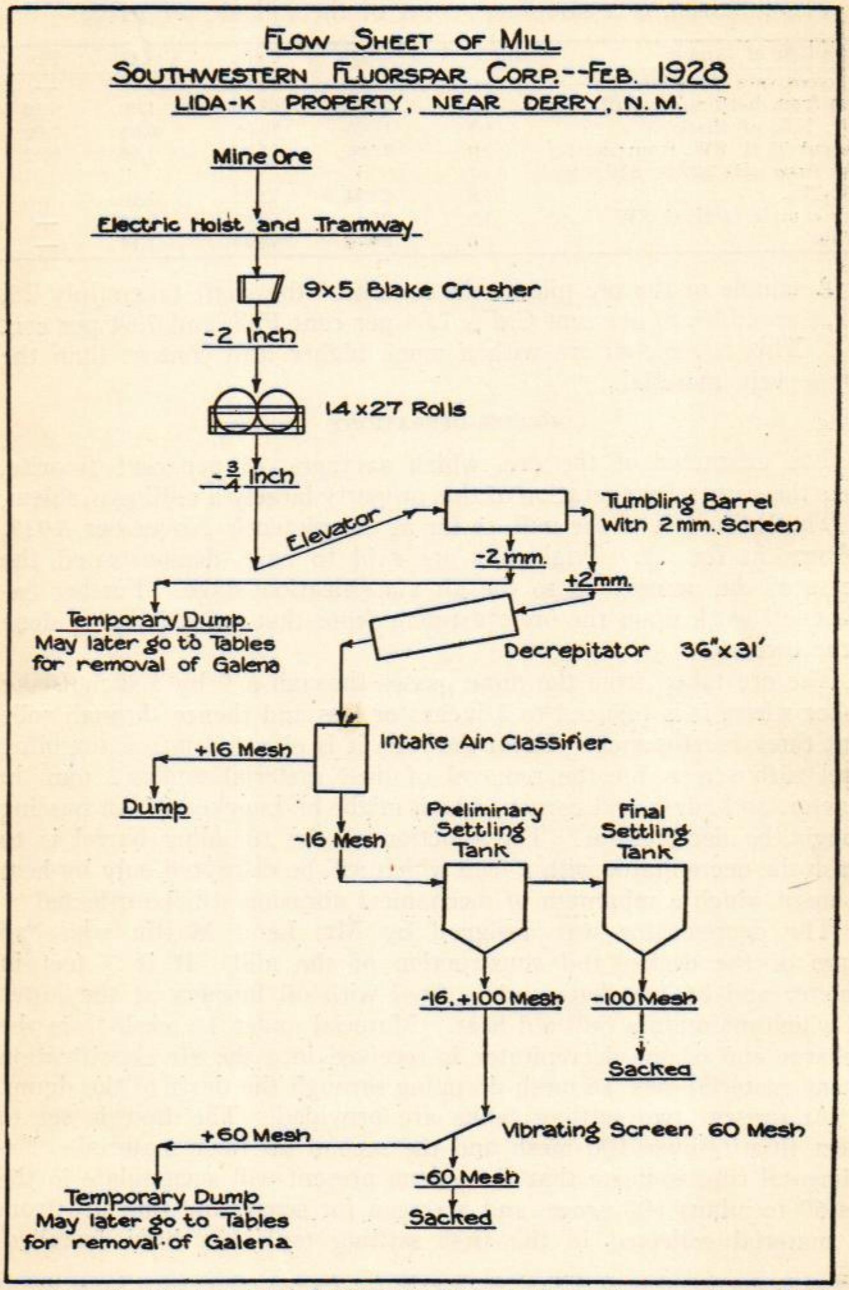

Figure 11.—Mill flow sheet, Southwestern Fluorpsar Corporation, near Derry, Sierra County.

Tables and possibly further air and screen classification will be added to the present plant.

Much experimental data has been obtained by Messrs. Merrill and Martin in the construction completed up to this time, and doubtless additional data, of value will result from their further work. Although the test runs have been made with an incomplete plant and marketable material has not yet been produced in quantity, the mill, is sufficiently flexible to permit the installation of a flow sheet finally decided on with no great difficulty.

Water for ore treatment as well as for the cooling system of the power plant must be pumped from the Rio Grande. It is' unlikely that a source nearer the mine can be found.

HISTORY

The dikelike outcrop of the Lida-K vein has long been known **to** prospectors in the Caballos. It was repeatedly assayed for gold under the belief that it was a quartz vein, and the fluorite was overlooked.

A number of years ago the fluorite was recognized, and after the outcrop had been examined by a number of local mining men it was located by the New Mexico Fluorspar Corporation which later sold the two claims to the Southwest Fluorspar Corporation of which Mr. Frank Merrill of Las Cruces is president.

The construction of a mill was started in 1926. A number of changes were found necessary in the course of construction, and it had not been completed when visited in August, 1927.

No ore has been shipped.

ORE RESERVES AND FUTURE POSSIBILITIES

The total exposed outcrop of the vein is 4000 feet long and its average width is 4 feet. Estimating 25 per cent recoverable spar, a total reserve of 80,000 tons of fluorspar will occur above a depth of 200 feet. The vein may continue to the southwest where it disappears under the upper edge of the gravels. If so, reserves will probably be greater than the estimate given.

Like other siliceous fluorite deposits of the Sierra de los Caballos the value of the Lida-K property is dependent upon milling costs. That a high grade of ground acid spar can be made from siliceous ores is well known. If ores of this type and grade can be profitably mined and milled the fluorite production of New Mexico will be substantially increased.

NAKAYE MINE

LOCATION AND ACCESSIBILITY

The fluorspar deposits of the Nakaye mine lie on the western slope of the Sierra de los Caballos, approximately 750 feet above the Rio Grande and about 5 miles from Derry. The property is reached by a very poor wagon road from Derry which follows a creek bed on the lower half of the ascent and the ridges near the mine. The nearest railroad is at Hatch on the Silver City branch of the Atchison, Topeka & Santa Fe Railway, 16 miles south of Derry.

GEOLOGY

The Nakaye mine lies half way up one of the west-facing fault scarps which characterize the southern end of the Sierra de los Caballos. Fig. 12 is a geological sketch map of the property.

A series of massive limestones, cherty in the lower part, rise

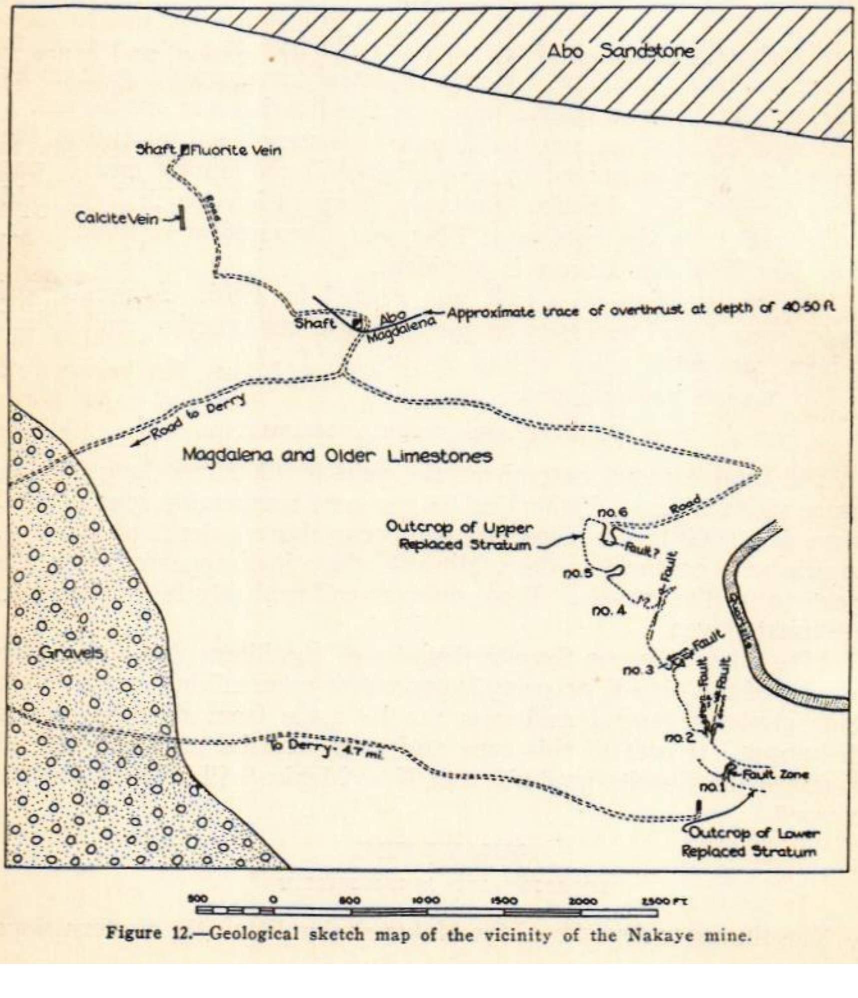

Figure 12.—Geological sketch map of the vicinity of the Nakaye mine.

beneath the gravels to the top of Nakaye Mountain with a total thickness of over 500 feet. Two hundred feet above the upper replaced stratum is a bed of iron-stained arkosic quartzite 40 feet thick containing quartz grains from a fraction of a millimeter up to 3 or 4 mm. in diameter. A few larger quartz pebbles occur in the quartzite. Upon fresh fracture surfaces pink feldspars are recognizable, but upon
weathered surfaces the feldspars are represented by cavities. This quartzite layer resembles in grain size, thickness, approximate strati-graphic position and feldspar content the quartzite bed of the Fluorspar Mines of America, near Hot Springs, at the northern end of the Sierra de los Caballos and possibly may be correlated with it.

The limestones below the quartzite are of the same massive gray character as those above. At the base of the section, near the upper edge of the gravels, they are conspicuously cherty. Detailed work on the section was not within the scope of the investigation, and hence the question of the age of the lower limestones was not determined. The Percha shale was not recognized.

To the north of the workings and in an east-west gap, the Abo red beds occur a hundred feet lower than the recognized Magdalena limestone of the Nakaye Mountain. At the bottom of the shaft northwest of No. 6, the Abo occurs below a gouge zone under Magdalena or older limestones. These relations suggest that the faulting is in the nature of an overthrust in which the Magdalena has moved to the north overriding the Abo sandstones. The relation of the north-striking fault scarp to this east-striking thrust was not apparent, but between the Nakaye mine and Derry, Abo beds are exposed in the creek bottom some 500 feet below and 2 miles west of the Nakaye mine, indicating a down-faulted block to the west.

ORE DEPOSITS

The fluorspar occurs as a replacement of limestone beds where they are cut by minor faults and extends away from the faults on either side. Capping the upper replacement bed is a massive shaly limestone. Fig. 13 is a diagramatic sketch illustrating the relationship.

Where the faults are close together the fluorspar is continuous, but where the faults are far apart unreplaced limestone separates the ore masses. From the fracture planes the replacement extends into the favorable bed farthest at the top just below the capping of a clayey limestone, and then rapidly thinning as the bottom of the replacement is approached. These replacement sheets attain a maximum thickness of 12 to 15 feet in the neighborhood of a fracture.

In addition to the sheet deposits, some fluorspar was deposited as a fissure filling along the fault planes and some occurs as vug and pipe linings in the limestones, doubtless deposited when solution of the limestone had proceeded more rapidly than deposition of the fluorite. Many of the fractures, however, are filled with breccia and gouge and contain no ore.

At least two limestone beds have been partially replaced by fluorite. The lower one is exposed in cut No. 1, and the upper bed, approximately 30 feet higher, extends along the mountain face for 2,000 feet or more. Cuts Nos. 2 to 6 are in this upper bed. The outcrop of the replaced stratum between the cuts is seldom exposed because of the covering of detrital material on the mountain side.

THE ORE

The fluorite is mostly bottle green in color but occasional masses are light purple. The green variety fades when exposed to sunlight. A pile of this material which had been exposed for some time on the ground in front of cut No. 4 was colorless. The crystals vary in size from a few millimeters up to 10 to 15 centimeters across a cleavage face.

In general, the ore when hand sorted is of good grade for fluxing lump. The only impurities in the replacement ores are fragments of limestone, some calcite, silica, and a very little barite. The calcite, silica, and barite are present in small quantities and occur as post-fluorite cavity and vug linings. The order of deposition appears to be (1) fluorspar as replacement of limestone, (2) calcite in vugs, which are later coated by (3) silica and (4) barite druses.

ANALYSES OF NAKAYE FLUORSPAR.

	CaF_2	SiO_2	$CaCO_3$
A.	91.84	0.15	7.24
B.	98.57	0.15	0.75
C.	99.15	--	0.65
D.	94.04	3.66	2.27

A. From adit No. 4 near roof.
B. From adit No. 3. Selected ore near base of limestone replacement in the first crosscut.
C. From cut No. 5. Selected fluorite from ore pile by open cut.
D. From inclined adit No. 2. Ore from pipes replacing limestone.

ORIGIN OF THE DEPOSITS

The fluorspar replacements are confined to certain favorable beds. In adit No. 2 the bed replaced is a medium-grained, gray limestone; the roof of the replacement is a fine-grained buff, clayey limestone containing a large amount of finely crystallized secondary quartz; and the floor of the replacement is a dolomite. Conditions favorable for replacement here consisted of a magnesium-free limestone bed adjacent to a fault plane capped by a clayey impervious bed. Ascending fluorite-bearing solutions rose in the fracture zone adjacent to the gouge-filled fault plane and replaced the favorable bed.

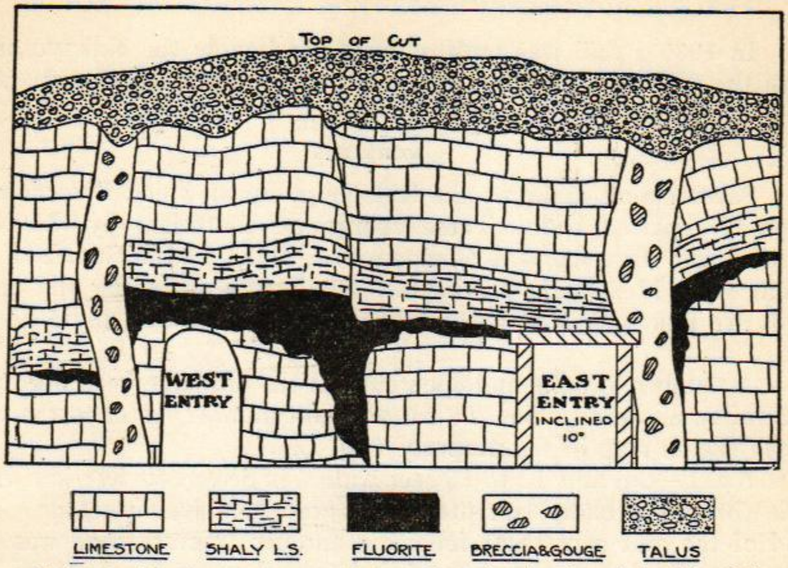

Figure 13.—Sketch of the face at Nakaye No. 2 showing the relationship of the fluorspar replacement to the favorable bed. The replacements are post-faulting.

ANALYSES OF LIMESTONES FROM ADIT NO. 2

	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3
A.	25.73	1.01	61.46	10.76
B.	93.78	Tr.	5.06	1.10
C.	26.82	0.93	52.39	18.80
D.	50.36	34.85	3.33	11.30

A. Roof of replacement. Fine grained, buff, clayey limestone with much secondary quartz.
B. Replaced bed. Medium grained, gray limestone, 10 inches from outer edge of fluorspar replacement.
C. Replaced bed. Silicified limestone in contact with fluorspar replacement.
D. Floor of replacement. Fine grained, gray dolomite.

Much secondary quartz was deposited in advance of the fluorspar replacements, often completely silicifying the limestone. Thin sections of replaced ore show a complete transition from the original quartz-free limestone to fluorspar with a few small residual quartz crystals scattered through it. Intermediate stages show amounts of quartz in excess of 40 per cent in the fluorite at the outer edges of the replacements. Farther into the fluorspar the amount of quartz decreases. This relationship strongly suggests replacement of quartz by fluorspar following the replacement of limestone by quartz.

HISTORY

Operations at the Nakaye mine began in 1918, and from 1920 through 1922 between three and four thousand tons of fluxing lump was shipped, mostly to Pueblo, Colorado.

making the roof. Pipes and vugs cutting the replaced bed are filled with well-crystallized fluorite. Some fracture filling at the edge of the gouge was noted.

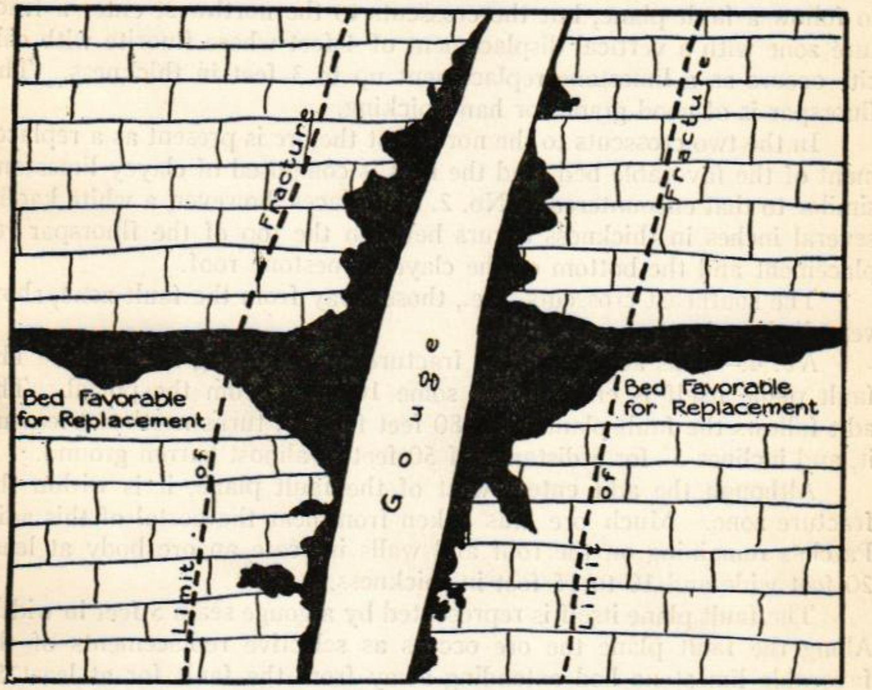

Figure 14.—Sketch showing relationships between the fault plane, fracture zone, and favorable bed. The fluorite-bearing solutions rose in the fracture zone and not in the gouge filled fault plane. Nakaye mine.

The inclined adit is between 50 and 60 feet long. At the bottom a crosscut toward the east approximately 100 feet in length follows lenses of fluorspar just below the roof of clayey limestone. In general the ore in the lower part of the adit and in the crosscut is very patchy and irregularly distributed.

Calcite and fluorite first replaced the limestone on either side of the fault. The solutions appear to have travelled in the shattered limestone of the drag zone within 2 to 4 feet of the fault, as the fault plane itself is gouge filled. The upper limit of replacement was determined by the clayey limestone bed. Following the replacement of the limestone by fluorspar and calcite much limestone was dissolved, and a later series of fluorite-bearing solutions filled pipes and cavities with well crystallized fluorite. At this stage some of the previously deposited calcite seems to have been replaced.

In this adit all of the ore in sight which could be profitably mined has been removed.

No. 3.—Approximately 500 feet northwest of No. 2 is an adit 90 or 100 feet in length with several crosscuts. This adit does not appear to follow a fault plane, but the crosscuts to the northwest enter a fracture zone with a vertical displacement of 4 feet where fluorite with calcite occurs as a limestone replacement up to 3 feet in thickness. The fluorspar is of good grade for hand picking.

In the two crosscuts to the northwest the ore is present as a replacement of the favorable bed, and the roof is composed of clayey limestone similar to that encountered in No. 2. In places, however, a white kaolin several inches in thickness occurs between the top of the fluorspar replacement and the bottom of the clayey limestone roof.

The southeast crosscuts, i. e., those away from the fault zone, show very little ore.

No. 4.—This adit follows a fracture zone striking N. 20° E. The fault plane itself is encountered some 100 feet from the portal. The adit follows the fault plant 75 to 80 feet farther, turns northeast leaving it, and inclines 5° for a distance of 50 feet in almost barren ground.

Although the adit enters west of the fault plane, it is within the fracture zone. Much ore was taken from near the portal of this adit. Patches remaining on the roof and walls indicate an ore body at least 20 feet wide and 10 to 15 feet in thickness.

The fault plane itself is represented by a gouge seam 5 feet in width. Along the fault plane the ore occurs as selective replacements of the favorable limestone bed extending away from the fault for at least 50 feet. Fracture fillings are common. The gouge itself is free from fluorite and secondary calcite. The general relations of the replacements along the gouge seam are shown in fig. 14. The fluorite-bearing solutions apparently rose through the fracture zone rather than in the fault plane itself. Within the fracture zone the fluorite seems to replace limestone less selectively than it does farther out. On the walls of the gouge the upper limit of replacement had not been exposed.

No. 5.—Here, in an open cut, the upper replaced bed is exposed. The limestone is replaced by much secondary calcite and some fluorspar. The fluorspar is of excellent grade.

No. 6.—This is an open cut in limestone from which four old adits enter the hillside. The workings were in poor condition and were not entered.

Other Development.—Half a mile northwest of No. 6 is a shaft 50 feet deep sunk on a fissure vein filled with calcite and some fluorite. The vein material was much stained with manganese oxides. The dump contained mostly calcite with a small amount of fluorite.

FUTURE POSSIBILITIES

No practical estimate of reserves is possible. In all of the workings examined the ore which could be profitably mined had been removed.

The occurrence of ore as replacements directly associated with the minor faults appears to have been overlooked in the past development of the mine. Detailed mapping of all faulting and a systematic prospecting program in which exploration is confined to the fault zones would possibly lead to the discovery of new ore bodies. Disregard in future development of the relationship of replacements to fault lines would cause an unjustified waste of labor.

ESPERANZA GROUP OF THE NEW MEXICO FLUORSPAR CORPORATION

LOCATION AND ACCESSIBILITY

A small group of fluorspar claims controlled by the New Mexico Fluorspar Corporation is situated approximately 3½ miles northeast of Derry in the southern end of the Sierra de los Caballos in one of the low limestone hills which rise above the high level Palomas gravels. The claims are reached by a wagon road branching from the Nakaye mine road about one mile up the creek bed from the old Nakaye mill.

GEOLOGY

The limestone in which the veins occur is the Magdalena. To the west of the hill approximately a quarter of a mile the Abo sandstone is downfaulted, bringing its outcrop some 50 feet lower than the Magdalena exposures in the hillside where the claims are situated. Such small downfaulted blacks of Abo sandstone are frequent in the triangle made by the Nakaye mine, the Bowman and Holt group, and the Esperanza claim, and the smaller fracture zones in which mineralization has taken place are probably accessory to that block faulting.

WORKINGS AND ORE DEPOSITS

The ore occurs as a vein filling of fluorite with silica and small amounts of galena and as replacements along joint and bedding planes. There are three open cuts upon the Esperanza claim. The first, located on the north side of the hill, shows fluorspar in small irregular layers replacing limestone. The replacement has taken place in stages. First a band of quartz, sometimes crystalline and occasionally cryptocrystalline, advanced into the limestone. This was followed by replacement of the silica by fluorspar. These relations are shown in fig. 15 where

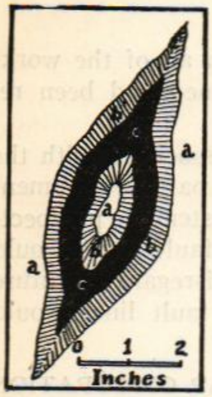

Figure 15.—Sketch of a replacement fragment from the Esperanza claim near Derry. Limestone (a) was replaced by quartz (b) which was followed by fluorite (c).

the limestone (a) has been replaced by crystalline quartz (b) with prisms normal to the limestone quartz contact. The fluorite (c) is advancing upon the quartz. This order of replacement was noted a number of times in different New Mexico deposits, not only in limestone country rock but also in rhyolite porphyry and granite.

Much chert is found in the vicinity of the fluorspar lenses. The lenses themselves are small, seldom exceeding 10 inches in thickness.

Up the hill and 80 feet to the southwest frm the first cut the fluorite occurs as limestone replacement along joints and bedding planes. The form of the replacement bodies is shown in fig. 16. Here there is very little quartz. The ore is in thin tabular bodies, the largest slightly over 2 inches in width.

On the La Luna claim southeast frm La Esperanza, is a circular cut crossing a small fracture zone. Here the fluorspar occurs with banded chert as a vein filling. Some replacement of included limestone fragments has occurred. The fracture zone as exposed in the cut is about 6 feet in width and strikes north. The fluorite occurs in small veinlets up to 6 inches in width.

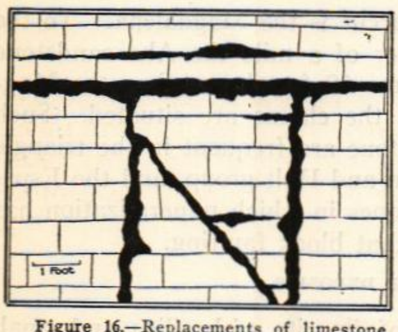

Figure 16.—Replacements of limestone by fluorite along joints and bedding planes, Esperanza group, near Derry.

