

LUNA COUNTY

GENERAL RELATIONS

The fluorspar deposits of Luna County are in the northern part in the Cooks Range, and in the south central part in the Florida and Little Florida Mountains. In the broad Mimbres Valley between the two fluorspar areas is Deming, to which most of the fluorspar mined in the county is taken. There it is beneficiated in the General Chemical Company's flotation mill or the Grattan flotation mill, or is shipped direct to consumers or brokers. Deming is on the Southern Pacific Railroad and on a branch of the Atchison, Topeka, and Santa Fe Railway with terminals at Silver City and Albuquerque. A network of Federal and State highways and mine roads provides access to most of the deposits (Plate 1).

The Cooks Range and the Florida and Little Florida Mountains consist of rocks of pre-Cambrian, Paleozoic, and Mesozoic ages that were invaded or covered by Tertiary igneous and clastic rocks. The resulting complex was extensively dislocated, by faults, the principal trend of which is northwest. Erosion, which probably has been practically continuous since Pliocene or earlier time, reduced and partly buried the mountains and filled the intervening valleys, forming extensive bolson deposits.

The Cooks Range is the synclinal province east of the Burro Mountains uplift and in this respect is related to the Silver City area. In both areas, moreover, a major fault system trends northwestward ; some of the faults in the Hanover district east of Silver City may be extensions of the main fault on the east side of Cooks Range.

The details of the stratigraphy and structure are presented with the descriptions of the fluorspar localities.

FLUORSPAR DEPOSITS

The fluorspar deposits in the Cooks Range and the Little Florida Mountains are in rocks of Tertiary age or in older rocks into which Tertiary rocks were intruded. In the igneous rocks and arenaceous sedimentary rocks the fluorspar bodies are in faults, fissures, and breccias ; in the limestones they follow the bedding and the soluble or permeable parts of the rock, or form veins or stringers in irregular fractures. Examples of both space-filling and replacement deposition may be found. Several stages of fluorspar deposition were accompanied or followed by silicification in varying degrees of completeness. Much of the fluorspar is of especially high grade and consists almost entirely of coarse-grained transparent green fluorite, typically repre-

sented in the mines in the southeast end of Fluorite Ridge. Some of it is fine-grained, white, and slightly siliceous. A red or brown fluorspar, generally microcrystalline, was formed by replacement and is stained with iron. Quartz, the chief gangue

TABLE 29. FLUORSPAR MINES AND PROSPECTS IN LUNA COUNTY

Name ^a	Approximate location	Reference ^b
<i>Cooks Peak district</i>		
Lookout No. 1 prospect	Near SE corner sec. 11, T. 20 S., R. 9 W.	
Bond prospect	NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 13, T. 20 S., R. 9 W.	
<i>Fluorite Ridge area (Southeast group)</i>		
Sadler mine (Opening No. 1) (Lower Camp)	Near center NW $\frac{1}{4}$ sec. 18, T. 22 S., R. 8 W.	7:537, 540 27:92-94
Greenleaf mine (Howard mine)	SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 22 S., R. 8 W.	27:96
San Juan mine	Near center E $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 18, T. 22 S., R. 8 W.	27:96 7:540-541
Greenleaf No. 4 prospect	SE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 22 S., R. 8 W.	
Lucky mine (Opening No. 2) (Locality No. 2)	250' W. of N $\frac{1}{4}$ -corner sec. 18, T. 22 S. R. 8 W.	7:537, 538 27:97
Hilltop Spar prospect	Near center NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 18, T. 22 S., R. 8 W.	
<i>Fluorite Ridge area (Central group)</i>		
Grattan mine (Opening No. 3) (Locality No. 3) (Upper Camp)	NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 12, T. 22 S., R. 9 W.	7:538, 541-542 27:97-98
Whitehill prospect	700' SE. of Grattan mine.	
Spar No. 2 prospect (Deckert shaft)	S $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 1, T. 22 S., R. 9 W.	27:98
Grattan State Land mine	SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 2, T. 22 S., R. 9 W.	
Tip Top prospect	S $\frac{1}{2}$ sec. 1 and N $\frac{1}{2}$ sec. 12, T. 22 S., R. 9 W.	
<i>Little Florida Mountains</i>		
Florida mine ^c (Duryea claims) (Spar claims)	Secs. 7 and 8, T. 24 S., R. 7 W.	27:88-91
Price prospect ^c	In the Florida Mountains.	