An analysis of a mixed sample of selected fluorite from La Esperanza and La Luna claims gave 97.73 per cent CaF_2, 0.56 per cent $CaCO_3$, and 1.22 per cent SiO_2.

An analysis by the U. S. Smelting, Refining and Mining Exploration Company of a picked sample of ore from the Esperanza claim gave 97.68 per cent CaF_2, 0.50 per cent SiO_2 and 0.88 per cent $CaCO_3$.

FUTURE POSSIBILITIES

Some prospecting has been done by trenching but no ore has been developed. The fractured condition of the country rock, and the presence of calcium fluoride as the principal vein material does, however, indicate that the vicinity of this group of claims justifies further prospecting.

BOWMAN AND HOLT CLAIMS

LOCATION AND ACCESSIBILITY

The Bowman and Holt group of 10 adjoining claims including La Luz, Bastraho, Gavilan, Esperanza, Rincon, Buena Vista, Outlet, Alameda, North Star. and Eastern Star are located approximately 7 miles east of Derry on the west side of a north-striking valley within the Sierra de los Caballos at an elevation of approximately 4850 feet. A small amount of fluorite has been mined in past years and shipped from Upham, a station on the Atchison, Topeka & Santa Fe Railway south of Cutter.

GEOLOGY

The country rock in which the deposits occur is Magdalena limestone. It is dense, gray to dark gray in color, and contains some chert. South of the claim a quarter of a mile, the Abo sandstone resting on the Magdalena is exposed, and southeast are small fault blocks in which the Abo has been down-faulted adjacent to the Magdalena. East of the claims is a small, alluvium-filled, north-striking fault valley with up-faulted ridges on either side.

WORKINGS AND ORE DEPOSITS

The ore occurs as fissure fillings with some replacements of the limestone. Its distribution is very irregular in the fissure and it is badly mixed with limestone fragments and clay.

Three openings on veins have been made on the most northern claims.

Near the northeast corner of the Esperanza claim is an adit 20 feet in length striking S. 70° W. into the hillside. It follows a fissure filling in much broken massive gray limestone containing thin chert beds. The fluorite occurs in narrow veins and pockety replacements within the fracture zone. The end of the adit shows a width of ore of less than 1½ feet.

At the portal of the adit is an old shaft approximately 60 feet deep sunk in limestone more shattered than that in the adit. The shaft was badly caved and was not entered. Approximately 5 to 10 per cent of the visible wall was fluorite.

At the collar of the shaft was an ore pile containing about two tons of lump fluorspar of very good grade. Some of the ore contains quartz lined vugs and an occasional lump has a kernel of chert. Such ore suggests replacement of the chert-bearing limestone. The fluorspar is brightly colored, ranging from pale green to dark green, rose, and violet.

Some 600 feet northwest of the Esperanza adit and shaft and located upon the Gavilan claim is an adit 45 feet long driven southwest into the hill. The breast is 5 feet in width and is estimated to contain between 15 and 20 per cent of fluorspar occurring in small pockets through the clay and broken limestone of the fracture zone. Some of the fluorite pockets are replacements of limestone fragments, but the greater part appears to have been deposited in fissures.

The most extensive workings in the Bowman and Holt property are approximately 600 feet north of the Gavilan adit. Here an adit with a westerly course was driven 60 feet following a fracture zone with no discernable displacement. Fluorite occurs through the fracture zone in veins which are 10 inches to 2 feet in width. As 3 or 4 veins cut the fractured country rock the total width of the shattered zone can be regarded as ore material. The breast of the adit was about 10 feet wide. This is estimated to contain 40 per cent fluorspar of a grade readily separated by careful mining and cobbing. A veinlet on the floor at the portal shows some fracturing subsequent to the vein filling.

Near the portal is an old winze estimated to be 50 feet deep. It was in too poor condition to descend.

THE ORE

The ore from this group of claims is characterized by its brilliant colors. Pale to bottle green, purple to blue, and rose to claret are common shades, the same vein often showing all shades. The greens and blues are developed throughout the crystals but the rose and claret is usually confined to bands in a single crystal paralleling one pair of octahedral faces.

A composite sample of selected fluorspar from the three workings described gave the following analysis: 98.17 per cent CaF_2, 0.98 per cent $CaCO_3$, 0.67 per cent SiO2 and 0.15 per cent $A1_20_3 \pm Fe_20_3$.

A sample of cobbed spar from the ore pile near the collar of the shaft on the Gavilan claim analyzed 97.98 per cent CaF_2, 0.63 per cent $CaCO_3$, 1.25 per cent Si02, and 0.21 per cent $A1_2O3 \pm Fe_20_3$.

ECONOMIC FEATURES

A number of years ago a small amount of ore was mined on the Bowman and Holt group and the ore shipped from Upham, some 20 miles to the east. No data on the amount shipped or on mining and hauling costs is available. The road to Upham, however, is not passable at the present time, nor is it possible to reach the property from Derry by automobile.

An estimate of ore reserves is impossible due to insufficient exploration and the poor condition of the present working. Very little ore was in sight at the time of the writer's visit.

DELISIAS-FLOWER QUEEN CLAIMS

Adjoining the Bowman and Holt claims on the north and overlapping them to some extent is the Delisias-Flower Queen group owned by Octaviano Salcido and associates of Percha Dam. It comprises 9 claims, Delisias Nos. 1 to 5 and Flower Queen Nos. 1 to 4.

A shaft on Delisias No. 1, approximately 50 feet deep, was sunk in gray, massive, cherty limestone following a vein striking N. 10° W. and dipping 20° E. The vein is between 2 and 3 feet wide and contains a small amount of brightly colored fluorite. The shaft could not be descended and there was no ore on the surface.

Two small cuts south of the shaft showing a small amount of ore were on the same vein.

No other workings were found and the value of the more northern claims is unknown to the writer.

Two miles north of the Delisias-Flower Queen group are three other fluorspar claims which were not examined, owned by Salcido and associates. They are said to contain ore similar in character to that found upon the Delisias-Flower Queen and Bowman and Holt groups.

CLAIMS OF THE NEW MEXICO FLUORSPAR CORPORATION IN WOOLFER CANYON

LOCATION AND ACCESSIBILITY

Seven miles east of Garfield in the southern part of the Sierra de los Caballos and in Dona Ana County is a group of 6 claims controlled by the New Mexico Fluorspar Corporation of which H. D. Hill of Hatch, New Mexico, is general manager. The claims included are the Last Chance, Mescalero, Bonanza, Esperanza, La Pala Azul and 2 de Abril. They lie at the head of Woolfer creek on the west slope of the mountains, some 800 feet above the Rio Grande and are reached by an old road which follows the creek bottom due west from Garfield. The situation of the road is such that it must be completely remade after each rain.

GEOLOGY

The southern end of the Sierra de los Caballos is marked by a number of north-striking parallel fault blocks with the down-throw usually on the west. The blocks making the ridges are in most cases Magdalena limestone, and in the structural depression the Abo sandstone commonly occurs.

The Woolfer Canyon group of claims lies in the neighborhood of one of the north-striking fault planes on the east side of a graben or down-faulted block composed of Magdalena limestone and Abo sandstone between two ridges of Magdalena limestone. Fig. 17 is a sketch

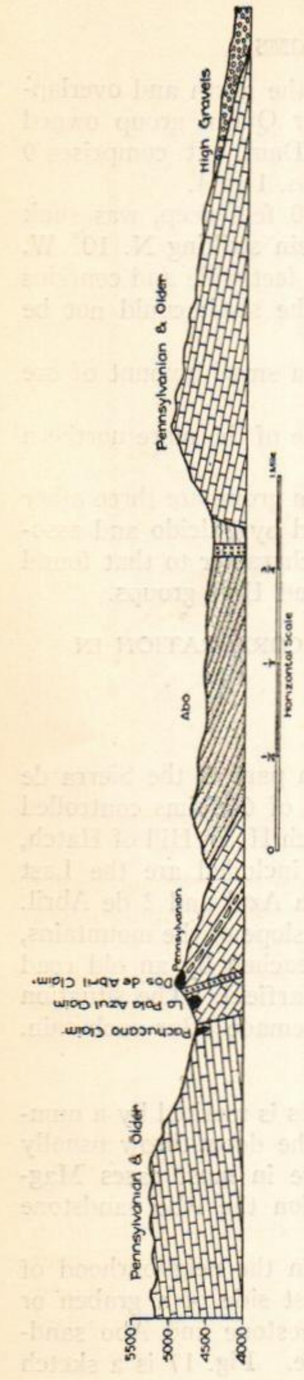

Figure 17.—Sketch section across the New Mexico Fluorspar Corporation's claims in Woolfer Canyon, near Garfield.

section across the graben showing the relations of the fluorspar deposits to the fault and to a basic dike near the fault plane. Fig. 18 is a geological sketch map showing the relation in plan. The Magdalena limestone is exposed on the mountain face of the claim, and to the west it dips under the Abo sandstone to outcrop again three-fourths of a mile to the west where it is faulted up, forming a conspicuous ridge.

Interbedded in the limestone is a persistent chert bed 12 to 20 feet in thickness striking N. 50° W. and dipping 48 to 50° to the southwest.

The country rock in the immediate neighborhood of the claim is cut by numerous small fracture zones perpendicular to the main fault plane. In the chert bed these fracture zones are more pronounced than in the limestone and serve as sites of deposition for the fluorite and associated minerals.

A small basic dike, much weathered in the outcrop, extends for 500 feet between the chert bed and the main fault plane.

WORKINGS AND ORE DEPOSITS

The ore occurs as fracture zone fillings with some accompanying replacement in the limestones and in the chert bed.

The most southern workings are located upon the 2 de Abril claim near the western boundary of the area. The ore occurs as a vein filling in the chert bed which is much fractured. An open cut crossing the bed from the southwest shows irregular veins of purple fluorite with many angular chert fragments included.

Down the dip of the chert bed toward the southeast is another open cut. Here the fluorite occurs in geode-like bodies showing evidence of having replaced some of the silica. The ore is very difficult to mine in the cuts now made, and further exploration seems desirable.

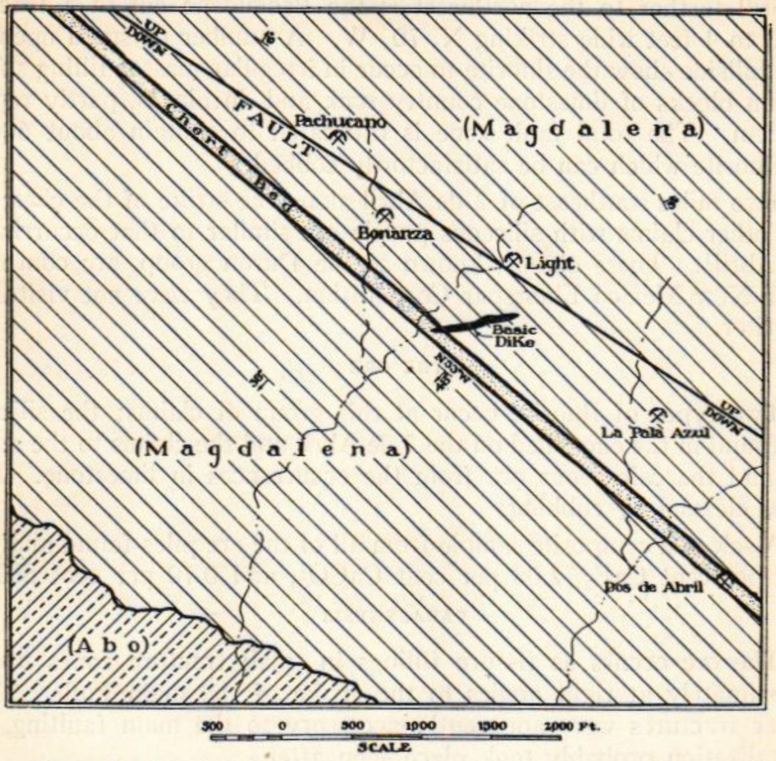

Figure 18.—Geological sketch map of the New Mexico Fluorspar Corporation's claims in Woolfer Canyon, near Garfield.

Near the lower cut on the 2 de Abril claim is an ore pile containing approximately 8 tons of cobbed fluorite. Despite careful cobbing much silica as chert and quartz druses remains.

About 1500 feet northeast of the chert bed occurrence is a small cut located upon La Pala Azul claim which follows a fracture zone perpendicular to the main fault. Here a network of small fluorite veins cuts the shattered zone, and some of the limestone blocks have been partly replaced by cryptocrystalline quartz followed by fluorite.

The Light claim some 1600 feet farther northeast is on the far side of the main fault. An open cut follows a small vein of barite containing some fluorite and calcite.

Northeast of the Light claim and on the northwest side of the main fault is the Bonanza claim. Here an open cut shows a number of small veins of fluorite 1 to 3 inches wide cutting fractured limestone. An adit in the hillside was caved too badly to enter, but an ore pile at the portal showed some good fluorite and much calcite.

Still farther to the northwest is the Pachucano cut in a fracture zone 3 to 4 feet wide striking N. 70° W. A number of small openings in the hillside show the fluorite to occur in irregular masses filling spaces between blocks of limestone country rock and, in places, partly replacing them. The total fault zone is estimated to contain about 60 per cent fluorite which can be satisfactorily cobbed.

Two miles southeast of 2 de Abril along the strike of the chert bed are 3 other claims with siliceous purple ore similar to that occurring at 2 de Abril[1]. These claims, known as the Duron group, are controlled by the New Mexico Fluorspar Corporation. They were not visited by the writer.

THE ORE

Two types of fluorite occur at this group of claims; the siliceous type found in the chert bed on the 2 de Abril and the claims to the southeast, and the calcareous ore from the occurrences in limestone. Both can be cleaned by cobbing.

A selected composite sample from all of the ore piles found analyzed 96.97 per cent CaF_2, 2.08 per cent $CaCO_3$, and 0.70 per cent $Si0_2$.

PARAGENESIS

The ore occurs as fissure fillings in small fracture zones usually approximately at right angles to the strike of the main fault. These smaller fractures were apparently accessory to the main faulting, and mineralization probably took place soon after.

In addition to the fissure filling there seems to have been replacement of fragmental country rock in the fracture zones. In the limestones this is most pronounced but in the cherts at 2 de Abril some replacement also occurred.

As is common in the New Mexico deposits, the first step in replacement of limestone is by quartz followed closely by fluorite. This is shown repeatedly in specimens where a quartz band of 1 mm. to 5 mm. in width is found between the unaltered limestone and the replacing fluorite.

FUTURE POSSIBILITIES

It is impractical to attempt to estimate the amount of recoverable fluorite in this group of claims. Some of the workings hold promise of good ore but more development is needed to determine whether or not that promise will be fulfilled. In general, the veins in limestone are better prospects than those in the chert bed because of the difficulty in cleaning the latter ore.

[1]Personal communication from H. D. Hill, Hatch, New Mex.

TONUCO MOUNTAIN DEPOSITS

LOCATION AND ACCESSIBILITY

Tonuco Mountain in Dona Ana County is east of Heathdon on the Albuquerque and El Paso branch of the Atchison, Topeka & Santa Fe Railway. It rises 800 feet above the valley of the Rio Grande, attaining a maximum elevation of approximately 4800 feet. The mountain rises abruptly from the bolson on the east and its western side overlooks the Rio Grande.

There are two properties on the mountain, the Tonuco mine of the Ore Production Company on the west side and the Beal claims on the east side. The Tonuco mine is 700 feet above the railway. It is reached by a fair road, too steep for trucks, which climbs to the mine in a distance of 1 mile and continues east to the Beal claims.

GEOLOGY

Tonuco Mountain is composed of a series of Tertiary volcanic agglomerates, in part pyroclastic and in part mud flows, with interbedded water-laid sandstones and conglomerates which are down-faulted against pre-Cambrian granite and mica schist. On the southeast side of the mountain there is a small fault block of Abo sandstone and shales of Permian age. Fig. 19 is a geological sketch map of the area.

The Rocks.—The total thickness of the agglomerate series is at least 800 feet. The lower half of the series consists of gray to blue gray pyroclastic material, ash beds and broken flows. The upper part is a series of dark, plum-colored mud flows which stand in bold cliffs. around the mountain. Some water-laid sandstones are interbedded in the upper part of the series. The mud flows are composed of angular to sub-angular fragments of latites and andesites with feldspar and quartz crystals up to 5 mm. in diameter in a groundmass of clayey material. Occasional andesite fragments several inches across occur, and some of the beds in the mud flow series have a groundmass of very finely crystallized quartz. The interbedded sandstones are conspicuously arkosic with subangular grains of orthoclase, plagioclase feldspars, epidote, and a little tourmaline.

At the most western opening on the Tonuco vein a basal conglomerate consisting of angular granite, mica schist, vein quartz, and basic extrusive rocks rests upon the pre-Cambrian series. This conglomerate passes upward into a series of fine grained water-laid arkosic sandstones, apparently the basal members of the Tertiary agglomerate series.

The pre-Cambrian rocks include a dark green mica schist intruded by pink granite. The schist in its exposures has been considerably weathered and shows extensive development of chlorite, sericite, and kaolin. The granite is fresh in a few exposures. It is made up of

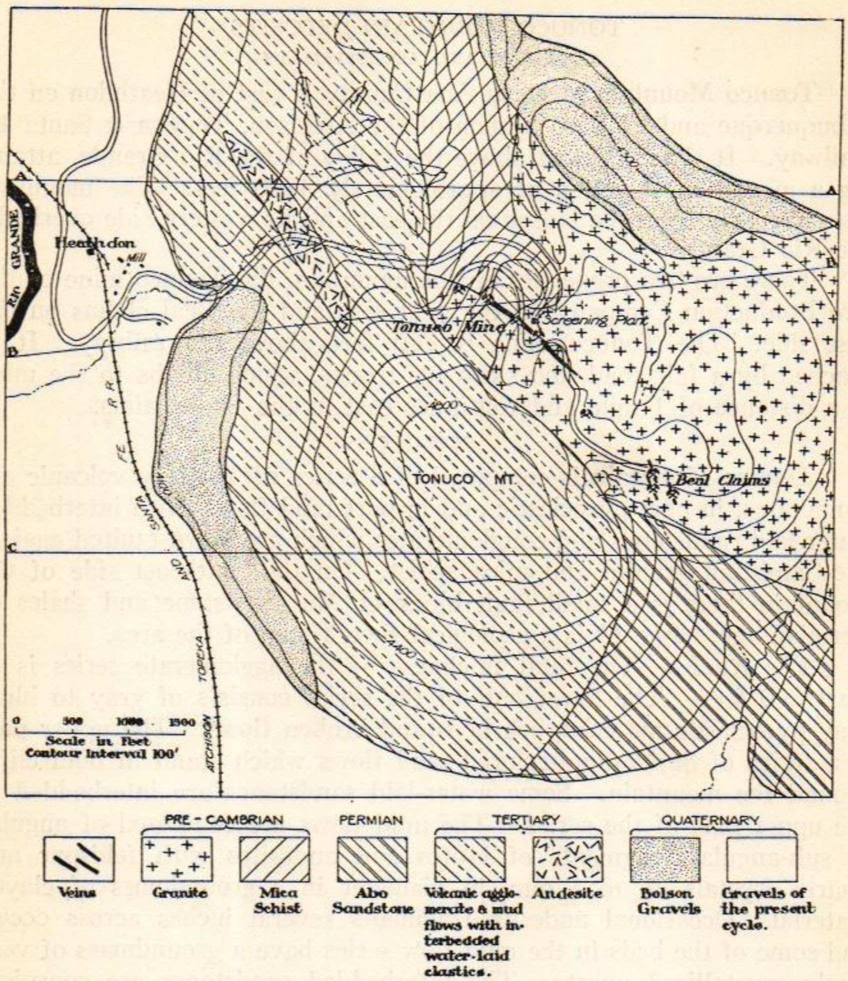

Figure 19.—Geological sketch map of Tonuco Mountain, Heathdon, Dona Ana County.

quartz, orthoclase, microcline, and muscovite with some apatite and tourmaline as accessories. In most of the granite exposures, however, the feldspars are well kaolinized and in the neighborhood of the fluorite veins, much secondary silica and some sericite is present. On the wall of the Tonuco vein, the granite has been altered by the addition of great quantities of finely crystallized silica replacing the feldspars in the rock.

On the southeast side of the mountain is a small fault block of Abo sandstone tilted to the east. The Abo is characteristically composed of thin beds of red, fine-grained sandstones separated by beds of dark red shale.

Perched on the shoulder of the mountain on the southwest and northeast sides are two areas of bolson gravels at elevations conformable with the bolson of the Jornada del Muerto to the east. Surrounding the area are gravels and alluvium of the present cycle of the Rio Grande.

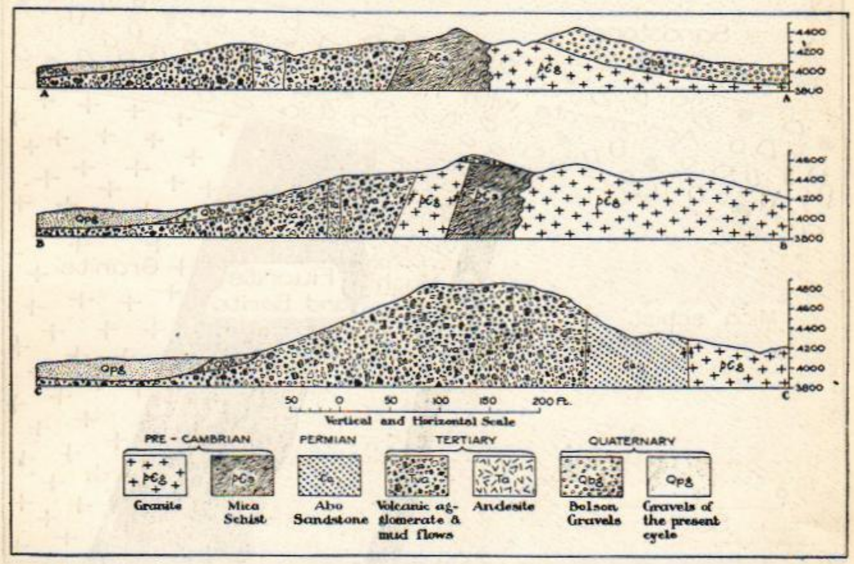

Figure 20.—Sketch sections across Tonuco Mountain, Heathdon, Dona Ana County.

Faulting.–Faulting in the area occurred in two periods. The first, to which the Tonuco vein belongs, is pre-Tertiary; the second, represented by the S-shaped fault running from north to south between the pre-Cambrian on the east and the agglomerates on the west, is Tertiary.

The earlier faults are in the pre-Cambrian granite and mica schist and are the sites of fluorite and barite deposition. The Tonuco vein, which belongs to this group, occupies a fracture striking N. 70° W. and dipping 70° to the southeast. In the upper tunnel on the west side of the mountain the vein attains a width of 10 to 25 feet with granite on the hanging wall and mica schist on the foot wall. Capping the pre-Cambrian rocks and truncating the vein is a 15-foot bed of agglomerate composed of fragments of granite, schist, latite and andesite. Some pieces of fluorite and barite are included. The agglomerate passes upward into a fine-grained, yellow arkosic quartzite having an exposed thickness of 20 feet. These water-laid clastic rocks represent the basal members of the Tertiary agglomeratic series which are down-faulted against the pre-Cambrian on the west. The relations of the vein to the capping agglomerate are fissures in granite and mica schist striking N. 20° to 30° W. They probably belong to the older fault system.

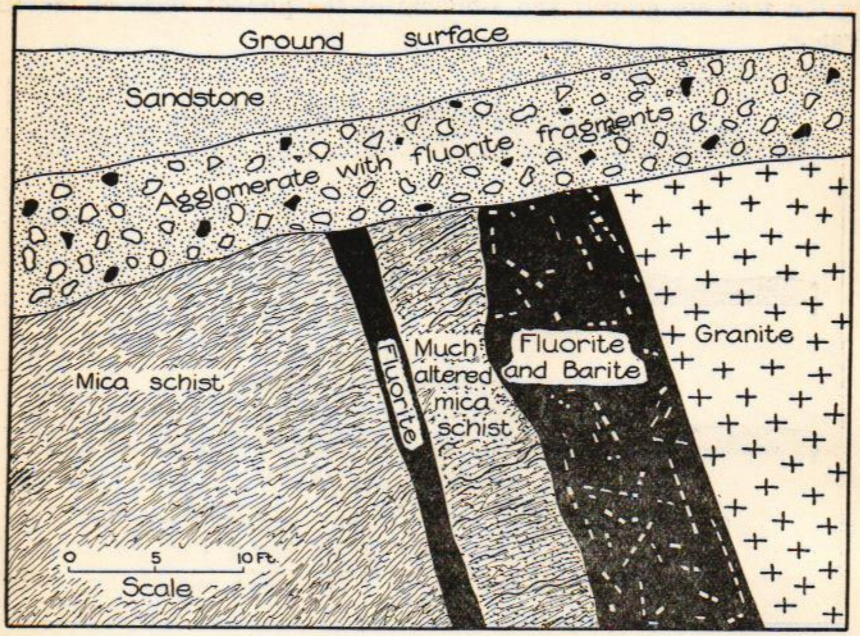

Figure 21.—Sketch section of the Tonuco vein at the western end.

The later faulting is represented by the great S-shaped north and south fault between the pre-Cambrian and Tertiary agglomerates on the north and Abo sandstone and agglomerates on the south. The agglomerate series has moved downward with reference to the older rocks on the east. A total displacement in excess of 700 feet is indicated by the basal water-laid clastics capping the Tonuco vein on the east side of the fault.

In the southeastern corner of the mapped area a block of Abo sandstone down-faulted against the pre-Cambrian granite on the north has been tilted to the east. The northwest-striking fault between the Abo and the granite probably belongs to the later series.

WORKINGS AND ORE DEPOSITS

The ore of the Tonuco Mountain deposits occurs as a fissure filling in the pre-Cambrian rocks. Fluorite and barite are the principal vein minerals, but quartz is locally abundant and some calcite occurs. No sulfides were noted.

Tonuco Vein.—The Tonuco vein occupies a fault fissure in pre-Cambrian granites and schists. At its western end it strikes N. 70°

W. but toward the east it swings to the south striking N. 25° W. at its most eastern exposure.

The western end of the vein is exposed in the upper adit on the west face of the mountain overlooking the Rio Grande. An open cut 40 feet long passes into a 70-foot adit with a course of N. 70° W. along the strike of the vein. In the outer part of the adit the ore was 10 feet across. It widened to a maximum width of 25 feet 60 feet from the portal, and then pinched to a width of 10 feet, remaining constant to the present vein face.

The ore is a mixture of barite and fluorite with much clayey material, horses of country rock, and some secondary quartz and gypsum cutting the face. Laterally the vein shows great variation in the barite-fluorite ratio. When first visited in August, 1927, the vein face was estimated to contain barite 60 per cent, fluorite 35 per cent, and country rock as inclusions and horses 5 per cent. Six months later, at the time of the writer's second visit, the breast had been advanced 30 feet and the face was estimated to contain barite 20 per cent, fluorite 60 per cent, and country rock 20 per cent. The barite and fluorite have crystallized in large masses easily separated in the course of mining. The country rock present in the vein as inclusions and horses is highly silicified and is replaced peripherally by fibrous quartz to a depth of ½ to 1½ inches.

The vein dips 70° to the southwest. The hanging wall is silicified granite with pronounced vertical slickensides and the foot wall is kaolinized and chloritized mica schist. Much sericite was noted in both walls.

A few feet north of the main vein is a small parallel fracture in the mica schist approximately 2 feet wide containing fluorite and barite. Only a few feet of drifting had been done and the persistence and relationship of the vein could not be determined.

Southwest of the upper adit and 60 feet lower on the hillside an adit was driven S. 75° E. for 350 feet in an unsuccessful attempt to pick up the vein.

On the east side of the Tertiary agglomerate capping the vein (fig. 19), an open cut 40 feet long, exposes 3 feet of barite and fluorite, apparently a pinch in theTonuco vein. The walls are granite and mica schist, both much altered.

Southeast across a ravine the vein again widens, reaching a maximum of 20 feet of ore. Here the strike is N. 25° W. and the dip 60° to the southwest. A tunnel 400 feet long follows the strike of the vein across a small spur extending north from the mountain on the south. The vein ranges from 5 to 18 feet in width in the length of the tunnel. At the southeast end it pinches to a width of a few inches and consists chiefly of barite.

Both walls of the vein are pink granite. In places there are zones in which brecciated country rock occurs as inclusions in the vein material, averaging 2 inches in diameter. These granite fragments have been silicified and peripherally replaced by a shell of fibrous quartz (fig. 22). Much post-fluorite quartz also occurs in the ore, most of which has been left in place. The greater part of the ore,' however, contains only a small amount of quartz. It is made up of a mixture of barite and fluorite, sometimes intimately intergrown and sometimes crystallized in separate masses easily sorted in the process of mining. An average of the vein material is estimated to be 40 per cent fluorite, 40 per cent barite, and 20 per cent quartz and country rock. About 20 per cent of the total material mined is said to have been marketable fluorite.[1] The ore above the level of the tunnel has been removed and the stopes open on the surface for a distance of 200 feet.

A winze descending 65 feet on the vein shows the fluorite, barite, and quartz to pinch rapidly to 2 or 3 feet with 1 foot of good fluorspar on the hanging wall. A drift 15 feet northwest shows an increase in barite.

Beal Veins.–On the eastern side of Tonuco Mountain a series of narrow parallel veins in granite strike N. 20° to 30° W. The vein material is a mixture of barite and fluorite, grading from one to the other along the strike and vertically. In general the veins are 2 to 4 feet wide.

The highest opening on the hillside is an adit 120 feet long following a vein 12 to 18 inches wide. Approximately 40 feet from the portal of the adit a winze 25 feet deep descends on 2 feet of vein material, mostly fluorite. At the bottom of the winze the vein is estimated to contain 70 per cent fluorite and 30 per cent quartz as chert veinlets cutting the ore. The vein here is free from barite. Approximately 1000 tons of metallurgical lump spar are said to have been removed from this vein.[2]

Lower on the hillside to the southeast a parallel vein striking N. 30° W. is divided by a parting of granite 1% feet wide. A shaft descends on the vein to a depth of 40 feet where the parting is lost and 2% to 4 feet of good fluorspar is exposed. Near the surface the vein material is largely barite, but at the bottom of the shaft the vein is estimated to contain less than 10 per cent of barite. With ordinary care in sorting most of the vein material can be marketed as metallurgical lump. A number of other parallel veins in the vicinity contain 1 to 2% feet of barite and fluorite.

THE ORE

The ore in all of the Tonuco Mountain deposits is a mixture of barite and fluorite, sometimes closely intergrown but usually crystallized in distinct masses easily separated in the process of mining.

The ore in the tunnel on the southeast end of the Tonuco vein,

[1]Roy Beal, personal communication.
[2]Roy Beal, personal communication.

which contains zones of brecciated granite, is of both genetic and economic interest. Fig. 22 is a sketch of the face of one of these zones. Blocks of granite have been silicified by the addition of fine-grained quartz which has replaced the mica, and, in part, the feldspar throughout the rock mass. Surrounding a silicified granite center is a replacement band of fibrous quartz ½ to 1½ inches thick with prisms normal to the surface of the fragment. The interstices between these replaced granite blocks are filled with clear green fluorspar. A final generation of quartz completes the cavity filling with groups of well-developed crystals connected by thin quartz films.

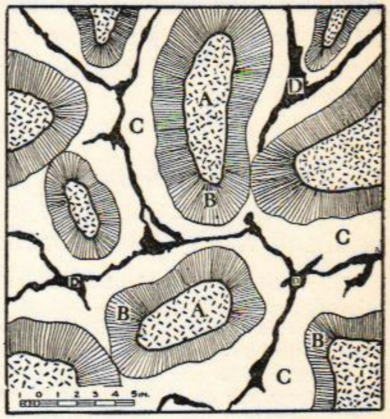

Figure 22.—Granite breccia ore from the Tonuco vein. Silicified granite (A) is replaced peripherally by fibrous quartz (B). Fluorite (C) and quartz (D) fill the interstices in the breccia.

By careful sorting an acid lump ore can be obtained, and a few cars of this material have been shipped. Metallurgical lump is, however, the most practical product.

In March, 1928, approximately 25 tons of ore were piled at the portal of the upper adit on the western side of the Tonuco vein. An analysis of the best material in this ore pile showed 96.67 per cent CaF_2, 0.45 per cent $CaCO_3$, 0.93 per cent $BaSO_4$, and 1.85 per cent SiO_2. This analysis represents picked material. The run of the ore pile is metallurgical lump.

An analysis of selected ore from the Beal veins showed 97.53 per cent CaF_2, 0.31 per cent $CaCO_3$, and 2.28 per cent SiO_2.

The grade of the ore produced by the lessees operating the Tonuco property will depend entirely upon the demands of the market. In every case more than 50 per cent of the material mined goes to the dump.

HISTORY

The Tonuco mine was located in 1917 by Roy Beal of Heathdon, New Mexico. In 1918 the Ore Production Company took over the property and shipped approximately 2,500 tons of metallurgical lump between April 1, 1919, when the mine was opened and June, 1921, when the mill was completed. Air drills were used during the period. The mill proved unsuccessful and the Ore Production Company was taken over by J. E. Brazeal of Rincon, the present owner of the property. From the time the mill closed to the present small quantities of metallurgical lump have been mined by native lessees, who have shipped a car occasionally. In the early part of 1928 lessees were working a number of openings on the property.

In 1920 Roy Beal located the claims on the east side of Tonuco Mountain and has worked them since 1926, producing approximately 1200 tons of ore. From September, 1927, to February, 1928, he shipped approximately 150 tons to Manasse and Hayner of Las Cruces, New Mexico.

MILLING OPERATIONS

Ladoo,[1] who visited the property in 1922, gives the final flow sheet of the mill. Harz jigs were used for the separation of the coarser material and Wilfley tables for the finer ore. He says:

> The main milling plant is located at the railroad about a mile from the main tunnel and was constructed at a cost of about $15,000. This mill has been remodeled several times in an effort to effect a separation of the barite and silica from the fluorspar, but the problem has not been solved. (A sample taken from the mill heads analyzed as follows: 47.33 per cent CaF,, 29.49 SiO,, 1.03 CaCOa and 17.26 BaSO4; sample of gravel from car on siding ready to ship analyzed 78.52 per cent CaF,, 10.33 SiO,, 0.50 CaCO, and 9.70 BaSO4. A sample from the drawoff from the best two cells on fine jig analyzed 79.87 per cent CaF,, 13.62 SiO,, 0.71 CaCO, and 5.20 BaSO4.)
>
> The barite product from the mill has been segregated in a separate dump in the hope of being able at a later time to work out some method of producing a marketable barite product. This dump at present contains about 200 tons of low-grade barite.

ORE RESERVES AND FUTURE POSSIBILITIES

It is impracticable with knowledge of the extremely variable character of the veins to estimate ore reserves. Particularly is this true where no development in advance of mining has been done. The Beal veins give promise of having extensive ore bodies as yet undiscovered. A small steady production of metallurgical lump by lessees on the Tonuco vein should continue.

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[1] **Ladoo, Raymond B. Fluorspar Mining in the Western United States: U. S. Bureau of** Mines, **Reports of Investigations, Serial 2480, May, 1923.**

DEPOSITS IN THE ORGAN MOUNTAINS

THE ORGAN MOUNTAINS

LOCATION AND TOPOGRAPHY

Lindgren[1] has summarized the major features of the Organ Mountains as follows:

> The Organ Mountains, named by the Mexicans Sierra de los Organs on account of the conspicuous granite spires along their western front, form a break in the long chain of north-striking ranges extending from the Sandia Range, near Albuquerque, on the north, to the Franklin Range, terminating at El Paso, in the extreme west corner of Texas, on the south. The Organ Range is separated from the Franklin Range by a gap southeast of Las Cruces, and continues northward for about 30 miles, its width varying from 5 to 15 miles. In its southern part the western slope is abrupt, in places scarplike. The eastern slope is, as a rule, more gradual. The range culminates in Organ Peak with an elevation of 9,108 feet (Wheeler). Fifteen miles northeast of Las Cruces, at the eastern base, is Organ, a small settlement and the center of the principal mining operations. Near this place the range ends at San Augustin Pass (elevation 5,654 feet) north of which rises the prominent peak of the same name (elevation 6,850 feet).

GEOLOGY

The Organ Mountains are included in the chain of ranges extending south from the Sandia Mountains at Albuquerque to the Franklin Mountains at El Paso. This structural chain is, with the exception of the Organs, composed of monoclinal block faulted ranges. The Organs, however, are formed from an exposed and slightly eroded laccolith intruded into Paleozoic sediments.

In the older literature[2] the crystalline rocks of the Organ Mountains were thought to be pre-Cambrian. Lindgren[3] first called attention to the fact that they were intruded into Pennsylvanian sediments. He says:

> The granitic rock forms a stock or batholith, in places with features of a laccolith, which is distinctly intruded into the limestone, and which, beyond all doubt, is of post-Carboniferous age. It is possible that pre-Cambrian rocks may be present in the Organ Mountains, as indeed they are in the Franklin Range, but they probably do not occur in the vicinity of the mining districts here described. The intrusive origin of the granitic rocks is proved by the structural relations at the contacts and by the contact metamorphism of the limestone. It is also supported by the fact that dikes of aplite, syenite porphyry, and dark diorite cut the sedimentary rocks as well as the main intrusive mass, and that a dike of granite or quartz syenite was observed in the limestone close to the shaft at the Stephenson-Bennett mine.

No detailed work has been done upon the Paleozoic rocks surrounding the Organ massif. To the south, in the Franklin Mountains, Richardson[4] gives the following section:

[1]Lindgren, Waldemar, Ore Deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp.205- 206, 1910.

[2]Antisell, Thomas. Pacific R. R. Survey, Vol. 7, pp. 161 et seq., 1857.
Keyes, C. R., Geology and Underground Water Condition of the Jornada del Muerto, New Mexico: U. S. Geol. Survey Water Supply Paper 123, p. 28, 1905.

[3]Lindgren, Waldemar, op. cit., p. 208.

[4]Richardson, G. B., El Paso Quadrangle, U. S. Geol. Survey Atlas, El Paso folio (No. 166) 1909.

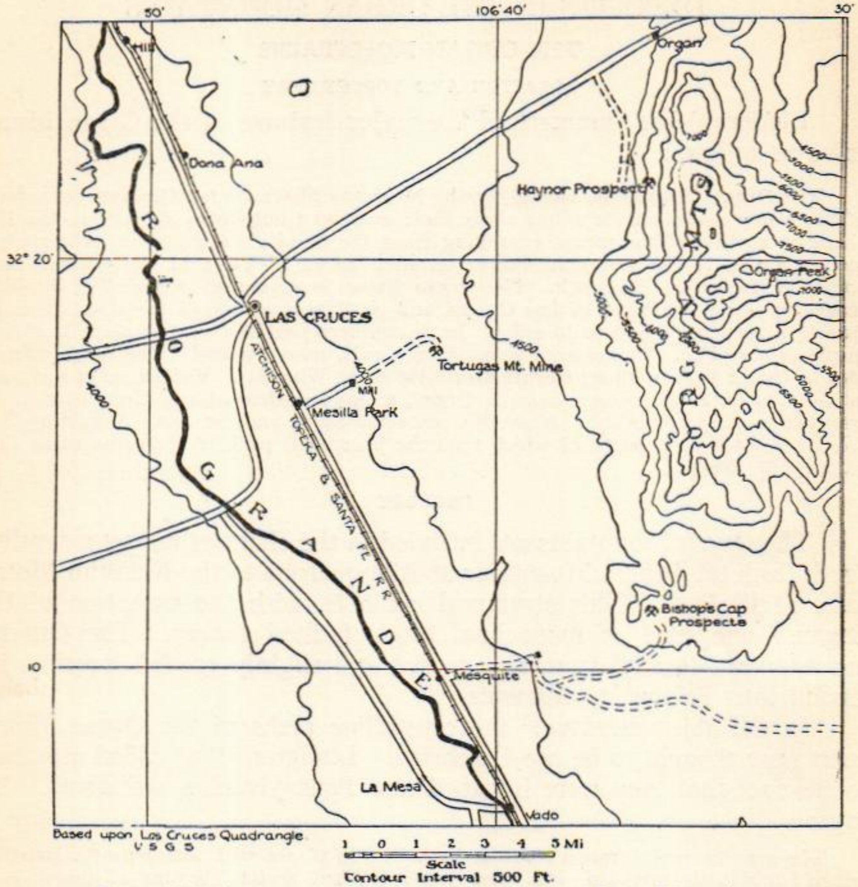


Figure 23—Index map to the fluorspar deposits of the Organ Mountains.

PALEOZOIC ROCKS OF FRANKLIN MOUNTAINS

Pennsylvanian	Hueco limestone	3,000 ft.
Silurian	Fusselman limestone	1,000 ft.
Ordovician		
Upper and Middle	Montoya limestone	250 ft.
Lower	El Paso limestone	1,000 ft.
Cambrian	Bliss sandstone	300 ft.

The Hueco limestone of the Franklin Range is the equivalent of the Magdalena limestone of Socorro and Sierra counties.

The Paleozoic rocks in the Organ Mountains are exposed in a narrow belt one-fourth to 4 miles wide surrounding the intrusive massif and, in turn, surrounded by bolson deposits.

In the vicinity of the Hayner claims, south of the town of Organ, the sedimentary rocks consist of much-folded limestones and thin shale beds. Near the intrusive rocks the purer limestone beds have been metamorphosed into a white, coarsely crystalline marble such as occurs on the footwall of opening No. 2.

Tortugas Mountain, on which the Tortugas mine is located, is an outlying fault block rising above the bolson deposits which surround it. The section here exposed consists of about 350 feet of massively bedded, dark gray to gray, cherty limestone resembling the lower part of the Magdalena limestone of the Caballos Mountain section. No fossils were found.

On the southwestern corner of the Organ Mountains the limestones have the form of a plunging anticline and disappear beneath the bolson to the south and west. This regional dip, in the vicinity of Bishop's Cap, is disturbed by extensive small scale faulting which gives local reversals. The faulted zones are loci for the deposition of fluorspar.

THE FLUORSPAR DEPOSITS

In the Organ Mountains the fluorspar occurs predominantly as a fissure filling, with replacement of secondary importance.

Associated with the fluorite are quartz, calcite, and some barite. Sulfides are absent except in the immediate vicinity of the sedimentary and intrusive contact, as at Organ where the fluorite occurs as a minor gangue mineral in lead-silver mesothermal or moderate temperature-pressure veins.[1] The fluorite veins are farther removed from the contact and were probably deposited under epithermal or low temperature-pressure conditions.

TORTUGAS MINE

LOCATION

The Tortugas mine is on Tortugas Mountain in Dona Ana County and is 5 miles northeast of Mesilla Park, a station on the Atchison, Topeka & Santa Fe Railway 2 miles south of Las Cruces. The property, which consists of 5 claims, is owned and operated by Manasse and Hayner of Las Cruces.

GEOLOGY

Tortugas Mountain, 3½ miles east of Mesilla Park, is a fault block of limestone which rises 500 feet above the gently westward-sloping bolson to an elevation of 4900 feet.

The beds dip to the west and are bounded on the east by a north-striking fault and on the northeast by a fault striking N. 55° W. The east and northeast sides are steep facets whose strikes parallel the mineralized veins of the mountain.

Between 400 and 500 feet of massive bedded, gray to dark gray, siliceous limestones are exposed in the mountain sides. As no fossils were found the correlation of these belts is uncertain, but they resemble lithologically the lower part of the Magdalena section in the Sierra de

[1]Lindgren, Waldemar, op. cit.

los Caballos. Throughout the limestone area the beds are highly siliceous and are cut by an intricate network of secondary silica veinlets varying in width from a fraction of an inch to several inches.

Five miles east of Tortugas Mountain is the massif of the Organ Mountain laccolith, and between are bolson deposits resting on Paleozoic sedimentary rocks which outcrop in a narrow band on the flanks of the intrusion.

ORE DEPOSITS

Two veins in Tortugas Mountain contain fluorite as the principal fissure filling. The first, extending for a minimum distance of 1200 feet on the outcrop, strikes north. The second vein outcrops on the east face of the mountain. It strikes N. 55° W. and joins the first vein near the northern end of its outcrop. They are known as the Tortugas and Jones veins, respectively.

Tortugas Vein.—The Tortugas vein, which has furnished most of the fluorite mined, is exposed in workings for a distance of 1000 feet along the strike and it can be followed by surface residual spar for a total distance of 1400 feet. In August, 1927, it had been followed to a depth of 286 feet without change in character. A longitudinal section of the mine with cross sections of the vein material is shown in fig. 24.

The ore occurs as filling in a north-striking fissure which dips 80° east at the surface. At about 250 feet the fissure is approximately vertical and at a depth of 286 feet it dips 60° west. The width of the vein is variable. Old stopes near the surface in the vicinity of the main shaft are 2 to 8 feet in width, pinching out at the extremities of the outcrop. On the 286-foot level it ranges from 2 to 8 feet in width, averaging for that level about 3½ feet. Pinches to one foot or less occur on all levels.

A gouge sheet, 1 to 10 inches in width occurs in the vein material throughout the mine. In places it is very clayey but elsewhere it is a calcareous sand containing up to 30 per cent of granular fluorspar.

Jones Vein.—The Jones vein outcrops as a fracture zone near the first shoulder on the east side of Tortugas Mountain and strikes N. 50° to 55° W.

A cross section of the vein at the breast of the adit is shown in fig. 25. The total width of the fracture zone is in excess of 15 feet, and She fluorite occurs as fracture fillings and replacements within the zone of shattering. The limestone horses remaining in the vein are more or less porous, probably the result of solution after deposition of the fluorite had ceased. The gouge filling the fissure which makes the southwest boundary of the mineralized belt contains cleavage fragments of fluorite, indicating post-fluorite movement in the vein. Some calcite and a little gypsum in the southwest wall were the last minerals deposited.

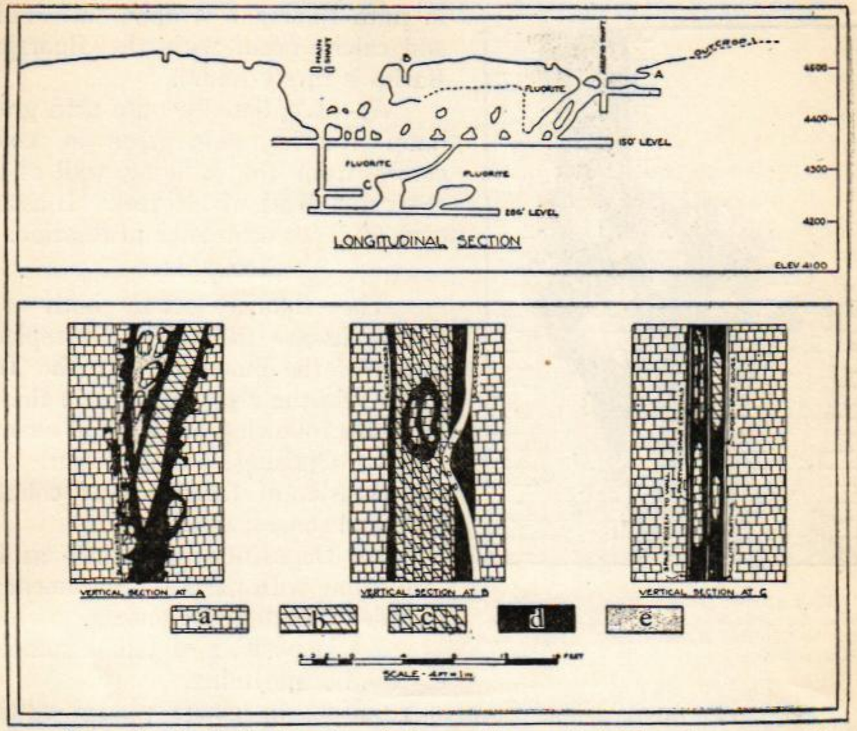


Figure 24.—Longitudinal section of the workings, and sketch sections across the vein, Tortugas mine, near Mesilla Park, Dona Ana County. a, limestone; b, calcite; c, banded calcite; d, fluorite; and e, clay.

The outcrop of the vein up the hillside to the northwest is marked by a series of silicified slickensides in the limestone. It appears to cut the Tortugas vein north of the most northern workings on that vein.

THE ORE

Samples of Tortugas ore gave the following analyses:

	CaF_2	$CaCO_3$	SiO_2	$Al_2O_3 + Fe_2O_3$
A.	96.97	1.88	0.57	---
B.	92.98	3.15	3.41	0.44
C.	99.50	0.35	0.12	---
D.	75.85	14.85	8.55	0.75

A. Hand sorted acid lump from crusher feed platform at mine.
B. Mine run lump from platform at crusher.
C. Jones vein, hand sorted acid lump.
D. Head feed, Tortugas mill.

The ore in both the Tortugas and Jones veins is bottle green in color and occurs in large crystals often 3 inches across a cleavage face. Sometimes the ore is banded with calcite, and occasionally a banded structure

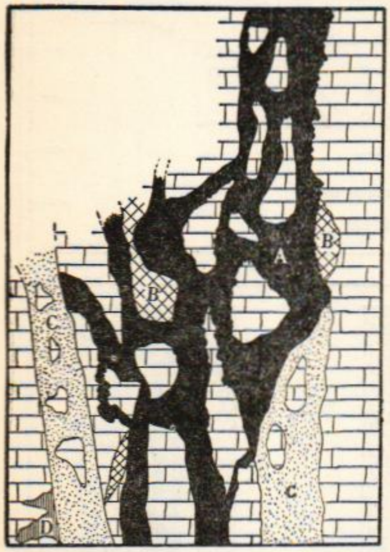


Figure 25.—Sketch section of the Jones vein, Tortugas Mountain, Dona Ana County. A, fluorite; B, calcite; C, gouge; and D, gypsum.

in pure fluorspar is apparent. Silica and calcite occur with the fluorspar. Barite is rarely found.