^a Names in parentheses are those that appear in other publications or are used locally.

^b Numerals in column 3 are references to descriptions in other publications. The first number is the index number of the publication in the bibliography at the end of Part 1 of this bulletin ; the second number or series of numbers refers to the page or pages on which the article appears.

^c Not described in this report.

mineral, forms tiny crystals that are intergrown with the fluorite and give the aggregate a white appearance. Quartz also occurs sparingly as jasper veins and drusy cavity fillings that were formed later than the fluorite. Barite was deposited as a late mineral in some veins.

For convenience of description and reference the fluorspar deposits of the county are grouped as follows. The Cooks Peak district includes the old mining area on the north slope of Cooks Peak, a prominent landmark; the district is continuous with the northern Cooks Range of Grant County, discussed on pages 98-103. The Fluorite Ridge area is in the mountains called Fluorite Ridge and Goat Ridge, which lie immediately southwest of the Cooks Range and are in reality a part of it. The deposits in this area have been an important source of fluorspar for many years. The deposits of a third area, the Florida and Little Florida Mountains, were not included in the field investigations and are not described.

COOKS PEAK DISTRICT

No original studies of the geology of the Cooks Peak mining district have been published since the work of C. H. Gordon,²¹ from which most of the following description has been taken.

The Cooks Peak district is situated on the north side of Cooks Peak about 20 miles north of Deming. It is best known for its lead-silver-zinc mines, which yielded nearly \$4,000,000 worth of metals during the period 1886 to 1927.²² Cooks Peak (altitude 8,408 feet) is the highest summit on Cooks Range. It is composed of granodiorite porphyry intruded into Paleozoic and Cretaceous strata, remnants of which cover its flanks. The metallic ore-bodies are irregular pipes, kidneys, and pockets in the arched upper part of the Fusselman limestone (Silurian). They occur just below the Percha shale (Devonian), which appears to have acted as a deterrent to the rise of the mineralizing solutions. Some offshoots of the main metalliferous bodies contain fluorite at their center. A fluorspar claim, filed by T. N. Bond and called the Lookout No. 1, is about three-quarters of a mile northwest of the site of the furnace for the Gladys mine in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 14, T. 20 S., R. 9 W.; another claim, filed by E. Nickles, is in the bottom of the canyon northeast of the furnace site.

²¹ Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 287-289, 1910.

²² Lasky, S. G., and Wootton, T. P., The metal resources of New Mexico and their economic features: N. Mex. School of Mines, State Bur. Mines and Min. Res. Bull. 7, p. 80, 1933.

LUNA COUNTY
LOOKOUT NO. 1 PROSPECT 23

The Lookout No. 1 prospect is on a ridge high on the flank of Cooks Peak. There are two exposures of fluorspar, one on the crest and the other to the northeast on the side of the ridge. A pit dug in the former exposure contains a fluorspar vein that is 4 feet wide, strikes about N. 50° W., is approximately vertical, and terminates southeastward against a southwest-trending fault or fissure. This vein can be traced for 35 feet northwest of the pit, to a point where it is covered by talus ; it could not be found in a limestone outcrop 75 feet northwest of the pit. The vein material is vuggy and siliceous and is estimated to contain about 50 percent CaF_2 . It appears to have been formed by replacement of limestone along intersecting fractures. The fluorspar body seen in the exposure on the side of the ridge also strikes northwest, but dips southwest at the relatively low angle of 15° to 20°; it is interpreted as a replacement deposit along a bedding plane in limestone. The fluorspar in this deposit is irregularly exposed for about 200 feet along the strike. Although the low dip of the deposit makes broad exposures of fluorspar on the slope, the true thickness of the deposit is estimated to be only 2 or 3 feet. The deposit contains distinctly crystalline fluorite and silica minerals in about equal proportions. Some of the fluorite is yellow or green and is edged with purple. Incrustations and botryoidal surfaces of fluorite on fracture walls or rock fragments are common.