An exceptionally pure acid grade lump fluorite, pale green in color, comes from the hanging wall of the shaft to a depth of 115 feet. It assays over 99.5 per cent calcium fluoride.

PARAGENESIS

The fluorite occurs both as a simple fissure filling and as replacements of the limestone. In the Tortugas vein the cross sections in fig. 24 show the following sequence of events:

1. Opening of main fissure with the inclusion of fragments of country rock and some gouge.
2. Deposition of fluorite as fissure filling with partial replacement of included limestone fragments.
3. Deposition of calcite completing the fissure filling.
4. Movement along fissures resulting in gouge planes cutting fluorite.

Vertical section B (fig. 24) shows almost complete replacement by ore of the limestone horses.

In the Jones vein replacement is more extensive than in the Tortugas vein, but post-fluorspar deposition movement has also taken place here. Some silicification of the limestone is the only wall rock alteration.

HISTORY

The Tortugas mine was first opened in 1920. Production, according to the records of the U. S. Bureau of Mines, amounted to 3,235 tons up to 1922, and 15,328 tons to 1927. The spar shipped, according to Ladoo,[1] varied in grade from ground spar for the glass industry analyzing 93.76 per cent CaF_2, 3.42 per cent SiO_2, and 2.50 per cent $CaCO_3$, to low-grade fluxing spar which analyzed 80.91 per cent CaF_2, 5.64 per cent SiO_2, and 13.15 per cent $CaCO_3$.

The present owners, Manasse and Hayner of Las Cruces, were operating the property when it was visited by the writer.

[1]Ladoo, Raymond B., op. cit., p. 122.

DEVELOPMENT

Five claims, Tortugas Fluorspar Nos. 1 and 2 and Fluorspar Nos. 1, 2, and 3, cover both veins.

Tortugas Vein.—The present workings extend for a distance of 1000 feet along the outcrop and to a depth of 286 feet below the collar of the main shaft, which is located on the center line near the north end of Tortugas Fluorspar No. 1 claim.

An inclined shaft follows the vein to the bottom of the mine, which has been stoped continuously from the surface to a depth of 150 feet. Along most of the outcrop it has been stoped to the surface. A cross section of the vein at the discovery shaft is shown in fig. 24b. Just south of the discovery shaft pure spar 2 to 3 feet wide was removed.

Above the 150-foot level all of the ore south of the main shaft as far as the Arroyo shaft has been removed. The fluorite varied in width from 1 to 8 feet, averaging 3½ feet.

On the 150-foot level and 400 feet north of the main shaft the ore swells to a width of 8 feet. A few feet farther north the vein pinches and again swells to 6 feet 40 feet beyond. The walls are unaltered limestone showing little replacement. At places along the drift 2 to 8 inches of very pure fluorite is frozen to either wall. Persistent at this level is a thin streak of post-fluorite gouge traversing the vein material. At the extreme north end of the drift, just below the Arroyo shaft, the vein filling disappears but the post-fluorite fracture continues into the limestone. This likely is a pinch in the original pre-fluorite fissure which was reopened in the later movement. Additional fluorspar may occur along the strike of the vein to the north of the present breast. The fluorspar-free pinched section of the vein shows much gypsum, probably deposited in comparatively recent times.

Beyond the main shaft at the south end of the drift on the 150-foot level the vein pinches to less than 1 foot in width, and the greater part of the vein material is post-fluorite calcareous sand.

On the 286-foot level the vein varies in width between 2 and 7 feet. Here the dip of the vein is 60° west, the reversal of the dip having occurred at 250 feet.

Some drifting to the south has been done on this level but the ore to the south begins to pinch at the bottom of the shaft. Post-fluorite faulting is shown by clay selvages on the west wall.

The drift extends 400 feet north from the main shaft with raises and stopes in good ore. Most of the fluorite between the 286-foot level and the 150-foot level remained in the mine in August, 1927.

At the end of the north drift at the level the ore plays out and the post-fluorite fault line is represented by broken limestone with gypsum.

The North Hill Tunnel (fig. 24a) follows the fracture zone for a distance of 60 feet through massive gray limestone with fillings and replacement by fluorite. The center of the fracture is occupied by a band of calcite, apparently in part a replacement of a limestone horse in the vein. Faint horizontal streaks and colorations in the calcite are suggestive of the bedding planes of the country rock. The fluorite is disseminated through the east wall in a network of veins and replacements. It is in large green crystals in masses up to 2½ feet across. Approximately 100 tons of marketable fluorite have been removed from this adit.

The Arroyo shaft was begun in a vein width of 20 feet of good spar which narrowed to 4½ feet at a depth of 35 feet.

On the 35-foot level are vertical slickensides parallel to the dip which is 68° west. The hanging wall is much shattered and contains fluorite replacements. Resting on the footwall is a keystone-shaped block of fluorite containing approximately 500 tons which has dropped 20 feet.

Striking S. 10° E. from the foot of the Arroyo shaft is a small fluorite-filled fracture containing 2 to 3 feet of ore which grades into calcite some 20 feet from the Tortugas vein.

North of the Arroyo shaft along the drift on the 35-foot level the fracture narrows to 2 feet and fluorite is absent. This is the post-fluorite fault encountered in the lower levels.

It is estimated that approximately 1000 tons of ore have come from the Arroyo shaft.

Jones vein.—The development of the Jones vein consists of an adit 30 feet in length connected at the breast with a shaft from the surface. This vein has produced approximately 100 tons of fluorite and a considerable quantity is still in sight.

MINING AND MILLING

The ore of the Tortugas vein is mined by overhead stoping and dropping to the 286-foot level through ore chutes. Here it is loaded in buckets on mine trucks and pushed by hand to the main shaft where it is raised to the surface by a gasoline hoist. At the surface it receives some cobbing, and the acid lump is sorted out. From the upper loading platform it is carried 300 feet on an aerial tramway to the lower platform at the foot of the east side of Tortugas Mountain. Here it is again picked for acid lump, and the mine run is crushed, loaded into trucks and hauled 4 miles to the mill near Mesilla Park. The handpicked acid lump is used to bring up the grade of the ore which has passed through the mill.

Ladoo,[1] who visited the Tortugas mine in 1922, has described the milling of the ore. He says:

[1]Ladoo, Raymond B.. Fluorspar, its mining, milling and utilization: U. S. Bureau of Mines Bull. 244, pp. 123-24, 1927.

Power and water for the mill are supplied by the near-by New Mexico Agricultural College. The water comes from a drilled well.

The ore at the mill (sample analyzed 77.41 per cent CaF2, 6.51 per cent Si02, and 15.68 per cent CaCO2) is unloaded into a small bin. The jigs have a capacity of 2 tons of heads per hour and the bull mill 1 ton per hour. Milling loss is 50 per cent and the tailings run 30 per cent flnorspar. The actual output was about 50 tons evert• 7 days. The coarse jig product was hand sorted, and with the product of the best two cell.; of each jig formed the grinding product. All but about 100 to 150 tons of the hutch product was discarded; this was shipped as fluxing spar. The screen product that was not used for grinding grade was thrown with the hutch product. There was no uniform method of handling the product of the jigs, but the mill operators were guided by the appearance of the spar in screening and selecting for grinding purposes. The product of the grinding mill passed a 16 mesh screen.

Ladoo's flow sheet is reproduced in fig. 26. Since his visit in 1922 no changes have been made in milling practice.

Samples of mill ore and products were taken by the writer in the summer of 1927. They were analyzed and the following results obtained.

	CaF_2	SiO_2	$CaCO_3$	$Al_2O_3 + Fe_2O_3$
A.	75.85	8.55	14.85	0.75
B.	94.92	1.61	2.55	0.92
C.	24.22	20.13	50.43	5.22
D.	59.90	16.31	24.11	0.68

A. Head feed at mill.
B. Ground product from bin at mill.
C. Tailings from dump.
D. Mixed hutch product.

Marketable material not of sufficiently high calcium fluoride content to be ground for the enamel trade is sold as metallurgical spar.

ORE RESERVES AND FUTURE POSSIBILITIES

The writer's estimate of the tonnage of recoverable fluorite in the Tortugas vein remaining in the mine above the 286-foot level is 9000 tons.

As the tenor of ore has been fairly constant with depth it is a rational supposition to consider an additional depth of 200 feet on the vein as practical mining ground. Assuming persistence to that depth, both as to width and length of vein, an additional 13,500 tons of spar can be added to the reserves, making the total reserve of the Tortugas vein some 22,500 tons of recoverable fluorite.

An estimation of the tonnage of the Jones vein is impracticable because of the limited development work done up to this time.

At the present rate of production the Tortugas mine has ore reserves for a number of years.

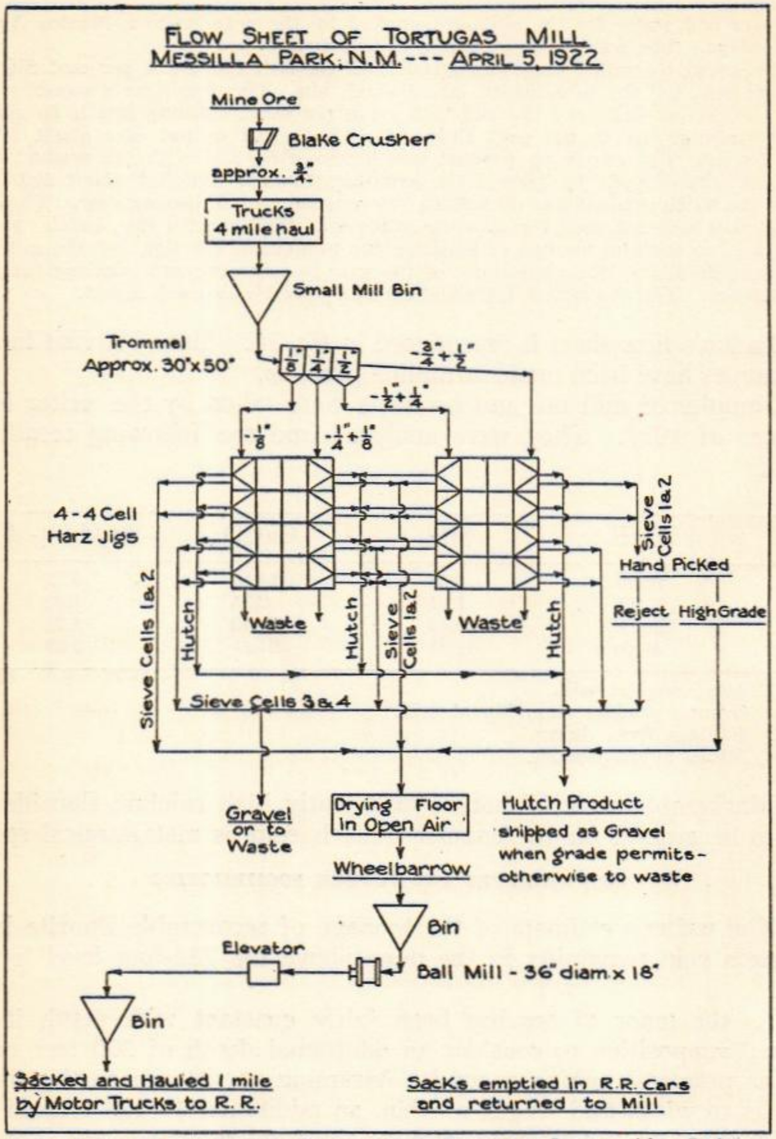


Figure 26.—Mill flow sheet, Tortugas mill, Dona Ana County. After Ladoo.

HAYNER PROSPECT

LOCATION AND ACCESSIBILITY

The Hayner prospect is on the west side of the Organ Mountains and approximately 4½ miles south of the town of Organ. It is located at an elevation of 5600 feet at the head of the talus fan extending to the west into the bolson, and approximately one-half mile west of the outcrop of the intrusive rocks which form the pinnacles or "organ pipes" of the range. The property is about 16 miles from Las Cruces.

GEOLOGY

The country rock in the vicinity of the prospects is composed of metamorphosed and contorted shales and limestones of Paleozoic age. Half a mile to the east the intrusive rocks stand in spires and pinnacles making the jagged skyline responsible for the naming of the range. Extending toward the west from the claims, an apron of boulder-covered talus drops to the more even surface of the bolson below. Between the upper edge of the talus apron and the intrusive rocks is a belt one-fourth to one-half mile in width in which the Paleozoic sedimentary limestones and shales outcrop.

WORKINGS AND ORE DEPOSITS

The fluorite is found in fissure veins cutting the limestones and shales with some replacement of the former. Two openings were being made at the time of the writer's visit. The first was a shaft sunk to a depth of 20 feet following a fracture zone striking N. 50° E. and dipping 45° SE. The footwall of the fault zone is composed of dense white, finely crystallized limestone, almost a marble. The hanging wall is composed of a much-broken, clayey limestone also suggesting considerable metamorphism. Throughout the hanging wall so far as exposed by the shaft were tabular lenses of apple green fluorite reaching a maximum thickness of 10 inches. The extent of the lenses into the hanging wall was not exposed in the cut.

Approximately 60 feet northwest of the first shaft and 30 feet lower on the ravine side an open cut and adit follow a fault zone striking N. 10° E. and dipping 55° E. Slickensides on the walls of the vein indicate that the displacement was diagonally along the plane of fracture. The bedding of the wall rock crosses the fault plane with an apparent dip of 20° to the southwest.

The fluorite occurs as a fissure filling showing some replacement of included limestone fragments and but little replacement of the wall rock.

A sketch of the breast of the adit is shown in fig. 27. In the sketch the vein is shown to be composed of five parts. A to B, C to D, and E to F are composed of massive green banded fluorite free from calcite.

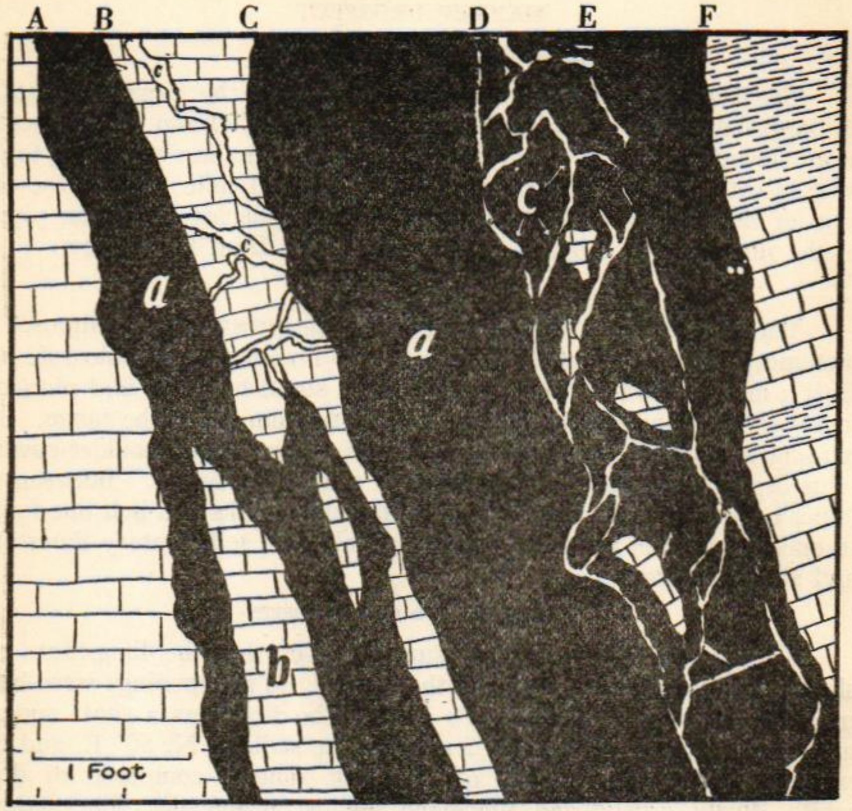


Figure 27.—Sketch section of a vein on the Hayner prospect in the Organ Mountains. a, fluorite; b, limestone; and c, calcite.

B to C is limestone country rock cut by narrow veinlets of calcite, and D to E is composed of white to pale violet fluorite containing fragments of limestone and cut by numerous narrow calcite veinlets. A total width of 2½ to 3 feet of recoverable fluorite is exposed.

The writer's interpretation of the sequence of events which gave rise to the relations exposed on the breast of the adit is as follows:

1. Opening of fracture zone extending from D to E.
2. Deposition of white to violet spar as fracture filling and some replacement of included fragments.
3. Shattering of zone extending from B to E.
4. Deposition of calcite in veinlets cutting fluorite and calcite.
5. Reopening along fault zone resulting in fissures extending from A to B, C to D, and E to F.
6. Deposition of green banded fluorite in the last fissures formed without replacement of the wallrock.

THE ORE

The ore is lilac to green in color and its texture ranges from finely crystalline and granular to massive. An analysis of selected, clear, massive material from the face of the adit gave returns of 98.24 per cent CaF_2, 1.08 per cent $CaCO_3$, and 0.64 per cent $Si0_2$.

FUTURE POSSIBILITIES

Prior to August, 1927, no fluorspar had been shipped from the Hayner deposit and it had not passed the prospect stage; consequently any prediction as to extent of future development or tonnage available is premature. As prospects, however, the fluorite occurrence here shows much promise. The proximity of the intrusive massif of the Organ Mountains and the shattered condition of the country rock form a favorable setting for spar deposition. The band of sedimentary rocks on the flanks of the intrusion can be regarded as very good prospecting territory.

BISHOP'S CAP PROSPECTS

LOCATION AND ACCESSIBILITY

A group of fluorite claims owned by Manasse and Hayner is situated 10 miles east of Mesquite, a station of the Atchison, Topeka & Santa Fe Railway, 12 miles south of Las Cruces in Dona Ana County. The distance from Mesquite to the claims by road is 16 miles. The claims are at an elevation of 4600 to 4700 feet, approximately 1000 feet above the level of the Rio Grande valley at Mesquite, on the sides of a southward sloping ravine east of Bishop's Cap (sometimes called Pyramid Peak), an outlier of the Organs which has the appearance, as its name suggests, of a bishop's miter.

GEOLOGY

On Bishop's Cap are exposed over 400 feet of massive siliceous limestones of Paleozoic age in which no fossils were found. The limestones are heavily bedded and contain chert nodules and occasional quartzite beds. In general, the lithologic character of the beds suggest the Magdalena limestone, but this correlation is unsupported by paleontological or stratigraphic evidence.

At the summit of Bishop's Cap the beds dip 3° to the east, and on the west side the dip increases sharply to angles as high as 70°, the steepest dips occurring just west of the summit. Across the west face the outcrop pattern of the beds extends in great irregular scallops forming conspicuous striations on the hillside. Toward the south on a south-striking ridge extending from the peak the beds dip southwest.

The spar deposits lie in the second small ravine east of the peak of Bishop's Cap in a large shattered zone extending to the south on the southwestern flank of the Organ Mountain intrusion. The prevailing dip of the beds is to the west at an angle of 5° to 10°. Toward the mouth of the ravine, where it opens into the bolson, the dip is to the southwest at angles from 12° to 18°. Crossing the ravine are a number of small fault blocks with east and southwest dips. The ravine containing the fluorspar is cut by an intricate pattern of minor fractures which form the locus of spar deposition.

WORKINGS AND ORE DEPOSITS

The ore deposits are a quarter of a mile up the ravine from the end of the road. They consist of siliceous fluorspar deposited in fissures and fracture zones in limestone.

On the west side of the ravine and 200 feet above the flat is an open cut 15 feet long in a fracture zone of highly siliceous limestone. The ore is composed of fluorite and white, sugary chert forming a matrix inclosing angular fragments of banded, cherty limestone. The total width of the fluorite-bearing zone is 6 feet.

Higher in the hillside and approximately 1000 feet to the north a fracture zone striking N. 20° W. is exposed. The fracture is filled with a silicified gouge containing chert fragments and fluorite in veinlets cutting the gouge.

Above the first cut some 100 feet and 1500 feet to the north is an open cut and adit 30 feet long with a course of N. 40° W. The outer 20 feet of the cut is in a hard, gray quartzite and the inner 10 feet of the adit is in massive gray limestone cut by random veins of silica and fluorite, all less than 3 inches in width. At the breast is a vein of milky quartz 14 inches in width striking N. 10° E. Cutting the quartz vein are veinlets of green fluorite one-half to 2 inches wide.

The limestone near the breast of the adit is cut by thousands of quartz veinlets forming an intricate pattern which is most pronounced near the fluorspar veinlets. The occurrence of these secondary quartz veins in the limestone is conspicuous throughout the Bishop's Cap property. Such limestones weather to a coxcomb surface of iron-stained quartz.

Up the hillside northwest of the former opening is a shaft 30 feet in depth sunk on a simple fissure vein. A sketch of the wall of the shaft is shown in fig. 28. The vein, which is 2 feet in width, is siliceous limestone. It is banded with chert, and 3 feet to the south another vein 6 inches in width of pure fluorite parallels the first. Approximately 8 tons of ore was piled at the surface. By careful cobbing and sorting a metallurgical lump product could be obtained.

South of the shaft approximately 400 feet and at the same level are two small cuts in fracture zones which show brecciated siliceous limestone and chert in a matrix of sugary chert, milky quartz and a little fluorspar. The whole area is cut by a network of very small quartz and fluorite filled fissures.

A small cut 10 feet in depth lies on the east side of the head of the ravine. It exposes another narrow fracture zone in which fluorite and quartz cement a breccia and chert.

Lower on the east side of the ravine is another small cut 10 feet in length and 4 feet deep following a fracture zone striking N. 50° E., likely a continuation of the lowest fluorite-bearing fissure exposed on the west side of the ravine. The zone is 3½ feet wide, with siliceous fluorite forming a matrix surrounding limestone and chert fragments. The wall rock is siliceous limestone with some vertical silica-plated slickensides. About 2 tons of ore, marketable after further picking, is piled beside the cut.

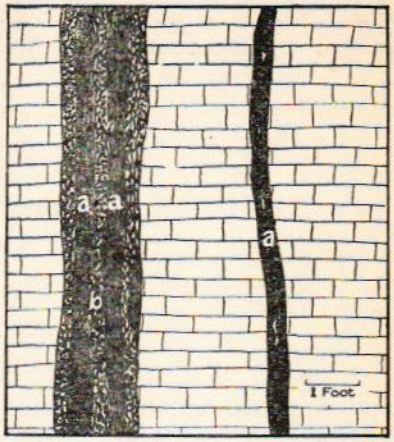


Figure 28.—Sketch section of shaft wall, Bishop's Cap prospect, Dona Ana County. a, fluorite; b, chert and fluorite.

THE ORE

The following analyses of ore from the Bishop's Cap mine are taken from Ladoo's report:[1]

	A	B	C	D	E
Calcium fluoride	90.00	92.51	83.94	62.34	55.78
Calcium carbonate	1.51	0.34	0.12	2.12	4.10
Silica	8.05	6.81	15.34	32.93	37.73
Barium sulfate	----	----	----	1.04	1.05

Descriptions of samples were not given.

The following analysis is of a composite sample of picked spar from the two ore piles found at the time of the writer's visit in August, 1927: 88.77 per cent CaF_2, 5.05 per cent $CaCO_3$, and 6.08 per cent SiO_2.

PARAGENESIS

Numerous fracture zones in the limestones forming the southwestern corner of the Organ Mountains were developed as the result of the intrusion of the Organ massif. The fractures were filled with (1) fine sugary chert, (2) milky quartz, and (3) fluorspar. Some barite, a little calcite and fluorspar were the last minerals deposited.

FUTURE POSSIBILITIES

Up to the time of the writer's visit the prospecting done had not

[1]Ladoo, Raymond B., Fluorspar Mining in the Western United States: U. S. Bureau of Mines Serial 2480, p. 5, 1923.

revealed ore of marketable grade in commercial quantities. The irregular occurrence of the fluorspar and the presence of large amounts of quartz make the property of little value. The rather widespread distribution of the fluorite suggests. however, that the vicinity of Bishop's Cap may be still regarded as good prospecting ground.

DEPOSITS IN COOKS RANGE AND THE LITTLE FLORIDA MOUNTAINS

THE DURYEA CLAIMS, LITTLE FLORIDA MOUNTAINS

LOCATION AND ACCESSIBILITY

A group of claims developed by the late Dr. J. T. Duryea of New York City are situated approximately 14 miles southeast of Deming, in Luna County, on the northeast slope of the Little Florida Mountains.

The claims are about 1 mile south of the Deming and Las Cruces highway on the northeast slope of the Little Florida Mountains at an elevation of approximately 4400 feet. To the east and northeast are bolson deposits whose upper edge rests upon the volcanic agglomerates 3000 feet east of the claims.