FLUORITE RIDGE AREA

Fluorite Ridge comprises an elongate group of barren rugged hills $3\frac{1}{4}$ miles southwest of the southern end of the Cooks Range, with which it is roughly parallel, and 10 miles north of Deming. It is $4\frac{1}{2}$ miles long and a half mile wide, and its crest is about 900 feet above the adjacent valleys. The fluorspar deposits are in two groups; one, called the Southeast group, is at the southeast end near the base of the ridge, and the other, called the Central group, is about $1\frac{1}{2}$ miles to the northwest, in the higher part of the ridge (Figure 11.) This grouping corresponds with Johnston's designations of Lower and Upper Camp ²⁴ and is used because the camp sites are no longer generally known. The deposits are known by various names both in the literature and in local usage.

The deposits are reached by an access road, constructed by the Federal government, that leaves paved State Highway 26 about $6\frac{1}{4}$ miles northeast of Deming. There are no springs or

²³ Description from field notes made by James K. Grunig, U. S. Geological Survey, March 1944.

²⁴ Johnston, W. D., Jr., Fluorspar in New Mexico: N. Mex. School of Mines, State Bur. Mines and Minn. Res. Bull. 4, pp. 92-99, 1928.

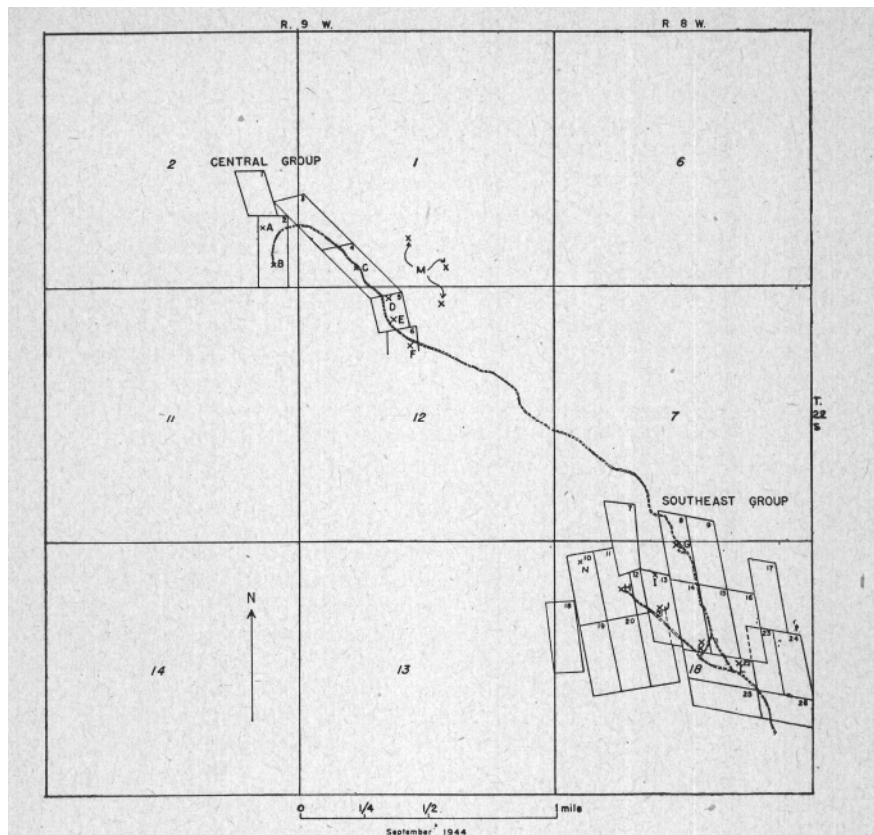


FIGURE 11.-Index map of Fluorite Ridge, Luna County, showing location of fluorspar claims.

MINES AND PROSPECTS

- A. Grattan State Land prospect.
- B. Grattan State Land mine.
- C. Deckert shaft.
- D. Grattan mine shaft No. 1.
- E. Grattan mine shaft No. 2.
- F. Whitehill prospect.
- G. Lucky mine.
- H. Sadler mine.
- I. San Juan mine shaft No. 2.
- J. San Juan mine shaft No. 1.
- K. Greenleaf mine.
- L. Greenleaf No. 4 prospect.
- M. Tip Top prospects (approximate locations).
- N. Hilltop Spar prospect.

CLAIMS

- 1. Greenspar No. 1-State lease.
- 2. Greenspar No. 2-State lease.
- 3. Spar No. 3.

- 4. Spar No. 2.
- 5. Spar No. 1.
- 6. Dorothy Bell.
- 7. Williams Brothers No. 2.
- 8. Lucky.
- 9. Deer.
- 10. Susan No. 2.
- 11. Susan No. 1.
- 12. Fluorite.
- 13. San Juan.
- 14. Greenleaf No. 1.
- 15. Greenleaf No. 2.
- 16. Greenleaf No. 3.
- 17. Valley No. 2.
- 18. Williams Brothers No. 5.
- 19. Fern.
- 20. Sierra.
- 21. La Purissima.
- 22. Greenleaf No. 4.
- 23. Greenleaf No. 5.
- 24. Valley No. 1.
- 25. Dorothy No. 1.
- 26. Dorothy No. 2.

streams in the area, and the permanent water table, reached in the Greenleaf mine at the southeast end of the ridge, is at a depth of about 355 feet.

GEOLOGY

Fluorite Ridge is composed of a stock of monzonite porphyry (Tertiary) intruded into older rocks that cap the eminences and occur as disconnected masses on the sides of the ridge. These older rocks consist of Paleozoic sedimentaries resting on a basement of pre-Cambrian granite and overlain by Lower Cretaceous sandstone. Tertiary clastic and pyroclastic rocks, which surround the ridge and in places extend up the lower slopes, are partly covered by alluvium.

The southeast end of Fluorite Ridge consists of a large block of Paleozoic rocks with a narrow exposure of pre-Cambrian granite at the base. The block is tilted 80° N., and its component strata are exposed in cross section in the steep southeast end of the ridge. Within a distance of 2,500 feet on the east face of this block the following formations, named in ascending order, are exposed : Bliss sandstone (Cambrian) ; El Paso and Montoya limestones (Ordovician) ; Fusselman limestone (Silurian) ; Percha shale (Devonian); and Lake Valley limestone (Mississippian).²⁵ The Sarten sandstone (Lower Cretaceous) borders the north and west sides of the ridge and caps the highest hill. The central part of the ridge consists chiefly of intrusive monzonite porphyry that includes andesitic phases. At the southeast end of the ridge a series of feldspathic and conglomeratic beds at least 300 feet thick overlies the monzonite porphyry. In several places the contact between the conglomerate and the monzonite porphyry is along faults; elsewhere this contact is obscured by talus. Overlying the conglomeratic beds is a series of agglomerates and flows with minor water-sorted members. The agglomerate is widely exposed on the flanks of the ridge. The presence of monzonite-porphyry fragments in the conglomerate indicates that the monzonite porphyry is the older. The youngest igneous rock is basalt, which forms dikes cutting the conglomerate and older rocks. Darton ²⁶ reports that the dikes occur in the agglomerate and bolson deposits also, and therefore are Quaternary in age. The bolson deposits, which occupy the valleys, consist of a thick series of unconsolidated and semi-consolidated strata composed of irregularly bedded boulders, pebbles, sand, and silt. The bolson deposits around Fluorite Ridge are all of Quaternary age, but the oldest members of the series in the Rio Grande and Gila valleys may have been deposited in late Tertiary time.

²⁵ Darton, N. H., U. S. Geol. Survey Geol. Atlas, Dering folio (no. 207), pp. 3-5, 1917. p. 9.

The stratigraphic sequence of rocks in the area is shown in Table 30.