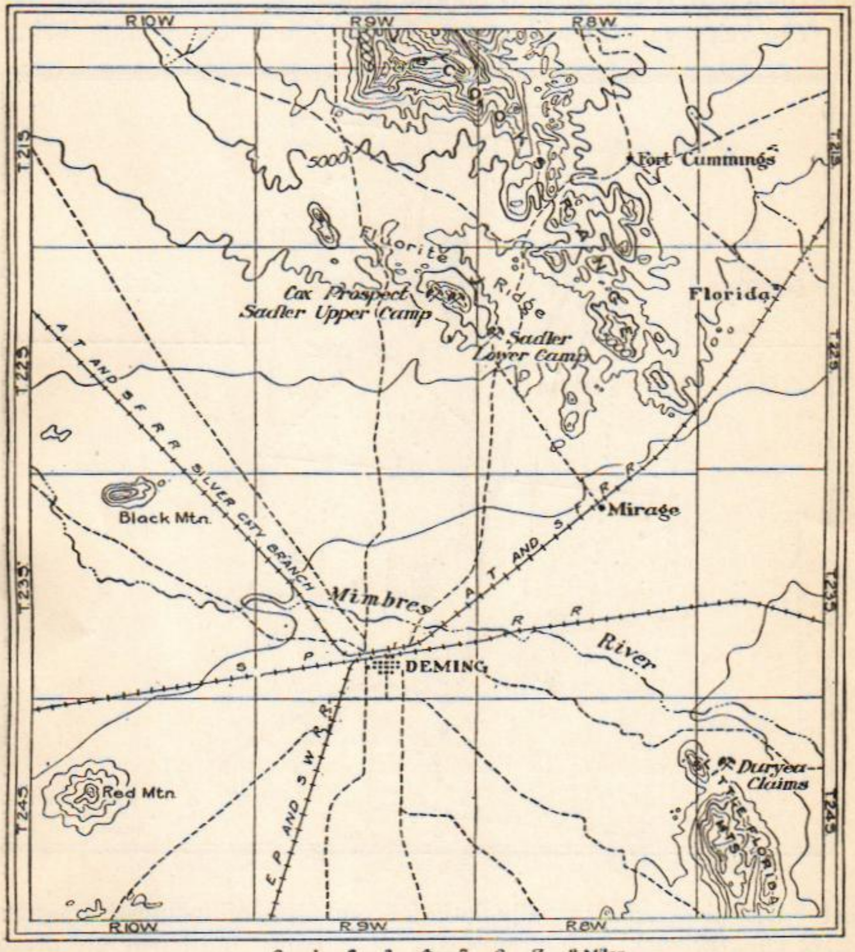
GEOLOGY

The Little Florida Mountains consist chiefly of eastward-dipping volcanic agglomerates of Tertiary age. In the mountain mass is a sheet of felsitic or vitreous rhyolite underlain by a flow of obsidian and a bed of compact, greenish, volcanic ash. Concerning the agglomerates, Darton[1] says:

> In Luna County the Tertiary system is represented mainly by a great thickness of irregularly stratified, nonfossiliferous deposits, chiefly of volcanic origin and pyroclastic character, interbedded with intrusive sheets and volcanic flows. The material consists of agglomerate, tuff, volcanic ash, flows of volcanic mud, and some flow breccias. The greater part of the finer material was wind borne, but portions have been deposited or rearranged by water. Some beds of sand, sandstone, gravel, and conglomerate of ordinary detrital origin are also included. The thickness of the deposits is more than 2000 feet, and as they are extensively exposed in nearly all the ridges it is probable that they also underlie a large part of the bolson areas. They lie unconformably on various formations up to and including the Colorado shale, of middle Upper Cretaceous age, and arc regarded as Tertiary-, although the lower part may be late Cretaceous, and some of the beds at the top may be of Quaternary age. They are overlain unconformably by th Quaternary bolson deposits. The thick sheets of volcanic flows of various kinds which are interbedded at intervals in parts of the area were the products of intermittent volcanic eruptions. The deposits are also cut by dikes, some of them the feeders of the eruptive flows.
>
> The typical agglomerate, which is the predominating deposit, is a massive rock, mostly very hard, made up of angular masses of eruptive rocks, chiefly dark gray andesite or purplish latite embedded in a matrix of tuff or ash. In places the matrix is crystalline and the rock is probably of flow breccia. There are also mud flows and thin sheets of lava, which have flowed over the unconsolidated deposits and become

[1]Darton. N. H., Geology and Underground Water of Luna County, New Mexico: U. S. Geol. Survey Bull. 618, pp. 77-79, 1916.

mixed with a large amount of fragmental ejected material. Accumulations of tuff and other volcanic materials deposited in part, at least, by water are of common occurrence, including irregular bodies of volcanic ash of considerable thickness and extent. Some of the water-laid material consists of ordinary sand and gravel, the detritus of various rocks, sedimentary and volcanic, now mostly hardened to sandstone or conglomerate, but in some places difficult to distinguish from the bolson deposits.



Figures 29.—Index map to fluorspar deposits in the Little Florida Mountains and Cooks Range.

WORKINGS AND ORE DEPOSITS

The fluorspar occurs as a fissure filling in the volcanic agglomerate associated with barite, iron and manganese oxides, and minor amounts of calcite and quartz. In general the veins have a northerly strike, but some near the southeastern corner of the property

While the greater part of the fluorspar occurs as a fissure filling, some replacement of the agglomerate forming the wallrock has taken place. Such replaced ore is colored red by iron oxides and, under the microscope, the outlines of the replaced fragments of the agglomerate are shown. It is cut by post-fluorite quartz.

The veins vary in width from 1 to 3½ feet, the average being 2

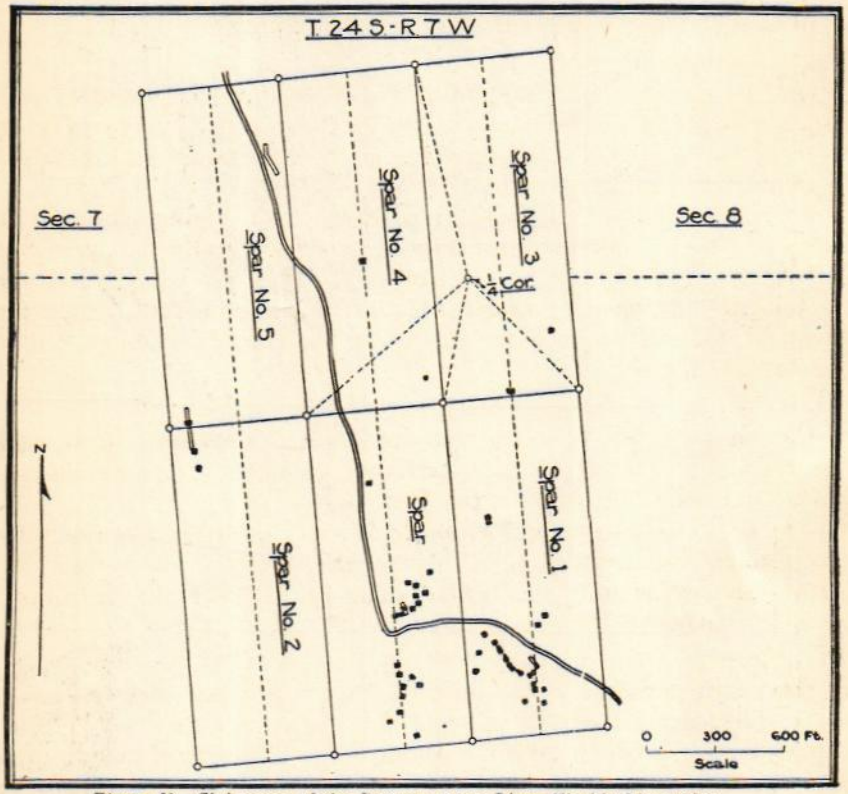


Figure 30.—Claim map of the Duryea group, Little Florida Mountains.

feet. Of this thickness fully half is composed of included fragments of the country rock. Iron and manganese oxides and barite are present in all of the veins. Those near the center of the west side of the property are composed principally of iron and manganese oxides and barite. Fluorite is present in minor amounts. The oxides occur in late fractures in the veins. They appear to have been the last minerals deposited.

Development prior to patenting the claims consisted in the opening of 33 shafts, 2 tunnels, 4 pits and 17 trenches, all small and of a prosshafts on north-striking veins varying in width from 1 to 3 feet. The shafts descend 35 feet or less and the trenches are seldom more than 3 feet in depth. They expose ore so badly mixed with inclusions of country rock as to be sorted with difficulty. Such ore could possibly be milled successfully. North of the road on the same claim are 3 or 4 north-striking parallel veins attaining a maximum width of 3 feet. Some iron and manganese oxides and barite occur with the fluorite. A total of about 10 tons of ore is piled beside the various openings. It is of a metallurgical grade and is obviously the result of extremely careful hand sorting.

On the Spar No. 1 claim, south of the road, are a number of veins striking northwest. They vary in width from 1 to 3 feet. The occurrence is similar to that on the Spar claim but possibly more breccia is contained in the latter veins.

A vein striking a little west of north is found at the center of the west side of the property lying partly in Spar No. 2 and partly in Spar No. 5 claims. It contains barite, iron and manganese oxides, and very little fluorite, and varies between 1½ and 2 feet in width. Important manganese deposits occur in the Little Florida Mountains about 2 miles south of the fluorite claims.

PARAGENESIS

Darton considers the agglomerates in Luna County to possibly range from late Cretaceous to Quaternary in age. Certainly volcanic activity continued until late in the Tertiary.

The association of fluorspar, barite, calcite, and quartz in the region of such volcanic activity implies a magmatic origin of the veins. The mineral association and the replacement of agglomerate by fluorite suggest conditions of moderate intensity.

HISTORY

Six patented claims, Spar and Spar Nos. 1 to 5, are included in this group. They were worked prior to 1925, when the patent was granted and have since then been closed. About 4 or 5 carloads of metallurgical lump fluorite has been shipped. At the present time the claims are owned by Dr. J. T. Duryea's estate.

FUTURE POSSIBILITIES

Under present mining and milling conditions the Duryea property cannot be economically worked. Much of the ore might be successfully milled but the reserves in sight do not justify the expenditure necessary for the installation of a mill. The property itself has been well prospected. Further prospecting in the vicinity might disclose more extensive deposits. The narrowness of the veins and their impure character are not, however, favorable indications for commercial fluorspar in the Little Florida district.

SADLER MINE

LOCATION AND ACCESSIBILITY

The Sadler property in Luna County is on Fluorite Ridge, an outlyer of the Cooks Range. It is approximately 11 miles northeast of Deming, N. Mex. The nearest railroad point is Mirage, a siding on the Silver City branch of the Atchison, Topeka & Santa Fe Railway, 5 miles southeast of the lower camp. The deposit has been described by Darton and Burchard.[1]

GEOLOGY

In describing Fluorite Ridge, Darton[2] says:

> It trends northwest and southeast and has a length of about 4 miles and a maximum width of 1[1]/2 miles. It rises from 500 to 1,500 feet above the surrounding desert and its highest central summit attains an altitude of slightly more than 5,700 feet. The surface is rough, rocky and of very irregular configuration, with many deep draws separated by high ridges and knobs. It has no surface water and supports only a scanty desert vegetation.
>
> The salient geologic features of Fluorite Ridge are shown in Fig. 31. There is a thick central mass of monsonite porphyry, the intrusion of which caused an irregular dome-shaped uplift of the strata. The dome is elongated to the northwest and southeast, and while the strata on the south and east sides stand nearly vertical, those on **the** north and west sides present moderately low dips. The plane of intrusion is low in the Paleozoic rocks at the southeast end of the ridge, but it rises rapidly to the north and west into formations of earlier Cretaceous age. Along part of the southwest side of the ridge the porphyry slopes extend down to the edge of the desert and the structural relations are not exposed.
>
> The sedimentary rocks appearing in Fluorite Ridge range from Cambrian to **early** Cretaceous in age and are intruded by granites, porphyry, and basalt.

WORKINGS AND ORE DEPOSITS

At the time that Burchard and Darton[3] examined the Sadler property in 1910 approximately 20 openings on veins at the lower camp had been made and much good ore was in sight. At the upper camp some trenching had been done.

When the writer visited the property in the summer of 1927, 17 years later, all of the visible ore in the veins of the lower camp had been mined and a number of openings at the upper camp had been made.

The Lower Camp.-The porphyry at the lower camp is cut by a series of fractures with apparently slight displacement. Many of the fractures are filled with fluorite varying in width from a few inches to 20 feet. The fracture pattern is so complicated that no single vein is continuous over a distance greater than 300 feet. Offsets and pinches terminate the wider veins. Both vertical and horizontal movement is shown by many slickensides on the vein walls. The vein described

[1]Darton. N. IL. and Burchard. E. F., Fluorspar Deposits near Denting, N. Mex.: U. S. Geol. Survey Bull. 470. pp. 533-545. 1911.
[2]Darton. N. H , op. cit., pp. 533.534.
[3]Darton, N. H., and Burchard, E. F., op. cit.

by Burchard as locality No. 1 has been developed to a depth of 185 feet, a hundred feet deeper than when he saw it, and all vein material 2 or more feet in width which was then in sight has been mined.

The vein material occupies a fissure in monzonite porphyry striking N. 10°E to N. 20°E. The walls are brecciated and slickensided.. All of the ore was found south of the shaft.

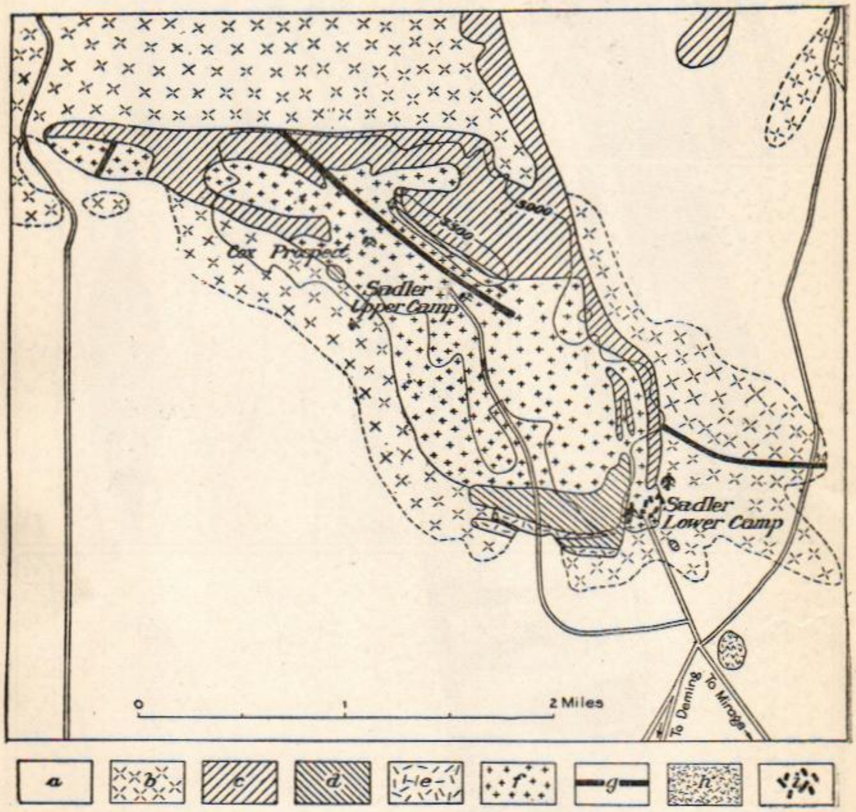


Figure 31.—Geological map of Fluorite Ridge, 12 miles north of Deming, N. M. By N. H. Darton. a, Desert fill; b andesitic agglomerate; c, sandstone (early Cretaceous); d, limestone, sandstone, and slate (Paleozoic); e, intrusive granite; f, monzonite porphyry; g, basalt dikes; h, rhyolite; i, fluorite veins.

On the 185-foot level a drift extends 30 feet S. 25° W. from the bottom of the shaft. A section of the breast of the drift is shown in fig. 32a. A crosscut due west 10 feet from the end of the south. drift is in porphry with no ore. A drift north from the shaft deflects to the east a distance of 40 feet without cutting other fluorite.

At the foot of the shaft on the 150-foot level the fissure pinches to three thin seams of fluorite a few inches in total thickness. About 30

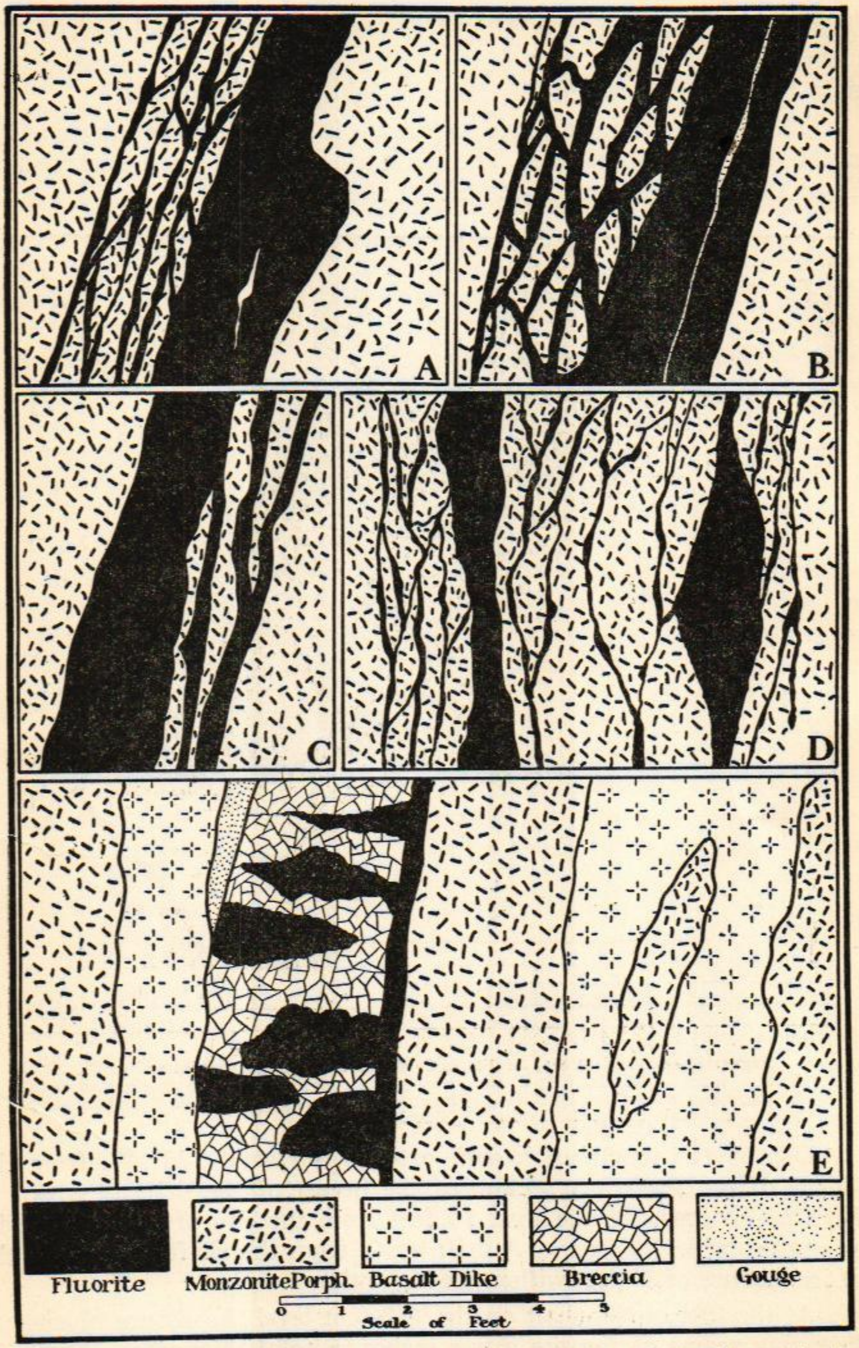


Figure 32.—Sketch sections of the veins on the Sadler property, 12 miles north of Deming, Luna County.

feet south of the shaft the vein begins to widen. Fig. 32b is a section of the vein material in the roof at the north end of the pinch. The drift continues south along the strike of the vein (N. 10° E.) for a distance of 180 feet where the vein is cut off by a low angle fault striking N. 60° W. and dipping 40° SW. Slickensided walls indicate horizontal movement. The ore body turns to the west following a cross fault for at least 6 feet. The fluorite is milky white and granular, suggesting crushing and partial recrystallization of the vein filling of the main fissure in the plane of the cross fault.

The deepest ore cut by the shaft is approximately 130 feet from the surface. Twenty feet higher it swells to a total width of 15 feet. Between the 150 and the 50-foot levels there are sublevels at 20-foot intervals extending to the south. The ore consisted of two and sometimes three veins of very pure fluorite 1 to 2 feet in width separated by brecciated porphyry much weathered and ironstained. The ore and porphyry partings were cut by a network of smaller veins varying from one-half to 3 inches in thickness composed of silica and fluorite.

On the 50-foot level both walls are porphyry cut by a network of small spar veinlets perpendicular to the plane of the main fissure. A drift extends 20 feet north. The breast shows about 2 feet of spar with stringers of silica. The hanging wall is a zone of brecciated porphyry 2 feet wide containing many small veinlets of fluorite. South from the main shaft along this level are caved stopes from which the ore has been removed.

Above the 50-foot level the ore body was widened by the disappearance of the brecciated porphyry parting, and 25 feet below the collar of the shaft it had reached a thickness of 15 feet. It is said that a maximum width of 20 feet of good ore was obtained above the 50-foot level.

At the present time all ore over 2 feet wide had been removed and such new development work as had been done has failed to disclose the presence of wider ore.

Up the hillside approximately 100 feet N. 15° **E.** from the first shaft is an open cut exposing two fissures. The first striking N. 35° W. and dipping 85° northeast is intersected by a second striking N. 30° E. and dipping 70° to the southwest with an offset on the first vein of about 15 feet. The second fissure is opened to the south of the offset. Here two bands of green fluorite each 1½ to 2 feet in thickness are separated by 1½ feet of brecciated porphyry. A shaft sunk on the vein shows a swell for the first 20 feet, followed at a depth of 40 feet by a pinch to a total width of 1 foot of ore. The lower workings were not accessible. At the intersection of the veins is a shattered zone containing a network of spar and silica veinlets. All of the wallrock is porphyry.

About 200 feet N. 50° W. from the main shaft is an open cut following a fault striking N. 30° E. The fissure is 2 feet in width and is filled with quartz and fluorite. The cut is badly caved and the relationships obscured.

Approximately one-fourth of a mile S. 70° E. from the camp buildings is a shaft 87 feet deep following a vein striking N. 3° to 5° E. On the surface two intersecting veins are exposed, one striking N. 3° to 5° E. and the other striking N. 20° to 30° E. The country rock at the surface is volcanic agglomerate. A few yards to the east is the upper edge of the bolson plain. Both veins show slickensides but the extent of the displacement is not discernable. A shaft on the intersection of the veins reaches a depth of 87 feet. From the bottom of the shaft on the 87-foot level a drift follows the vein S. 3° W. a distance of 100 feet through ore which is 4 feet in width at the shaft but pinches to I foot at the end of the drift. Raises and stopes, all badly caved, indicated that most of the available ore has been removed. There is no drift following the vein to the north on the lower level. Above 45 feet the workings stand as open cuts. At the shaft on this level the main vein is intruded by a fracture striking N. 20° E. with highly polished slip surfaces. An open cut follows N. 20° E. along the fracture for a distance of 150 feet. The green, massive fluorite is 1 to 2 feet in thickness. The walls are volcanic agglomerate. The workings above the 45-foot level are open cuts badly caved. A maximum thickness of 5 feet of fluorite was observed in a pillar, but the mine has been worked out.

About 200 feet north of the camp buildings is a vein striking N. 10° W. and dipping 68° to the east. At the surface a width of 7 feet is shown but the vein pinches to 3 feet at a depth of 50 feet, only half of which is fluorite. An inclined shaft 54 feet deep descends on the vein. At the bottom of the shaft a drift follows the vein 30 feet to the south. A section of the breast of the drift is shown in fig. 32c. The walls are monzonite porphyry, considerably altered by weathering and the addition, following fracturing, of a large amount of chertlike quartz recementing the weathered feldspar phenocrysts and giving a quartzite appearance to the country rock. Usually both walls are clean, but here and there fluorite from 2 to 3 inches thick remains frozen to the walls. The ore in the drift is massive, crystalline, light green fluorite. Very little work had been done on this prospect with the exception of the drift on the 50-foot level.

Northeast of the inclined shaft about 25 feet is an open cut following a vein 2 to 3 feet wide whose strike agrees with that of the vein on which the shaft was sunk. In the breast of the drift some of the stringers of silica one-eighth to one-fourth inches wide cross the spar, and occasional vugs in fluorite are lined with minute quartz crystals.

Locality No. 2 of Darton and Burchard is approximately a quarter of a mile northwest of the lower camp. Here a cut 75 feet long has open stopes exposed to, a depth of 50 feet. The stopes were badly caved and the lower levels were not explored. The main opening is at the intersection of two fault planes. The first, which strikes N. 10° W. and dips 80° to the east, shows slickensides at the north end of the cut which dips 60° S. 10° E. in the plane of the fault. The second movement was along a fracture striking N. 35° W. and dipping 85° to the northeast which shows slickensides dipping 65° S. 35° E. in the plane of the fault. The second set of slickensides cuts the first set. The wallrock is a volcanic agglomerate containing rounded pebbles and cobbles of rhyolite, monzonite, andesite, and

Figure 33.—Basalt dikes in monzonite porphyry. Upper camp, Sadler mine.

The fluorite occurs as a vein filling along both sides of fractures and in numerous smaller veins crosscutting the country rock near the intersection of the two principal fractures. The major deposition was at the intersection of the principal faults where a vein thickness of 2½ feet of good spar with parallel veins 1 foot or slightly less in width is found. The ore is deep apple green, massive and easily mined.

The general strike of the veins is from north to south and they are inclined 45° to the east. Some ore as exposed on the hanging wall of the second fracture shows a secondary deposition of silica occurring as druses covering crystal faces of fluorite, in vugs, and as a parting between the fluorite and the hanging wall one-half to 2 inches in width suggesting a slight post-fluorite opening of the fissures. All of the fluorite over 1½ feet in width has been mined.

northwest and approximately 500 feet higher than the lower camp, were described by Darton and Burchard as locality No. 3.

The fluorite veins at the upper camp are associated with a basalt dike in monzonite porphyry. The course of this dike at the south end is north but at the north end its course is northwest. Sometimes the veins lie in the porphyry and sometimes in the dike, but all of the fluorite occurs near the dike.

The most southern opening along the dike is an old shaft 80 feet deep of which only the upper 40 feet could be examined by the writer. The shaft is in a disturbed zone in the dike which varies in width from 2 to 8 feet. The fluorite occurs in irregular cracks ranging from 10 inches to 2 feet in width paralleling the general strike of the shattered zone. In general the spar veins are narrow, a working face of 4 feet yielding but 1½ to 2 feet of hand-sorted metallurgical lump. The remainder of the face is chert in large banded lenses, and monzonite and basalt country rock. On lower levels it is reported that the spar reaches a width of 3½ to 4 feet. The vein is stoped above the 80-foot level for 150 feet to the north, and some work to the south has been done. South of the shaft the vein turns to the west and disappears under the talus on the hillside.

Approximately 200 feet north along the strike of the vein is an open stope 45 feet deep. Here the vein has left the dike, and the wall rock is porphyry. The fluorite occurs in narrow veins as shown in the section in fig. 32d.

Some 100 feet farther north along the strike the vein enters the basalt dike at a small angle. The dike and porphyry contact is vertical and very sharp. A narrow band of the porphyry along the contact is stained with iron, but otherwise it is unaltered. Where the vein cuts across the dike the ore contains much silica and the fluorspar content is small.

Farther north a distance of 150 feet along the vein are two shafts 25 feet apart and approximately 60 feet deep. The southern one shows a fluorite vein 1 foot wide in the basalt dike. Here the dike has a width of 30 feet. It is branching and contains many horses of porphyry. The relations of the spar vein to the dike and the porphyry are shown in fig. 33. The vein iri the northern shaft shows 1 to 1½ feet of fluorspar.

From the last opening described the dike turns to the northwest, disappears under the talus, and appears again at the surface approximately 1000 feet away in a direction N. 50° W. At this point an old shaft is sunk on a spar vein 2 to 3½ feet wide. The fluorite is light green in color and somewhat siliceous. The dike strikes N. 40° W. and is traceable for about 500 feet. It is 30 feet in width. Occasional horses of porphyry are included in it.

Approximately 500 feet N. 50° W. along the west side of the dike from the former shaft is another opening consisting of a shaft 25 feet deep with a drift following a spar vein along the west side of the dike. The ore body is 3 to 5 feet wide, the fluorite occurring as horizontal lenses in a matrix of clay, calcite, quartz, and chert breccia with some basalt and porphyry in the fracture zone. A section of the vein at this prospect is shown in fig. 32e. This is the most northern opening of the upper camp of the Sadler property.

THE ORE

The fluorspar from the veins of the lower camp is bottle green in color with occasional white and light purple pockets.

Burchard[1] lists analyses made by the Colorado Fuel & Iron Co. of carload lots of fluxing spar shipped in the early years of the mine. Some of these are as follows:

Shipping Point	CaF_2	SiO_2	$Al_2O_3+Fe_2O_3$	$CaCO_3$	$MgCO_3$
Mirage, N. M.	93.68	4.68	0.74	0.76	Trace
Do	88.80	9.83	1.10	0.48	Trace
Do	90.13	7.86	0.70	0.74	Trace
Do	88.59	9.66	0.96	0.83	Trace
Do	93.99	3.84	:.12	1.12	Trace

At the upper camp, at the time of the writer's visit in the summer of 1927, there was an ore pile containing between 6 and 8 tons of acid lump spar. It ranged from pale green to pale violet, the lightness of the color probably being due to its exposure for some time to the sun-light, as ore in the vein face was much darker.

PARAGENESIS

The persistent association of fluorite veins with the basalt dike at the upper camp suggests a genetic relationship. It is possible that the fluorite-bearing solutions were the end products of the basaltic magma. However, no direct evidence of this relationship is obtainable.

In the vicinity of the lower camp the fluorite occurs as a fissure filling in monozite porphyry and volcanic agglomerate. No basalt outcrops in the neighborhood, but this does not indicate, however, that the fluorite depositing solutions and the basaltic magma are unrelated.

In all the veins the fluorspar was followed by quartz. Occasionally quartz was the first mineral deposited. A small amount of barite and some calcite appear to be contemporaneous with the fluorspar.

HISTORY

The American Firemen's Mining Company of Kansas City began mining fluorspar at the Sadler property in the summer of 1909. By

[1]**Burchard, E. F.,** op. cit.. p. 544.

the close of 1910 approximately 5,000 tons of metallurgical lump had been shipped at an average price, f. o. b. Mirage, of $5.25 a ton. Mr. G. M. Sadler of Deming who took over the property in 1910, continued to work the veins in the lower camp, and began to develop the veins associated with the basalt dike at the upper camp. After a few years the lower veins were exhausted, and as the upper veins had not proved as rich as first supposed, the property was shut down. Later, Sadler's holdings were acquired by Manasse and Hayner of Las Cruces, who now own the property.

FUTURE POSSIBILITIES

With few exceptions all visible ore greater than 2 feet in width at both the lower and upper groups of claims has been mined. No further development of the Sadler property seems justified unless the price of metallurgical spar advances materially. In this event a resumption of mining in existing workings would be possible, and more detailed prospecting of Fluorite Ridge would be desirable.

THE COX PROSPECT

A prospect near the crest of Fluorite Ridge in Luna County has been operated by Mr. S. A. Cox of Deming, New Mexico. The country rock is monzonite porphyry. Above it is a conglomerate capping which is the basal member of the Cretaceous series. The ore occurs in a weathered zone in the porphyry which is 12 to 20 feet wide. In this zone are small veins 3 to 12 inches wide. It is estimated that a 10-foot cut will yield between 1 and 1½ feet of fluorite. An open cut follows the soft porphyry a distance of 300 feet. The small veins of fluorite parallel the general strike of the weathered zone (N. 3° E. to N. 2° W.). Occasional veinlets extend into the unweathered porphyry. The zone of weathered porphyry containing the fluorite veins contains much sericite and suggests a hydrothermal origin.

An ore pile near the base of the cut contained about 1 ton of picked ore with the following analysis: 86.46 per cent CaF_2, 1.84 per cent $CaCO_3$, and 11.30 per cent $Si0_2$.

A little ore was shipped from the prospect but mining was unprofitable. Because of the narrowness of the veins it is unlikely that the Cox prospect will develop into a mine.

WHITE EAGLE MINE

LOCATION AND ACCESSIBILITY

The White Eagle mine[1] is in the north end of Cooks Range in Grant County a few miles north of the Luna County line. The outcrops of the veins are covered by three claims owned by L. H. Duriez, George

[1]The White Eagle mine is called the Sadler in Ladoo's reports. The Sadler property is on Fluorite Ridge in the southern end of Cooks Range, northeast of Deming.

Masters, W. D. Howard, and associates. The property is 18 miles northeast of Spaulding, a siding 17 miles northeast of Deming on the Silver City branch of the Atchison, Topeka & Santa Fe Railway. It can be reached by road either from Spaulding, a distance of 18 miles, or from Deming, a distance of 31 miles. The roads are graded for the greater part of the distance, and the ungraded roads are over bolson deposits and usually in good condition.

GEOLOGY

Cooks Range ends a few miles north of the Grant County line. The northern portion of the range rises a few hundred feet above the bolson as a pre-Cambrian granite ridge faulted to the northeast against volcanic agglomerates of Tertiary age. The granite is intruded by a long dike of felsitic rhyolite porphyry paralleling the fault plane. Northwest of the property a small block of early Paleozoic limestone, resting on the granite, is cut off to the northeast by the Cooks Range fault.

WORKINGS AND ORE DEPOSITS

The fluorspar occurs in a main vein in granite striking N. 72° W. and a number of smaller veins to the southeast. One prospect on the northwest end of the vein shows ore in the Paleozoic limestone block.

The main vein outcrops over a total distance of 650 feet following the crest of the granite ridge southwest of the granite and agglomerate fault contact. It is exposed in a number of open cuts and drifts.

At the southeast end of the main vein of the White Eagle mine an open cut shows 21/2 feet of siliceous fluorite. Near the center of the outcrop an adit into the hillside follows the vein for a distance of 165 feet. A raise was driven to the surface from this level and a winze follows two converging veins of ore to a depth of 30 feet. At the collar of the winze two veins striking northwest are separated by a horse of granite. The east vein has 1 to 2 feet and the west vein has 2 to 4 feet of siliceous ore. Both veins are cut by small stringers up to 1 foot wide of quartz-free fluorite. At the bottom of the winze a 17-foot face exposes the convergence of the two veins composed of highly siliceous sugary ore cut by smaller quartz-free veins of fluorite. Approximately 80 feet northwest of the winze the veins are cut off by a fault striking N. 10° E. and dipping 25° to the northwest.

An upper adit, 60 feet above the lower, has been driven on the vein for a distance of 40 feet. To the southwest a few small trenches expose narrow fluorite veins paralleling the main fissure.

THE ORE

The fluorspar is generally mixed with white sugary quartz in such a way as to require careful sorting to produce a metallurgical lump spar. Smaller veins in the siliceous material are made up of good purple to green fluorite which is quartz-free.

About 500 feet N. 40° **W.** from the main vein in granite a prospect in limestone 15 feet deep exposes a thin seam of fluorite 6 to 8 inches wide dipping to the east. This fluorite is gray to green and of good grade. Some of the ore replaces limestone.

The following analyses are of ore from the main fissure in granite:

WHITE EAGLE FLUORSPAR ANALYSES BY ABBOT S. HANKS, SAN FRANCISCO[1]

	1	2	3	4	5	6	7	8
Calcium fluoride (CaF_2)	86.06	79.02	91.71	87.85	88.74	89.04	87.86	82.24
Silica (SiO_2)	5.05	10.27	3.74	8.20	5.73	7.00	7.90	1.02

No. 1. Taken at the face of the upper tunnel over a width of 3 feet.
No. 2. Taken at the face of the lower tunnel over a width of 3½ feet.
No. 3. Taken at 25 feet back of the lower tunnel over a width of 3 feet.
No. 4. Taken at 17 feet outside of the raise over a width of 2½ feet.
No. 5. Taken in floor of open cut 210 feet east of raise over a width of 3 feet.
No. 6. Taken in floor of pit 520 feet east of raise over a width of 3 feet.
No. 7. Taken on surface at 215 feet west of raise over a width of 5 feet.
No. 8. An average of a carload, on the ground, sorted from old dumps.

The samples taken are averages across the vein. No effort was made to exclude the few stringers of amorphous silica, which, in shipping, would be sorted out.

A sample of hand-sorted ore from a 17-foot face of siliceous ore and breccia at the junction of two veins at the bottom of the winze on the lower tunnel gave the following analysis: 88.30 per cent CaF_2, 8.62 per cent SiO_2, and 2.69 per cent $CaCO_3$.

The writer's apportionment of the ore in the 17-foot face of the winze is as follows:

Ore recoverable by hand-sorting for sale as metallurgical lump	10 per cent
Milling ore	45 per cent
Waste	45 per cent

PARAGENESIS

As the fluorite occurs in fissures adjacent to a great Tertiary fault and to an intrusion of Tertiary rhyolite porphyry containing vugs lined with fluorspar crystals, it is probable that the fluorite-bearing solutions were end products from the same magma which gave the rhyolite porphyry. Such solutions circulated in small fissures accessory to the main fault and deposited fluorite and silica. In the limestone they caused some replacement by fluorite. At first quartz and fluorite were deposited together but later fluorite crystallized after the deposition of quartz had ceased.

FUTURE POSSIBILITIES

An estimate of reserves is not possible because of the variable

[1]From a report on the White Eagle claims for the United States Smelting. Refining and Mining Exploration Company, dated June 9, 1924. A copy of the report was furnished by Mr. W. D. Howard. one of the owners of the property.

character of the vein material. Much of the ore is too siliceous for shipment and must await the development of a satisfactory milling process. The ore which can be shipped without milling is scattered through the siliceous material in such a way as to necessitate the mining of much non-marketable ore along with that which can now be sold. It seems unlikely that this property can compete with other sources of metallurgical lump spar at the present time.

DIAMOND PROSPECT

Approximately 3 miles north of the White Eagle mine some prospecting on two fluorite veins has been done. The property is owned by H. L. Duriez of Fierro and his associates. The claims were not visited by the writer, and the following description was given by Mr. Duriez.

Two parallel veins striking northwest are included in one claim. The east vein is said to attain a width of 6 feet, most of which is good ore. The second vein 200 feet west of the first has 4 feet of siliceous ore. The veins are traceable on the surface for about 500 feet. The 6-foot vein contains quartz vugs and some chert. Half a mile northeast of these veins another vein about a foot wide outcrops.

Selected spar from the large vein assayed 90.76 per cent calcium fluoride and 7.30 per cent silica.

DEPOSITS IN THE LITTLE BURRO HILLS

FLUORSPAR DEPOSITS NORTH OF SEPAR

LOCATION AND ACCESSIBILITY

A number of small fluorite veins are found on Young Bound's ranch, 18 miles north of Separ in Grant County, a station on the Southern Pacific Railway, 20 miles southeast of Lordsburg.

The deposits are reached from Separ over fair ungraded bolson roads. They lie in the midst of the low, rolling hills called the Little Burro Hills which merge to the northwest into the Telegraph Mountains.

GEOLOGY AND ORE DEPOSITS

The country rock is pink granite of pre-Cambrian age, capped by volcanic agglomerates and Tertiary flows. The fluorite, with some quartz and cherty silica, occurs in slickensided fissure veins up to 2 feet wide in the granite.

An old shaft approximately 1 mile northeast of Bound's ranch (Sec. 8, T. 23 S., R. 15 W.) has been sunk 60 feet on a vein striking N. 35° W. and dipping 55° to the northeast. The walls are granite with prominent vertical slickensides. Most of the ore occurs as the cementing material in an 8-foot zone of breccia on the footwall, approximately 35 per cent of the brecciated zone being fluorite. A parting on

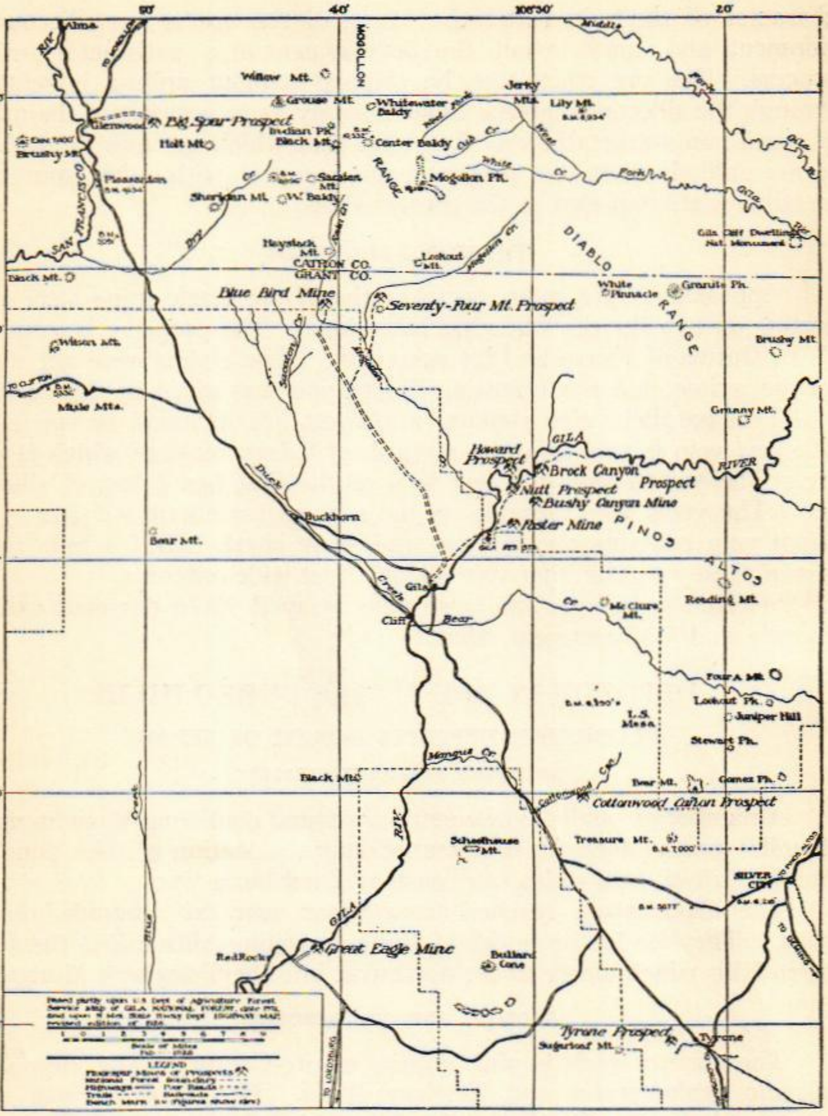


Figure 34.—Index map to the fluorspar deposits in the Telegraph, Little Burro, Glenwood, and Mogollon Mountains.

the hanging wall between 10 and 12 inches in width is pure, green fluorite. Near the collar of the shaft and extending downward 10 feet, a vein of fluorspar 12 to 14 inches thick follows the footwall. Here the space between the hanging and foot walls is occupied by a block of granite with little spar. This block becomes much brecciated at a depth of 30 feet and the fluorite content of the brecciated zone attains a maximum of 35 per cent at the bottom of the shaft. No drifting has been done.

The following analysis is of a composite sample of the clear fluorite in the partings on the hanging and foot walls: 96.14 per cent CaF_2, 1.16 per cent SiO, and 2.62 per cent $CaCO_3$.

About 30 feet northeast of the shaft is a trench 40 feet long and 20 feet deep cutting a vein striking N. 10° E. The vein material is very siliceous. The fluorspar at the level of the ground is 2 inches in width but it increases to 1½ feet at the bottom of the trench. Two other small open cuts to the northeast show thin bands of fluorite 1 to 3 inches wide.

A number of other prospects to the north are said to have been openedbut they were not examined.

DEPOSITS IN THE TELEGRAPH, PINOS ALTOS, LITTLE: BURRO, AND MOGOLLON MOUNTAINS

GREAT EAGLE MINE

LOCATION AND ACCESSIBILITY

The Great Eagle mine is in Grant County, 8 miles east of Red-rock post office and 32 miles north of Lordsburg, N. Mex., on the Southern Pacific Railway, the nearest shipping point. It is located on the Gila River at the southwest corner of the Telegraph Mountains in the Anderson Mining district. The road from the property to Redrock post office cuts across gravel spurs between arroyos tributary to the-Gila, ascends to the bolson plain and continues south to Lordsburg.. Between the mine and the edge of the bolson, a distance of 9 miles, area number of steep grades,but once upon the bolson the road is level and, except after occasional rains, it is in good condition.

GEOLOGY

Fig. 35 is a sketch map of the vicinity of the mine. The country rock is a pink and gray coarse granite with quartz, andesine, microcline, and muscovite as its principal constituents. The muscovite and feldspars are much sericitized. The granite is probably pre-Cambrian.

Intruded into the granite east of the vein is a stocklike mass of dark gray rhyolite. Cutting both the rhyolite and the granite are a. number of thin sills of gray-green diabase, much sericitized and kaolinized. The diabase and rhyolite are probably of Tertiary age.

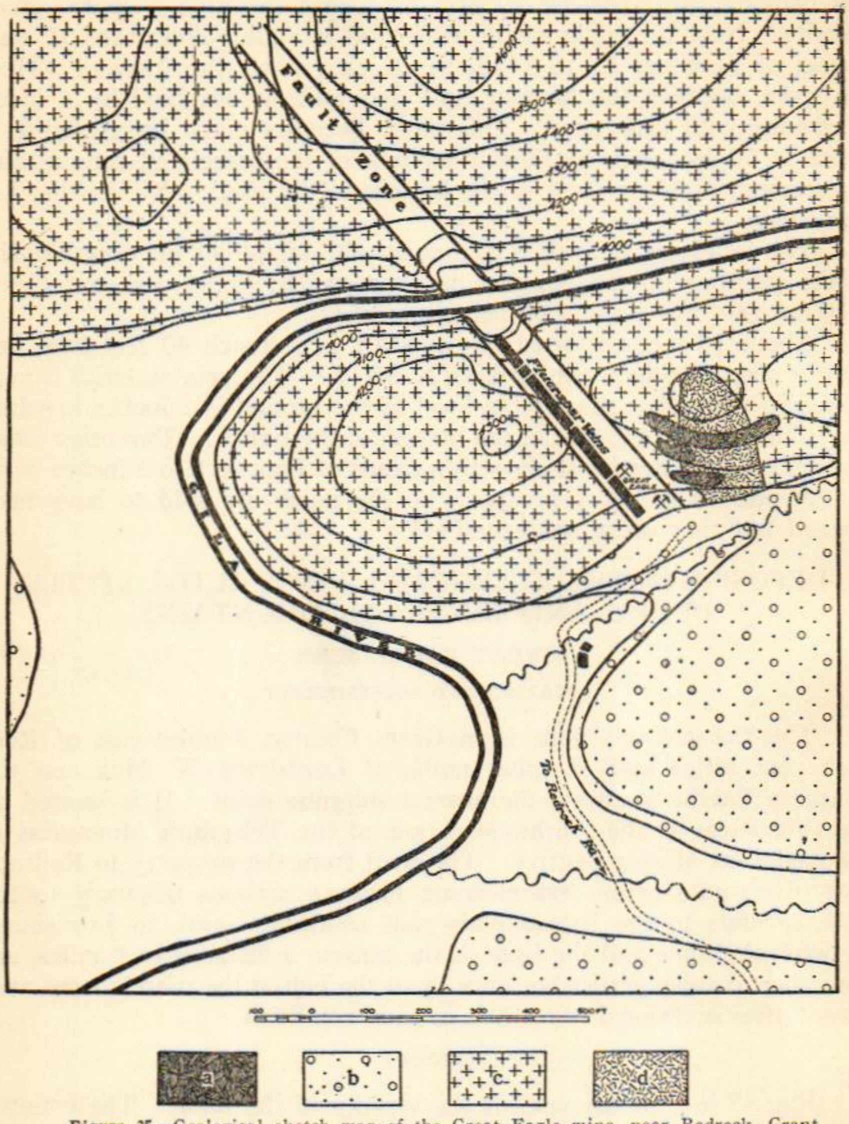


Figure 35.—Geological sketch map of the Great Eagle mine, near Redrock, Grant County. a, diabase; b, Gila gravels; c, granite; and d, rhyolite.

For the 6 miles of its course across the Telegraph Mountains, the Gila River is confined to a gorge in the granite. Just west of the fluorspar deposits the granite disappears beneath the Gila gravels[1] and the bolson deposits extending to the south and west, and the river flows out upon a narrow floodplain, one-half to 1 mile wide.

Striking N. 40° W. across the western end of the granite area south of the Gila River is a fault zone 100 feet wide which is a conspicuous topographic feature. South of the river it forms a saddle between granite masses, and north of the river it appears as a boxlike recess in the lower part of the gorge. Where it crosses the river a short flood-plain extends back into the granite on either side for a distance of 50 to 100 feet. To the southeast the fault line is lost beneath the bolson and on the northern side of the river it narrows to 50 feet as it cuts across the shoulder of a granite spur. The Tertiary intrusive rocks are east of the fault zone.

WORKINGS AND ORE DEPOSITS

The fluorspar occurs south of the river as a fissure filling in veins within a fault zone, paralleling the strike of the zone. The veins are variable in width, attaining a maximum of 20 feet, not all of which, however, is marketable ore. Much white, finely crystalline silica is associated with the fluorite. It occurs as horses and partings in the wider veins and grades laterally into pure fluorspar. A series of samples obtained by the writer graded from fluorspar of acid grade into what appears to be chert but which, under the microscope, shows regular spherules of fluorite 1 to 3 millimeters in diameter in a groundmass of very finely crystalline quartz.

From pillars remaining in the vein at its widest place in the upper workings it is estimated that the 25-foot vein face yielded with hand sorting about 40 per cent of metallurgical lump, the remainder of the vein consisting of several horses and partings 1½ to 3 feet in thickness and ore too siliceous for metallurgical use.

At the time of the writer's visit in the summer of 1927 the upper workings were extensively caved and the deeper levels were flooded. Ladoo[2] visited the mine in the summer of 1922 soon after work had ceased. In describing the development of the property he says:

> The main workings of this mine consist of an adit tunnel driven in the west wall at an angle of about 30 degrees to the vein and intersecting it about 100 feet from the portal and continuing along the vein for a distance of 250 feet or more. This level is 60 feet above the water level of the Gila River.
>
> The main production to date has been secured from an open stope above this level extending for a distance of 210 feet. The stoping width varied from 8 to 20 feet, the vein filling being described above. The vein at both ends of this area was similar and contained no recoverable fluorspar. About 90 feet *in* from the point where the tunnel

[1]Here the Gila gravels grade laterally into the bolson.