TABLE 30. COLUMNAR SECTION OF ROCKS IN FLUORITE RIDGE ^a

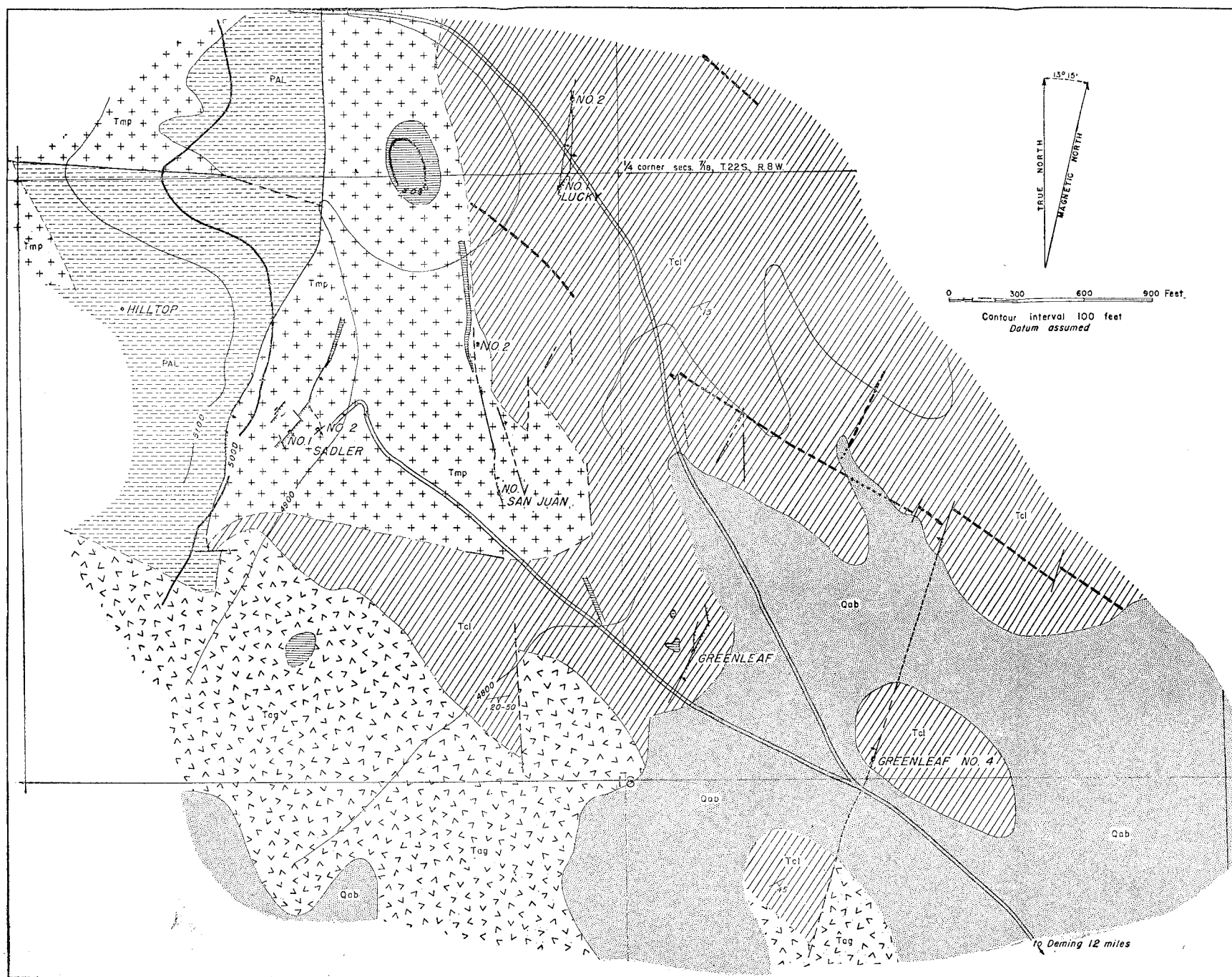
System	Series or group	Formation name and thickness (feet)	Description of rocks
QUATERNARY			Dikes of basalt cutting bolson deposits and older rocks.
		Bolson deposits	Poorly sorted feldspathic gravel, sand, and silt, with subangular boulders of older rocks. At the southeast end of Fluorite Ridge they rest on a thin layer of residual material derived from the underlying Tertiary conglomeratic rocks.
TERTIARY		<i>Unconformity</i>	
		Agglomerate and associated rocks	Irregularly stratified fragmental rocks of volcanic origin, including agglomerate, tuff, volcanic ash; mud and lava flows; and intrusive masses. The agglomerate consists of fragments of dark-gray andesite or latite in a gray or purplish matrix of tuff or volcanic ash.
		Conglomerate and associated rocks	Thick beds of bouldery conglomerate alternating with thinner beds of coarse- and fine-grained pinkish-green and olive-green feldspathic sandstone. The conglomerate has a matrix composed largely of coarse-grained fragments of monzonite porphyry. There are a few thin nodular limestones and limy feldspathic sandstones.
		<i>Unconformity</i>	
		Monzonite porphyry	Greenish-gray monzonite porphyry containing phenocrysts of white striated feldspar, dark-green embayed hornblende, and green biotite in a fine-grained greenish-gray matrix. An andesitic phase occurs near the center of the ridge.
CRETACEOUS	Comanche	<i>Unconformity</i>	
		Sarten sandstone 0-300	Light-gray massive quartzitic sandstone with a few interbedded slabby limy strata and a basal conglomerate.
		<i>Unconformity</i>	