[2]Ladoo, Raymond B., op. cit., p. 129.

cut the vein a winze had been sunk on the vein 60 feet to water level. An inclined adit on the vein starting 60 feet above the water level on the outcrop on the south -side of the hill was driven for the purpose of intersecting the bottom of the winze mentioned above, but was not advanced far enough to connect. This inclined adit tunnel showed no ore to a point about 10 feet above the Gila River, or 50 feet below the main workings, which was as far as it could be examined on account of accumulated mine seepage. The winze was not accessible for examination, but was reported to show the same general character of ore, except that iron pyrite had replaced the iron oxide. On the extreme north side of the hill overlooking the Gila River were a *series* of pits on the outcrop of the vein. These pits all showed the same general character of ore as in the other workings. The higher pits, which were the widest and *best*, showed a width of about 8 feet. None of these pits was over 4 or 5 feet deep.

The total exposed length of the vein on the surface is 500 feet.

The fact that in the summer of 1927 the water in the mine stood -40 feet above the Gila River is the basis for the two following conclusions concerning ground water conditions:

(1) Since rainfall in the region is scant and the catchment area of the vein is confined to the narrow saddle between the Gila River and the bolson deposits on the south, an area of four or five acres at most, the rise of the water in the mine must be due to a hydrostatic head in the fault zone.

(2) Water in the fault zone is not in direct communication with the Gila River and mining below the Gila will not result in a large immediate inflow of water from it.

A little fluorite was encountered in prospects on the fault zone north of the river, but the quantities found were small.

THE ORE

The fluorspar of the Great Eagle mine when free from silica is a bright bottle green, but the siliceous ore is lighter in color. Some of the fluorspar is unusual in that it breaks with a conchoidal fracture, ..cleavages being poorly developed. Much of the ore is siliceous. The average fluorspar content of 1983 tons of ore shipped between July 1, 1918, and January 1, 1919, is said to be 91.5 per cent, with a maximum of 96 per cent for a single car.[1]

A pillar in the upper workings of the main tunnel sampled as nearly as possible to represent the best ore which would be mined, gave an analysis showing 92.98 per cent CaF_2, 0.78 per cent $CaCO_{;t}$, 2.92 per cent $Si0_2$, and 3.30 per cent Al2O3+Fe2O3.

A sample of hand-picked ground spar taken from a Hardinge mill at the time that Ladoo[2] visited the property analyzed 95.29 per cent CaF_2, 4.13 per cent $S10_2$, and 0.44 per cent $CaCO_3$.

PARAGENESIS

The fault zone in which the veins occur is in pre-Cambrian granite.

[1]Prospectus of Great Eagle Mining Company. No date.

[2]Ladoo, Raymond B., Fluorspar: U. S. Bureau of Mines Bull. 244, p. 129, 1927.

Two hundred feet east of the southeastern end of the vein small intrusive masses of Tertiary diabase and rhyolite outcrop. It seems probable that the faulting and mineralization of the pre-Cambrian granite accompanied the later intrusions.

The fluorite and quartz were deposited together in most cases. In the very siliceous material the fluorite preceded the quartz. A little calcite was the last mineral to be deposited. No barite or sulfides were observed.

HISTORY

The Great Eagle property was located in 1911 by A. B. Conner of Redrock and worked by him in 1914. Later it was acquired by **J. H.** Cauthen of Lampasos, Texas, the present owner. In 1917 intensive mining was begun which resulted in the shipment of about 3000 tons of metallurgical lump fluorspar up to 1921, when the property was closed. Some mining on lease after 1921 was done but the amount of ore shipped was small.

In 1919 a mill said to have cost $80,000 was erected. It did not prove satisfactory and after having produced a few tons of ground spar it was dismantled.

Some of the factors which brought about the closing of the mine were a transportation cost of $7.00 per ton to the railroad, the siliceous nature of much of the fluorite, and the slump in the production of open hearth steel which came in 1921.

ORE RESERVES AND FUTURE POSSIBILITIES

Insufficient data is at hand for an estimate of the ore reserves in the Great Eagle mine.

At the present time the workings are in very poor condition, and any new development must avoid the older workings or plan for extensive timbering in them. There is no cause to expect any change in the tenor, of the ore with depth, and the lower limit of mining will be determined by other conditions.

It is doubtful whether any milling process will be devised which can successfully treat the intimate association of fluorspar and silica in the lower grade ores.

Despite the foregoing detrimental factors it is probable that much good ore remains. With lower trucking costs and a higher price for metallurgical lump spar, the mine could undoubtedly be operated profitably.

TYRONE PROSPECT[1]

A small vein of fluorspar is located near the western boundary of

[1]For a general description of the area see Paige. Sidney. Metalliferous Ore Deposits near the Burro Mountains. Grant. County. N. Mex.: U. S. Geol. Survey Bull. 470, pp. 131-150, 1910. Also, Paige, ,Sidney, U. S. Geol. Survey Geol. Atlas, Silver City folio, (No. 199), 1916.

the property of the Burro Mountain branch of the Phelps Dodge Corporation at Tyrone, Grant County. It occurs in Gulch No. 1 of the Phelps Dodge property, 1¼ miles southwest of Tyrone. The width of the vein varies between 10 and 16 inches. It strikes N. 15° E. and dips 60° to the east. The walls are much kaolinized and sericitized granite porphyry.

An adit striking N. 75° W. cuts the vein at 100 feet. Drifts follow the ore to the north and the south. On the south drift a fracture zone 15 feet wide is filled with fluorite-cemented breccia. On the footwall a parting contains 10 to 14 inches of good fluorite somewhat iron stained. It has been stoped for 60 feet vertically. The north drift is badly caved and little ore was reported.

On the hillside above the adit the vein can be traced approximately 300 feet to the south, where it passes into a brecciated area and is lost beneath the talus covering of the hill. The silicified footwall at the surface contains some fluorite.

An ore pile at the portal of the adit contained approximately 8 tons of metallurgical lump.The spar is dark green, well crystallized, and somewhat iron stained. An analysis of a selected sample of the ore pile showed 96.60 per cent CaF_2, 1.69 per cent SiO_2, and 1.33 per cent CaCO3.

Several cars of metallurgical lump spar have been shipped but most of the ore in sight has been mined. Possibly with a high fluorspar market a lessee could work the property at a small profit but the total production of this vein would be small.

COTTONWOOD CANYON PROSPECT

LOCATION AND ACCESSIBILITY

The Cottonwood Canyon fluorite deposits in Grant County occur approximately 3½ miles up the Cottonwood Canyon from the Silver City and Cliff highway and 17 miles northeast of Silver City. They are at the head of the belt of terrace gravels paralleling Mangus Creek, a tributary of the Gila River.

GEOLOGY

The veins occur as fissure fillings in Fierro limestone at the head of the gravel deposits where the sedimentary series stand in a bold, southwest facing scarp. A sketch map of the lower part of Cottonwood Canyon is shown in fig. 36.

The geological section extends from the Fusselman limestone of Silurian age through the Cretaceous Beartooth quartzite. The sedimentary rocks are capped by Tertiary rhyolite flows and intruded by basalt. The names of the formations follow Sidney Paige's classification in the Silver City Folio:[1]

[1]Paige. Sidney. U. S. Geol. Survey Geol. Atlas Silver City folio (No. 199), pp. 3-6, 1916.

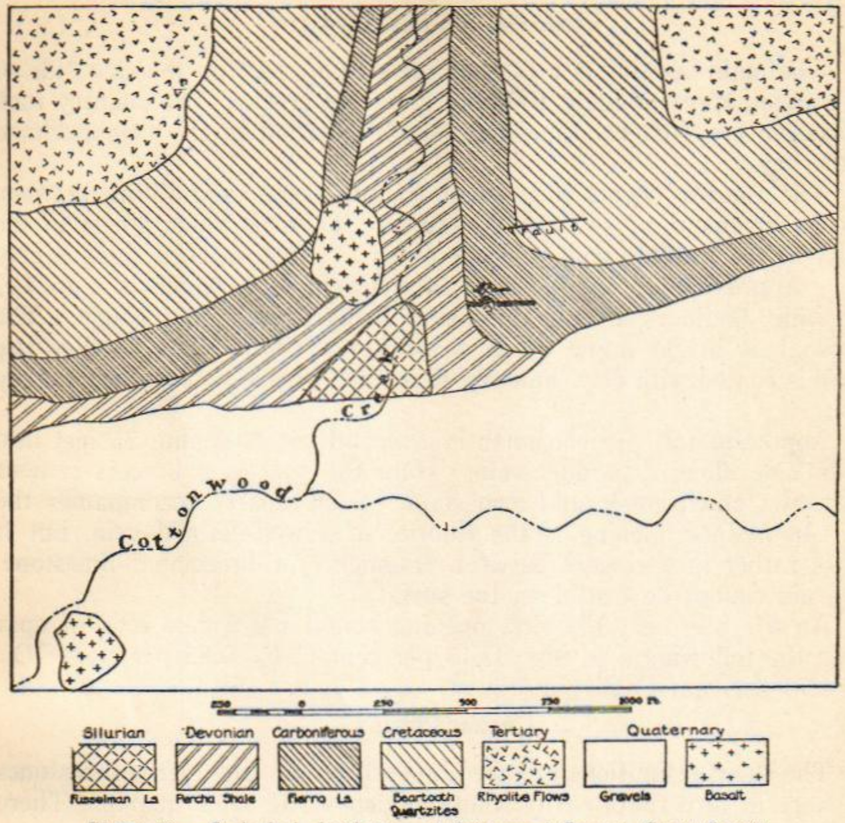


Figure 36.—Geological sketch map of Cottonwood Canyon, Grant County.

GEOLOGICAL SECTION IN COTTONWOOD CANYON

	Thickness
Quaternary	
Basalt intrusions in gravels	
Gravels, bolson deposits and stream gravels	
Tertiary	
Rhyolite flows, reddish, porphyritic with small orthoclase phenocrysts	0-40
Cretaceous	
Beartooth quartzite	
Quartzite, buff to reddish, massive, coarse, sand grains up to 1 mm. in diameter. Cliff-making beds	80
Conglomerate, quartz with clay cement	18
Mississippian and Pennsylvanian	
Fierro limestone	
Limestone, gray, cherty, massive, fine grained	42
Limestone, yellow, thin bedded, cherty, sandy, crossbedded. Has crinoidal layers at base	15
Devonian	
Percha shale	
Shale, dark gray, calcareous. Thin limestone beds near top. Grades into black shales below	40
Shale, black, laminated.	90
Silurian	
Fusselman limestone (?)	
Limestone, dark gray, massive, sandy. Bottom not exposed	40

WORKINGS AND ORE DEPOSITS

The main opening is a 60-foot cut striking east on the east side of the canyon, approximately 100 feet above the creek. The country rock is massive gray, cherty limestone, much silicified in the neighborhood of the vein.

The fluorite occurs in a small fracture zone as a filling between breccia fragments of silicified limestone. There is much gouge in the center of the fracture zone, but the outer 1½ feet on both sides is clay free. Approximately 20 per cent of the vein face, which is 4 to 4$ feet wide, is fluorspar, the remainder being breccia and gouge. The fluorspar is bright apple green to white in color. The shallow ore mined is coated with clay, limonite films, and crusts of secondary clayey calcite.

Approximately 30 feet north is a second cut extending 25 feet into the hillside along a parallel vein. Here the spar is a breccia cement and shows much gouge and iron stain. Some quartz accompanies the ore. In neither opening is the fluorite in a well-defined vein, but it occurs rather as stringers between fragments of brecciated limestone. The vein cannot be traced on the surface.

An ore pile near the first opening containing a few tons of spar shows the following analysis: 87.13 per cent CaF2, 0.85 per cent $Si0_2$, and 1.74 per cent CaCO3.

PARAGENESIS

The fluorite solutions followed brecciation of the Fierro limestones and were in turn followed by solutions depositing some quartz. There is no obvious relationship to a particular igneous rock.

FUTURE POSSIBILITIES

The Cottonwood Canyon district deposits are small and show little promise of opening into larger masses of ore. It is unlikely that they will produce more than a few tons of metallurgical lump.

FOSTER MINE

The Foster mine is 6 miles northeast of Gila in Grant County, and near the crest of a low ridge on the western edge of the Pinos Altos Mountains, approximately 500 feet above the Gila River to the west. The country rock is a bluish gray rhyolite porphyry containing orthoclase phenocrysts up to one-half inch in length. On the south end of the ridge is an open cut and drift driven N. 15° E. for a distance of 250 feet. It follows a fracture zone from 3 to 7 feet wide in the rhyolite porphyry. The fluorite occurs in a vein from 1 to 2$ feet wide cutting the porphyry. Fluorite and calcite cement the breccia throughout the fault zone. The fluorite is bottle green in color and in the vein contains little calcite. It has been stoped for a height of 10 to 25 feet above the drift. Two openings lower in the hillside enter on the same vein. To the south across a ravine, the projected strike of the vein is in bolson deposits.

This is a small vein capable of furnishing employment to two or three men, and economically workable only during a high fluorspar market.

BUSHY CANYON MINE

LOCATION AND ACCESSIBILITY

The Bushy Canyon mine in Grant County is approximately 1½ miles northeast of the Foster mine on the east side of the ridge, 8 miles from Gila. It is situated on the east slope of a north and south ridge approximately 100 feet below the crest. To the east, Bushy creek flows north to the Gila River through a narrow canyon. The ore is transported 2 miles by burros to the Gila road.

WORKINGS AND ORE DEPOSITS

The country rock of the deposits is white felsitic rhyolite showing minute phenocrysts of orthoclase. The fluorspar occurs as a fissure filling.

The ore is bottle green to light blue. An analysis of material from two small veins on the breast of the south drift showed 91.06 per cent CaF_2, 2.61 per cent $Si0_2$, 1.82 per cent $CaCO_3$, and 4.28 per cent $A1_20_{3}+Fe_20_{3}$.

The vein outcrops in a small draw in the east face of the ridge. Drifts follow it to the north and south at the level of the draw, and open cuts expose the outcrop to the north for 250 feet.

To the south a drift extends for 110 feet on ore up to 2½ feet in width which has been stoped to a height of 10 to 15 feet. Near the end of the drift the ore pinches and is represented in the breast by two small veins each 4 inches wide separated by powdery, calcareous clay. A winze near the portal of the drift is said to descend 60 feet on the vein. At the time of the writer's visit water stood within a few feet of its top.

A drift north along the vein was caved and could not be entered. The open cuts along the outcrop of the vein extend for approximately 250 feet to the north. From 1 to 3 feet of fluorite with some quartz and clay is exposed.

A location notice, dated September 22, 1926, was signed by W. D. Howard of Deming, L. H. Duriez of Fierro, and W. A. Howard of Gila.

FUTURE POSSIBILITIES

The Bushy Canyon mine, like the Foster mine, may furnish employment for two or three men during high fluorspar markets, but the tonnage produced will be small.

PROSPECTS ON THE GILA RIVER NORTH OF THE BUSHY CANYON MINK

A number of prospects in Grant County along the Gila River north of the Bushy Canyon mine have been opened on small fluorite veins.. They are described below. None of them give promise of yielding commercial ore.

Brock Canyon.—At the mouth of Brock Canyon where it joins the canyon of the Gila River, two small cuts in the canyon wall follow a fluorite vein less than 2 feet in width. On the north side of the canyon an open cut striking northeast across the edge of a small ridge exposes a vein 1 to 2 feet in width. All of the ore in sight has been removed.

Nut Prospect.—Approximately one-half mile southwest of Wood's ranch on the trail from the upper Gila to Cliff a cut on the side of a ravine 250 feet above the Gila River exposes a small vein of fluorite striking N. 30° W. The fluorite is 2 to 3 inches wide in the cut, but 100 feet up the ravine side a rather poor outcrop indicates a fluorspar bearing zone 6 or 7 feet in width. There is no development on the-wider portion of the vein and the outcrop does not show whether or not the fluorspar is continuous across its entire width. Approximately 500 feet north of the first cut there is another opening with a vein of siliceous ore 6 inches wide on the west wall. The country rock in both prospects is rhyolite porphyry.

Howard Prospect.—On the north side of the Gila River across from the Nut prospect is another opening said to be on a 15-foot fracture-zone containing 18 to 24 inches of fluorite. This was not examined by the writer.

BLUE BIRD MINE

LOCATION AND ACCESSIBILITY

The Blue Bird mine is on the southwestern flank of the Mogollon Mountains in Grant County and on the east side of Rain Creek Canyon approximately 200 feet above its bed. It is 19 miles north of Cliff. Two unpatented claims covering the outcrops of the veins are controlled by Alva H. Gunnell of Vanadium, N. Mex.

GEOLOGY, ORE DEPOSITS AND WORKINGS

The country rock exposed on the southwestern flank of the Mogollon Mountains in the neighborhood of the mine is gray to tan latite porphyry. The ore occurs in a fissure vein striking north and paralleling the creek on the west. From an open cut 200 feet long three drifts at different levels have been driven on the vein.

On the lowest level an open cut exposes a face 5½ .feet on the vein. On the west wall is a band of very siliceous ore 6 inches wide, and on the east wall is 2 feet of pure banded fluorite. The central part of the vein is made up of breccia and gouge containing approximately 5 per cent of fluorite as cementing material.

The middle level is 15 feet higher than the lower and 25 feet to the north. Here an adit 15 feet long exposed on the east wall 2% feet of massive crystalline fluorspar, and on the west wall 3% feet of brecciated country rock, gouge, and calcite cement containing a little fluorite. The maximum width of fluorite of good grade exposed in the main workings is 2% feet. A few silica druses and vugs are found in the ore.

The upper drift shows a 6-foot face containing 2 feet of banded fluorspar with some quartz. Brecciated porphyry occurs on either side of the fluorspar. Approximately 800 feet north of the main workings an open cut has been excavated on a continuation of the vein. There is no replacement of the country rock.

The ore is mainly bright green, but numerous small masses are purple. Exceptionally pure material can be obtained by careful sorting.

Several tons of ore were piled at the foot of the burro trail. An analysis of a grab sample of the ore pile showed 92.65 per cent CaF2, 1.05 per cent $CaCO_3$, and 6.36 per cent SiO_2.

ECONOMIC FEATURES AND FUTURE POSSIBILITIES

Some ore has been shipped from Silver City with a trucking charge to the railroad said to have been $5.00 per ton, to which was added $1.00 per ton for packing the ore from the mine to the head of the road.

With the limited width of the vein and the distance from the railroad it is doubtful whether the Blue Bird mine will produce ore except on a very high fluorspar market.

SEVENTY-FOUR MOUNTAIN PROSPECT

A prospect near the summit of Seventy-Four Mountain, 4 miles east from the Blue Bird mine along the Mogollon Mountain front, is said to show good fluorspar. This property was not examined and an adequate description of the occurrence could not be obtained.

BIG SPAR PROSPECT

The Big Spar prospect in Catron County is near the head of Little Whitewater Creek in the Mogollon Mountains, 6 miles east of Glenwood. Its elevation is about 6500 feet, which is 1800 feet above that of Glenwood.

The fluorite occurs as a breccia cement in a vertical shattered zone in rhyolite porphyry 16 feet in width. This zone is truncated above and below by intrusions of latite porphyry. These have cut the fluorite-bearing zone in such a way that its vertical dimension is 5 feet or less.

At the portal of the prospect the shattered rhyolite porphyry is capped by latite porphyry with a felsitic phase 10 inches wide at the contact. The relations at the floor of the prospect were not exposed, but a similar latite and rhyolite contact appeared to be present.

The fluorite is dull green, powdery, and contains much clay. An analysis of a selected sample across the face shows 96.53 per cent CaF_2, 0.83 per cent CaCO, and 2.53 per cent SiO_2.

The prospect is 6 miles from the road and 70 miles from Silver City, the nearest shipping point. Mr. Jesse Campbell of Glenwood is. the owner.

DEPOSITS IN THE ZUNI MOUNTAINS

CARNATION-COLUMBINE PROSPECT

LOCATION AND ACCESSIBILITY

The Carnation-Columbine prospect is in Smelter Gulch, Valencia County, 15 miles southwest of Bluewater, a station on the main line of the Atchison, Topeka & Santa Fe Railway. The prospect is reached from the town of Bluewater by way of Copperton or in dry weather by the road which ascends Bluewater Creek canyon.

Mr. Wesley Riggs of Diener, New Mexico, and associates are the owners. The group consists of 10 claims.

GEOLOGY OF THE ZUNI MOUNTAINS

The Zuni Mountains consist chiefly of uplifted pre-Cambrian igneous and metamorphic rocks which are flanked by sediments of Permian to Cretaceous age. These dip away from the pre-Cambrian mass and present a series of inward-facing erosional escarpments. Mt. Sedgwick, the culmination of the uplift, attains an elevation of 9200 feet. Northwest of Mt. Sedgwick the Abo sandstone of Permian age rests upon the pre-Cambrian rocks.

LOCAL GEOLOGY, ORE DEPOSITS AND WORKINGS

The country rocks in Smelter Gulch are granite gneisses and small amounts of weathered mica schist. These rocks are intruded by a fine-grained rhyolite porphyry of probable Tertiary age.

On the west side of Smelter Gulch is the Columbine claim on which are two shallow cuts striking N. 85° W., following a narrow vein in mica schist and rhyolite porphyry. The vein shows a maximum thickness of 10 inches of good fluorite.

The Carnation-Zuni King group of claims on the east side of the gulch approximately 200 feet up the hillside contain openings on a number of veins. An adit driven N. 80° E. in fine grained, pink granite gneiss, exposes a breast of 5 feet cut by a series of narrow fluorite veinlets in gouge and breccia. Following the strike up the hill to the crest of the ridge are a number of trenches exposing a series of small parallel veins through a zone 100 feet wide. The maximum observed width of fluorite was 14 inches.

Approximately 1000 feet north along the crest of the ridge an adit striking N. 85° W. on the Zuni King claim follows a vein for 30 feet_ The fluorspar occurs as a cement in brecciated porphyry. The hanging wall dips 70° to the south. On the footwall a 10-inch seam of good fluorspar seems to be persistent. The dump contained much brecciated ore and some barite. Down the hillside, 60 feet below the upper adit and following the strike of the vein to the west, a shallow trench shows a maximum of 10 inches of fluorite with some barite. The country rock here is fine-grained granite gneiss cut by minute veinlets of fluorite one-sixteenth to one-half inch in width. Still lower on the hillside on the same strike (N. 85° E.) a trench exposes 2 feet of green fluorite containing barite crystals and vugs lined with amethystine quartz.

THE ORE

A sample of selected broken ore showed the following analysis: 88.13 per cent CaF_2, 4.30 per cent $Si0_2$, 2.30 per cent $CaCO_3$, 3.42 per cent $BaSO_4$, and 0.98 per cent Fe_20_3.

FUTURE POSSIBILITIES

A small quantity of ore has been mined but no shipments have been made. The amount of fluorspar exposed in the openings on the Carnation-Columbine grant is too small for commercial development of the property. Such a deposit, even if adjacent to the railroad, could at best furnish occupation for two or three men at times of high fluorspar markets.

PROSPECT NORTH OF LA MADERA

A possible fluorite deposit has been prospected by the American Mines and Minerals Corporation in the Carson National Forest, 3 miles. north of La Madera, in Rio Arriba County.

A narrow vein showed some fluorite on the crest of a hill. From a point about 200 feet lower in elevation than the outcrop an adit was driven 600 feet N. 80° E. into the hill with the object of intersecting this vein. The adit passes through rhyolite agglomerate, mica schist, granite gneiss, and a basic dike. It crosses at least two conspicuous fault planes but shows no fluorite mineralization. The property is abandoned.

DEPOSITS IN THE SANDIA AND MANZANO MOUNTAINS

CAPULIN PEAK PROSPECT

LOCATION AND ACCESSIBILITY

A small prospect was opened in 1925 on Capulin Peak in the northern part of the Sandia Mountains. The deposits are near the summit of the peak approximately 1000 feet north of the National Forest highway, 33 miles from Albuquerque.

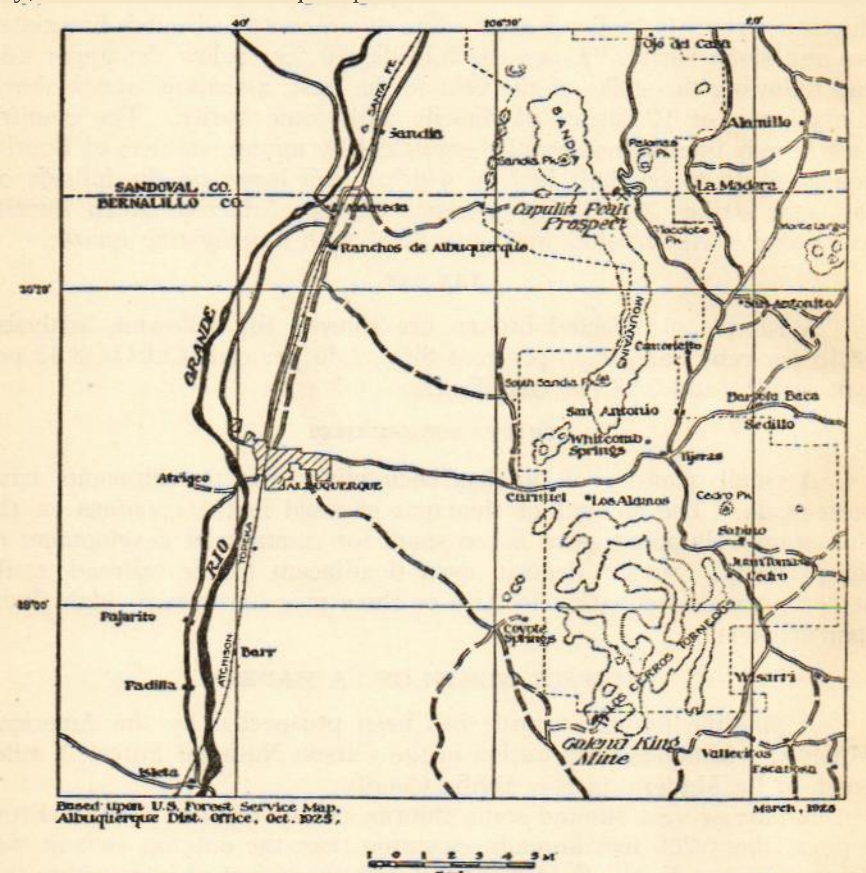


Figure 37.—Index map to fluorspar deposits in the Sandia and Manzano Mountains.

GEOLOGY

Capulin Peak is an isolated summit east of the west-facing escarpment of the Sandia Mountains, a great monocline faulted on the west and tilted toward the east. The range extends from Tijeras Canyon, due east of Albuquerque, for 20 miles to the north.

The maximum elevation is attained in Sandia Peak which rises to a height of 10,300 feet. Capulin Peak, 3 miles to the east, has an elevation of 8,300 feet.

The main mass of the Sandia Mountains is composed of pre-Cambrian granites, gneisses, and schists, upon which rest the Pennsylvanian shales and limestones of the Magdalena group, overlain by the Manzano group of Permian age. The fluorspar deposits are in Magdalena limestone.

ORE DEPOSITS

The location notice, dated June 15, 1925, named Nicholas E. Gutierez of La Madera as owner.

The principal opening is an inclined shaft 20 feet deep which follows a fault fissure in limestone striking N. 30° W. and dipping 60° to the southwest. The fissure is 3 feet in width and is filled with fine-grained purple fluorite surrounding and partially replacing fragments of limestone included in the vein. There is a thin clay selvage on the footwall with vertical slickensides at the surface and patches of gouge on the hanging wall.

Galena crystallized with fluorspar is found in small pockets throughout the face. Some barite in small plates is contemporaneous with the fluorspar, but it also occurs as druses lining cavities in the vein where it is associated with quartz and calcite. At the surface the material is dirty and clay stained, but at the bottom of the shaft, 20 feet down, the vein is clean.

Approximately 600 feet south of the main opening a small pit exposes fluorspar and galena in unimportant amounts.

ECONOMIC CONSIDERATION

The Capulin Peak occurrence has the appearance of a good prospect and further development work should be done.

GALENA KING MINE

LOCATION

The Galena King mine is on the Isleta Indian Reservation in Bernalillo County. It is in the Manzano Mountains 20 miles southeast of Albuquerque and 4 miles south of Coyote Springs.

GEOLOGY

The Manzano Mountains extend south from Tijeras Canyon east of Albuquerque as a structural continuation of the Sandia Mountains on the north. Like the Sandias, they are a great eastward-dipping monoclinal block of pre-Cambrian granites, gneisses, and schists, capped by Pennsylvanian and Permian sediments. The western face stands as an escarpment, not so pronounced as in Sandia crest, with downfaulted sediments showing here and there through the gravels west of the fault line.

The Galena King mine is in a small ravine and in an area of pre-Cambrian granite gneiss.

WORKINGS AND ORE DEPOSITS

The Galena King was developed as a lead mine and several cars assaying between 53 and 68 per cent lead and 1% oz. of silver are said to have been shipped.

The vein is entered on two levels. On the lower one an adit driven N. 65° E. intersects the vein at a distance from the portal of 325 feet. A crosscut continuing in the same direction 125 feet farther failed to pick up additional ore. At the vein a drift for 30 feet to the south shows a maximum width of 16 inches of fluorspar druses on a fracture plane. At the intersection of the adit and vein a winze descends 150 feet, following the vein which dips 70° to the east. For the first 35 feet the vein is mostly galena and ranges between 2 and 4 inches in width. Below 35 feet from the collar of the winze the vein widens into a fracture zone up to 2½ feet wide containing fragments of granite gneiss and druses of fluorite partly cementing the fragmental material. No drifting has been done from the winze. A few feet north of the winze on the lower level the vein attains a maximum width of 3 feet of fluorspar and pockets of galena. It pinches to 3 inches or less at the end of the drift 200 feet to the north. A raise in the widest part of the vein just north of the winze shows 3 to 4 feet of ore, most of which has been removed.

The upper level is approximately 170 feet above the lower. It is entered on the vein and followed north for a distance of approximately 300 feet. The vein pinches to a few inches and swells to 4 or 5 feet a number of times in this distance. In addition to fluorspar the vein contains some lead and a little barite. A winze 100 feet from the portal of the adit was not explored. Most of the ore has been removed from the wider portions of the vein. The mineralized zone has a length of about 300 feet.

THE ORE

The ore consists of blue-green fluorite. scattered pockets of galena, and some barite. The fluorite is well crystallized and numerous cavities are lined with well-developed cubes. Galena crystals in the upper workings are coated with anglesite, and here and there the ore is stained with copper carbonate.

Ladoo[1], who visited the property in 1922, gives the following analysis of an ore pile near the portal of the lower adit containing approximately 13 tons of ore: 69.69 per cent CaF2, 8.84 per cent SiO_2, 2.14 per cent $CaCO_3$, and 12.75 per cent $BaSO_4$.

This is an unusually poor grade ore for the mine, as most of the

[1]Ladoo, R. B., Fluorspar: U. S. Bureau of Mines Bull. 244, p. 132, 1927.

fluorspar is not intimately mixed with barite and can readily be separated from it.

FUTURE POSSIBILITIES

As all ore of commercial dimensions has been mined and prospect adits have failed to reveal new bodies, it is unlikely that the Galena King mine will be reopened.

DEPOSITS IN THE SAN ANDREAS AND OSCURA MOUNTAINS LAVA GAP PROSPECT

LOCATION

The Lava Gap prospect of the Fluorspar Mines of America Corporation is in the northern end of the San Andreas Mountains in Socorro County, 2 or 3 miles north of the Lava Gap shown on the U. S. Geological Survey topographic map of the Tularosa quadrangle and 3 miles N. 85° W. from Capital Peak. The shipping point is Three Rivers, a small station on the El Paso & Southwestern Railway approximately 27 miles east of the prospect. Engle, on the Atchison, Topeka & Santa Fe Railway, is 60 miles to the west and connected with the prospect by a poor road.

GEOLOGY

In describing the San Andreas Range, Darton[1] says:

> The San Andreas Mountains form a long, narrow ridge that extends through the northern part of Dona Ana County and the southeastern part of Socorro County and separates the Tularosa Basin on the east from the Jornada del Muerto on the west. The ridge consists mainly of a monocline of limestones and red beds dipping to the west and passing under the Jornada del Muerto. The uplift in general, however, is an anticline, and eastward-dipping strata are exposed at its foot toward the north and south ends of the ridge. For many miles along the steep eastern face of the mountains there are exposures of pre-Cambrian granites and schists capped by the westward-dipping Ordovician to Pennsylvanian limestones. The Pennsylvanian limestone constitutes most of the summit and higher western slopes of the range and finally passes beneath the red sandstones of the Abo, and these in turn under the sandstones and limestones of the Chupadera formation which slope down to the desert at the western foot of the range.

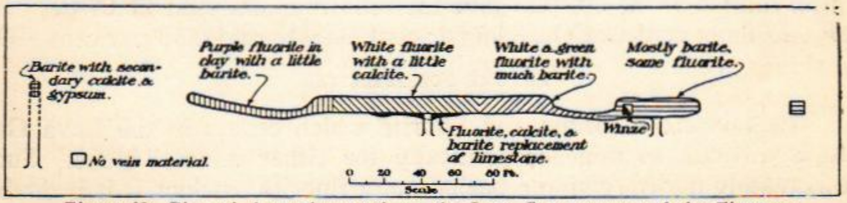


Figure 38.—Plan of the main trench on the Lava Gap property of the Fluorspar Mines of America, showing lateral variation in the character of the vein material.

[1] Darton, N. H., Geologic Structure of Parts of New Mexico: U. S. Geol. Survey Bull. 726, p. 229, 1922.

WORKINGS AND ORE DEPOSITS

The ore occurs as a vein filling in massive, dark gray, cherty, fossiliferous Magdalena limestone of Pennsylvanian age.

Two claims end to end cover the outcrop of a single fluorite and barite vein which strikes N. 20° E. and is exposed by occasional openings for a distance of 3000 feet. The vein follows a low ridge on the west side of an open ravine clothed with yucca, mesquite, greasewood, and cactus.

The main workings are near the north end of the southern claim. Here an open cut 4 to 5 feet wide and 300 feet long follows the ore. Fig. 38 illustrates the lateral variation in the open cut. For 60 feet from the southern end the vein consists of fluorite in a clay matrix and minor amounts of calcite and barite. This passes into a white, coarsely crystalline fluorite carrying a small amount of calcite. Some replacement of the limestone on the east wall by fluorite, barite, and calcite has taken place. The vein in the northern part of the cut contains progressively more barite, and north of the winze barite is the principal and fluorite the subsidiary vein mineral.

Two pits on the vein at the northern end of the northern claim show 4 to 5 feet of iron-stained barite carrying some fluorspar and a little calcite.

South of the open cut an adit crosscuts a pinch on the vein which at this point consists of a few inches of barite coated with secondary druses of calcite and gypsum. A pit north of the portal of the crosscut is in limestone and shows no vein material. Some 500 feet south of the main working in another part is the most southern exposure of the vein. It is composed of 2 to 3 feet of barite in a clayey residual matrix.

The extreme lateral variation shown by the vein minerals is unusual for New Mexico fluorspar although it has been noted in the fluorspar deposits of central Kentucky.

THE ORE

Near the main open cut several tons of hand picked ore were piled. A grab sample of the ore pile gave the following analysis: 86.07 per cent CaF_2, 2.98 per cent $CaCO_3$, 8.43 per cent $BaSO_4$, and 0.38 per cent $S10_2$.

FUTURE POSSIBILITIES

The mixture of barite and fluorite which occurs in the Lava Gap vein is difficult to mine economically for either mineral alone. Such ore is readily milled, giving a barite and a fluorite product. It is doubtful, however, if the size of the deposit justifies the erection of even a small mill at this time. The road to Three Rivers is in bad condition and the construction of a good road through the canyon to the east of the prospect will be difficult. It is probable that the development of this deposit will await better market conditions.

HANSONBURG LEAD MINE[1]

LOCATION AND TOPOGRAPHY

This property consists of 6 unpatented claims lying along the summit of the westward-facing escarpment of the Sierra Oscura Range, in eastern Socorro County. This range is a northern continuation of the San Andreas Mountains and forms the northeast boundary of the Jornada del Muerto. In the vicinity of the mine the face of the Sierra Oscura is very steep. At the base of the escarpment the slope flattens out and merges into the flat, dry plains of the Jornada del Muerto. The top of the range slopes gently with the dip of the limestone toward the east. Several narrow, deep, and generally dry canyons drain westward from the heart of the mountains.

The mine is about 2 miles south of the artificial lake on H. 0. Bursum's ranch, which lies 27 miles east of Carthage, on the New Mexico Midland Railroad. An excellent, newly graded road leads from Carthage to within 6 or 7 miles of the mine.

GEOLOGY, ORE DEPOSITS AND WORKINGS

The existence of abundant float showing fluorite, barite, and galena, has been known for many years, though it was not until 1916 that any attempt at mining was made. In this year the Western Mineral Products Company took the property over and erected a 50-ton dry mill to extract the galena. So far as is known the value of the fluorspar and barite was ignored by the operators.

The ore occurs as fissure fillings in Magdalena limestone which rests directly upon pre-Cambrian granite. Some solution of the limestone evidently took place before the mineralization, as 150 feet from the portal there is a large cavity lined with barite and fluorite. Numerous smaller cavities along a fault plane have been filled with fluorite and galena, and a small amount of barite. No replacement of the limestone was noted. Mineralization is much more apparent at the outcrop than in the tunnel, where long stretches of the vein are devoid of economic minerals,

The mine workings consist of a tunnel 500 feet along the vein; about 300 feet of crosscuts and exploration work, and 200 feet of raises and winzes. No timber was used except in the latter workings and the tunnel has held up well. The track is still in place and two small ore cars were seen at the adit mouth. A small, empty blacksmith shop stands adjacent to the 50-ton mine ore bin. A 500-foot, double-track gravity incline leads to the mill.

[1]By T. P. Wootton.

MILLING OPERATIONS

Ore was received at the mill in a 50-ton bin. From this bin it was shoveled over a grizzly and spalling floor to a 10 by 20-inch Blake breaker. From the breaker the rock went through a series of rolls and trommels until reduced to 12 mesh. This crushed material was allowed to fall through an ascending blast of air (to be "de-dusted") into the crushed ore bin. A Plumb pneumatic jig was fed from this bin. From the amount of galena in the mill dust and in the tailings dump it is assumed that this system of concentration was not successful, but no extraction figures are available.

The power unit is situated adjacent to the south side of the mill and consists of two semi-Diesel engines totaling 100 horse-power.

FUTURE POSSIBILITIES

The deposit appears to be surficial in character and it is unlikely that commercial bodies of either fluorspar or galena exist.

DEPOSITS IN THE SIERRA LADRONES

JUAN TORRES PROSPECT

LOCATION

A fluorspar prospect is located in the Sierra Ladrones south of Ladrone Peak in Socorro County. It is in sec. 18, T. 2 N., R. 2 W. and is 18 miles northwest of San Acacia, a station on the Albuquerque-El Paso branch of the Atchison, Topeka & Santa Fe Railway.

GEOLOGY

The Sierra Ladrones stand out in a bold, conical mass attaining a maximum elevation of approximately 9000 feet in Ladrone Peak. They are made up of a core of pre-Cambrian granites on which rest sediments of Pennsylvanian, Permian, Triassic, and Cretaceous ages. These rocks are intruded by Tertiary rhyolite and andesite and capped by the corresponding flows. A few quaternary basalt dikes cut the surrounding bolson deposits.

Fluorspar occurs in a series of small, horizontal, quartz-lined veins in pre-Cambrian granite adjacent to a fine grained andesite dike.

Fig. 39 is a sketch of the north wall of a small trench from which the fluorspar was obtained.

WORKINGS AND ORE DEPOSITS

The pre-Cambrian granite is cut by a 5-foot dike of fine-grained andesite. East of the dike and extending beyond the limits of the trench are two small horizontal veins which merge at the andesite and granite contact. These veins attain a maximum width of 2½ to 3 feet. Lining the veins and in contact with the granite walls, is a band of quartz occurring in crystals up to 6 inches in length and showing well-developed pyramid-terminated prisms. The fluorspar fills the space between the quartz on the walls of the vein. Some specularite occurs with the quartz, and a little chalcocite, apparently of secondary origin, fills fractures in it. The maximum width of fluorspar observed was 2 feet, but it is usually narrower.

PARAGENESIS

The relationship existing between the veins and the dike (fig. 39) is well shown in the trench where the abutment of the veins against the dike is exposed. At the contact between the dike and the granite forming the country rock the granite is broken and penetrated by apophyses of dike material. That the opening of the veins and their mineralization resulted from the intrusion of the dike seems certain. Whether or not the specularite-bearing quartz crusting the vein walls was deposited from the same solutions which gave the fluorspar is uncertain. The occurrence of specularite

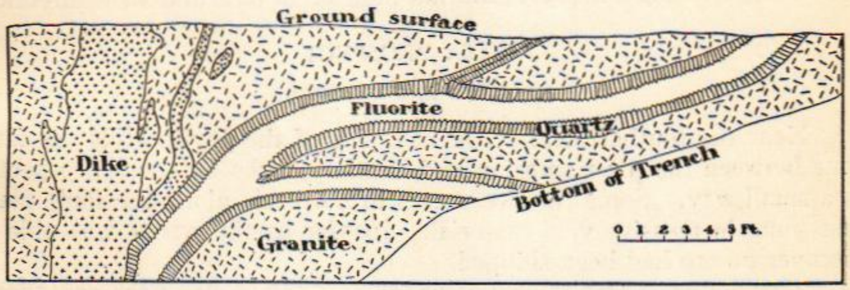


Figure 39.—Sketch of the vein face, Juan Torres prospect in the Sierra Ladrones.

conditions due probably to the proximity of the dike. The chalcocite occurs in cracks in the quartz with some copper carbonates. No other sulfides were observed.

FUTURE POSSIBILITIES

Juan Torres of Magdalena, N. Mex., worked the prospect in 1927 and shipped one car of metallurgical lump spar. The deposit is small and remote from the railroad. That it can be profitably worked seems unlikely.

DEPOSITS IN THE JOYITA HILLS

THE JOYITA HILLS

Approximately 4 miles east of San Acacia and 15 miles north of Socorro on the east side of the Rio Grande in central Socorro County is a low ridge of pre-Cambrian granites and schists known as the Joyita Hills. They begin in the north central part of T. 1 S., R. 1 E. and extend for 3 miles to the northeast. The hills rise 500 feet above the Rio Grande to the west. They are cut by many ravines with sharp intervening ridges. Fig. 40 is a section from east to west across the hills.

On the west the pre-Cambrian rocks are overthrust against westward-dipping Magdalena limestones which pass under the Abo and Chupadera formations farther west. The east side of the granite area is faulted against a series of Tertiary rhyolite flows and ash beds.

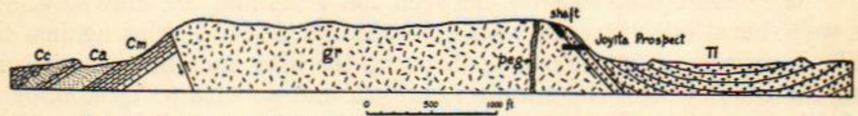


Figure 40.—East and west section of the Joyita Hills, Socorro County. gr. granite; peg. pegmatite; Cm. Magdalena limestone; Ca. Abo sandstone; Cc. Chupadera formation; and Tl. Tertiary lavas.

Fluorspar occurs in the Joyita prospect in the fault zone on the eastern edge of the granite and in the Dewey vein which outcrops for 4000 feet, crossing the pre-Cambrian area in an east and west direction.

JOYITA PROSPECT

LOCATION AND GEOLOGY

Near the southern end of the east side of the Joyita Hills the fault zone between the pre-Cambrian and Tertiary rocks has been prospected in a small way. Some fluorite occurs in a breccia along the fault plane and some in massive vein material. Insofar as the writer was able to discover no ore had been shipped.

The major geological relations of the Joyita prospect are shown in the cross section of the Joyita Hills, fig. 40. The east boundary of the pre-Cambrian rocks is marked by a low, eastward-facing escarpment. East of the pre-Cambrian area is a series of Tertiary ash beds and rhyolite flows faulted down against the older rocks. The Tertiary rocks have a prevailing westerly dip, but near the contact with the pre-Cambrian rocks the dip reverses due to drag along the fault.

The faulted zone contains at least two well-marked planes of movement. The outer or eastern one is displayed in a narrow brecciated zone running north and south and dipping to the east. This breccia zone is in rhyolite and the footwall forms the east face of the Joyita Hills in the neighborhood of the prospect. A distinct fault plane dipping to the east and exhibiting well-marked slickensides occurs 60 feet west of the brecciated zone. It is exposed in the adit half way up the hillside and in a shaft at the crest of the hill. The throw represented by the faulted zone appears to be 1000 feet or more, as at least that thickness of Tertiary ash beds and rhyolite flows are exposed east of the prospect.

WORKINGS AND ORE DEPOSITS

Fluorite occurs both in the brecciated zone and on the fault plane between the granite and rhyolite.

Half way up the slope an adit has been driven S. 30° E. for 70 feet. For 20 feet from the portal the adit is in brecciated rhyolite which includes a 7-foot band of brecciated and recemented fluorspar.

The brecciated ore appears to have been formed by the reopening of a fluorspar-filled vein with subsequent cementation by quartz and iron oxide. A considerable tonnage of such material is exposed along the brecciated zone.

The adit ends at the granite foot wall of the inner fault. Here slickensides are conspicuous, but no ore was found.

On the crest of the hill is a north-striking vein of fluorite, calcite, and small amounts of quartz and galena which dips 40° to the east. This appears to be on the inner fault encountered at the end of the adit. The fault fissure is 8 feet wide and contains 2 feet of fluorspar on the footwall. A shaft has been sunk approximately 25 feet on the vein, just above the adit.

THE ORE

The brecciated ore at the mouth of the adit consists of green and white angular fragments of fluorspar up to 2 inches in diameter cemented by quartz and iron oxides. An analysis of a sample of this material showed 60.89 per cent CaF_2, 2.00 per cent $CaCO_3$, 29.16 per cent $Si0_2$, and 7.96 per cent Fe_20_3.

An analysis of vein material from the footwall on the shaft gave returns of 84.49 per cent CaF_2, 9.64 per cent $CaCO_3$, 4.47 per cent SiO_2, and 1.20 per cent $Al_20A\text{-}Fe_20_3$.

FUTURE POSSIBILITIES

These deposits are small and the ore is low grade. In times of high fluorspar market a few tons of metallurgical lump could doubtless be obtained from the vein outcropping at the top of the hill. As the brecciated ore must be milled, it is improbable that it will be developed in the near future. A large reserve, however, of the brecciated material exists.

DEWEY MINE

LOCATION

The Dewey shaft at the west end of the Dewey vein in the Joyita Hills is approximately 5 miles N. 82° E. from San Acacia, a station on the Atchison, Topeka & Santa Fe Railway.

GEOLOGY, ORE DEPOSITS AND WORKINGS

The country rock of the Dewey vein is chiefly coarse pegmatitic granite consisting of quartz and pink feldspar. The vein has an easterly course and is exposed for a distance of approximately 4000 feet. Near the west end of the vein the Dewey shaft attains a depth of 300 feet. It was in bad condition when visited and an examination of the underground workings could not be made.

The Dewey mine has been described by Gordon[1] as follows:

> A vein which is 3 to 5 feet wide cuts the gneiss nearly parallel with the strike of the limestones and associated beds. The ore (galena) occurs in bunches distributed in a gangue of quartz, barite, and fluorite, which occupies the full width of the vein. The walls are usually well defined and are covered to a thickness of one-fourth to one-half inch with clay gouge. At the Dewey mine a shaft has been sunk on the vein to a depth of 300 feet. No water was encountered. In the upper 230 feet the dip is about 65° SE.; below that it is 75° to 80°. Above the change of dip the ore mostly follows the hanging wall, but below that point it occurs principally along the foot-wall side. No shipments have been made from the mine, but about 100 tons of ore now lie on the dump. It is a low-grade galena ore carrying very little gold or silver. The well defined character of the vein and the fact that it maintains this character to the bottom of the shaft indicate its continuation to a point considerably below the present workings.

An analysis of a grab sample of the ore pile at the Dewey shaft, which is selected material and not an average of the vein, gave returns of 41.18 per cent CaF_2, 1.78 per cent $CaCO_3$, 11.78 per cent $BaSO_4$, 7.94 per cent PbS, 23.32 per cent $Si0_2$, and 13.6 per cent $A1_20_3$+Fe_20_3.

West of the Dewey shaft the vein becomes more siliceous and is lost before it reaches the Magdalena limestone on the west side of the Joyita Hills. To the east it can be traced for 3000 feet. A few prospect holes show the variable character of the vein material, in some places barite being the dominant mineral and in others fluorite. About 1500 feet east of the Dewey shaft a shallow shaft on the vein shows 4 feet of fluorite, barite, chert, and a very small amount of galena. An analysis of the material mined from this shaft gave the following results: 12.16 per cent CaF_2, 1.57 per cent $CaCO_3$, 38.06 per cent $BaSO_4$, 0.90 per cent PbS, 34.65 per cent SiO2 and 12.52 per cent $A1_20_3$+Fe_20_3.

Near the east end of the Dewey vein and about 400 feet west of the contact between the pre-Cambrian rocks and Tertiary volcanic rocks is a shallow pit in which the vein material is largely cherty quartz. A small amount of chalcopyrite occurs in the vein and the secondary copper minerals chalcocite and malachite are sparingly present.

FUTURE POSSIBILITIES

The ore of the Dewey vein cannot be mined profitably for any one of its chief constituents, which are fluorite, barite, and lead. Radical advances in milling procedure whereby both fluorite and lead, and perhaps barite also, could be saved and marketed might alter the situation.

[1]Gordon, C. H., Ore Deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68. pp. 240.241. 1910.