TABLE 30. COLUMNAR SECTION OF ROCKS IN FLUORITE RIDGE ^a
(CONTINUED)

System	Series or group	Formation name and thickness (feet)	Description of rocks
CARBONIFEROUS	Pennsylvanian	Magdalena group 30-1000	Light-gray massive limestone, partly brecciated, with dark-gray fossiliferous shale and cherty limestone in upper part.
	Mississippian	Lake Valley limestone 200+	Gray limestone, slabby to massive, with interbedded calcareous shale. Top is cherty; basal 100 feet is massive and cliff-forming.
DEVONIAN	Upper Devonian	Percha shale 150±	Dark-gray to black fissile shale.
<i>Unconformity</i>			
SILURIAN	Niagaran	Fusselman limestone	Dark-gray compact limestone.
ORDOVICIAN	Richmond	Montoya limestone	Light-gray limestone with thin-bedded chert layers at two horizons and dark massive limestone at the base.
	<i>Unconformity</i>		
	Beekmantown	El Paso limestone 400±	Light-gray slabby limestone with some cherty and dolomitic beds. Reddish-brown patches on bedding planes.
<i>Unconformity</i>			
CAMBRIAN		Bliss sandstone 160±	Gray to brown quartzitic massive sandstone with interbedded slabby sandstone and sandy glauconitic shale. Limy near the top.
<i>Unconformity</i>			
PRE-CAMBRIAN		Granite	Pinkish massive granite with subordinate darker varieties, gneissic granite, and diorite.

^a Modified from N. H. Darton's columnar section for the Deming quadrangle, U. S. Geol. Survey Geol. Atlas, Deming folio (no. 207), p. 3, 1917.

The rocks in Fluorite Ridge have been extensively faulted, especially at the southeastern end of the ridge. Arching of the strata was produced primarily by intrusion of the monzonite porphyry. On the southeast end Paleozoic rocks, which strike east and dip 80° N., are discordantly overlain by younger rocks—a condition that probably reflects deformation during pre-Cretaceous time. These rocks are cut by a fault of considerable magnitude that strikes N. 0°-20° E. and dips 65° E., bringing the monzonite porphyry into contact with the Paleozoic rocks (Plate



EXPLANATION		
SEDIMENTARY ROCKS		
Qab	Alluvium and bolson deposits	QUATERNARY
Tcl	Clastic rocks (arkosic conglomerate, sandstone and siltstone, and thin argillaceous limestone)	TERTIARY
PAL	Limestone, shale, and quartzite	PALEOZOIC
IGNEOUS ROCKS		
Basalt (dikes)		QUATERNARY
Tag	Andesite agglomerate	TERTIARY
Tnp	Monzonite porphyry	
	Fluorspar vein	
	Quartz veins and irregular quartzose masses	
	Fault, showing direction of dip	
	Concealed fault	
	Strike and dip of strata	
	Shaft	

Base and topography by R. G. Smalley, 1943

Geology by H. E. Rothrock, R. H. Earhart, and J. K. Grunig, 1943-44

Geologic map showing fluorspar deposits at the southeast end of Fluorite Ridge, Luna County

15). The Tertiary rocks east of this fault are cut by numerous faults, which so far as could be determined are normal. Their strike ranges from N. 28° E. to N. 17° W. Many of them contain fluorspar.

All the deposits in Fluorite Ridge are fissure veins except those of the Tip Top and Hilltop Spar prospects, which are fillings in solution cavities in limestone. Mining has been confined to the fissure veins, which occupy faults and fractures and are richest near the intersections of these structures or in areas of great pre-mineral brecciation. The wall rocks include monzonite porphyry, the basalt that cuts it, and the younger eruptive agglomerate. The fluorspar varies considerably in appearance and grade. Much of it is high-grade green transparent coarsely crystalline ore that can be sold as metallurgical-grade fluorspar after simple hand-sorting. The remainder is, white, green, or red, transparent to opaque, and coarse- to fine-grained. Quartz, in small drusy or acicular crystals and in cryptocrystalline masses, is the only conspicuous gangue mineral; other diluents of the veins are inclusions of wall rock and some clay from altered gouge.

SADLER MINE

All the southeast group of deposits (Table 29) except the Hilltop Spar are near the base of the ridge and are reached by the access road from State Highway 26.

The Sadler mine, on the Susan No. 1 claim, is the oldest fluorspar mine in the Fluorite Ridge area. It was opened by the American Fireman's Mining Company in the summer of 1909,²⁷ and since then has been operated intermittently by G. M. Sadler, Hayner and Manassee, La Purissima Fluorspar Company, and the General Chemical Company, which acquired it in 1942.

The mine workings consist of trenches, pits, shafts, stopes, and levels made in a group of fluorspar veins that crop out on the southeastern end of Fluorite Ridge. The principal workings are on the two most easterly veins of the group. In the fall of 1943 exploratory levels had been made at depths as great as 180 feet. Mining was done from two shafts. Shaft No. 1 is on a sinuous vein that strikes N. 25° E. and is called No. 1 vein; and shaft No. 2 is 115 feet to the east, on a cross vein called No. 2 vein.

Prior to its acquisition by the General Chemical Company, the Sadler mine had yielded about 32,000 tons of ore,²⁸ virtually all of which was sold as metallurgical-grade fluorspar.

²⁷ Darton, N. H., and Burchard, E. F., Fluorspar near Deming, New Mexico : U. S. Geol. Survey Bull. 470, p. 540, 1911.

²⁸ Data from Mineral Yearbooks, U. S. Department of the Interior, Bureau of Mines, for the period 1909 to 1938.

All the veins are in monzonite porphyry except one at the faulted contact of the porphyry and the Paleozoic rocks. The veins occur along faults of both large and small displacement and in fractures along which no displacement is apparent. The general trend of the faults is N. 35° E. and the dip is about 70° SE. Striations indicate both horizontal and vertical movement, and chatter marks and plucked and bruised surfaces on the slickensides suggest that some of the faulting was normal. The movements formed brecciated masses and closely spaced sub-parallel fractures, in which the first stage of deposition formed veins of high-grade fluorspar. Recurrent movement shattered these veins, but a later stage of deposition recemented them with fluorite and in some places with considerable quartz. Part of this later movement was across the vein system and it offset segments several feet.

By the fall of 1943 No. 1 vein had been stoped both southwest and northeast of shaft No. 1. The southwest stope is 65 feet long at the surface, 90 feet long on the 100-foot level, and approximately 90 feet long on the 160-foot level. The southwest face of the stope contains a cross fault that offsets the vein 7 or more feet to the northwest. The northeast stope is about 30 feet long and extends from the surface to the 100-foot level. The average width of these stopes is estimated to be about 5 feet. The ore taken from them generally occurs in from one to three veins whose aggregate thickness ranges from 2 to 20 feet.²⁹

Developmental and exploratory workings extend beyond the stopes. Southwest of shaft No. 1 the drift from the stope on the 100-foot level follows the drag of the faulted vein westward about 10 feet and thence southwestward for about 45 feet along a shattered vein approximately 3 feet thick. On the 160-foot level the vein was followed to a point 140 feet southwest of the shaft, where a cross fault was encountered. Vein widths in this drift range from 1.5 to 5 feet, and the estimated content of CaF₂ from 50 to 70 percent. The vein is also present on the 180-foot sub-level, where it is 3 feet wide at a point 45 feet southwest of the shaft.

Northeast of shaft No. 1 and the end of the stope, a shallow cut 50 feet long exposes low-grade vein material. The cut contains a shaft about 20 feet deep, inaccessible when visited, which ends at a cross fault. On the 100-foot level northeast of the stope a drift extends for about 40 feet in ore of marginal grade, 3 to 4 feet thick. The face of the drift is in a cross fault.

The workings in No. 1 vein indicate that the ore body rakes southwest and suggest that the bottom and southwest limits of ore have not been reached.

²⁹ Johnston, W. D., Jr., Fluorspar in New Mexico : N. M. School of Mines, State Bur. Mines and Min. Res. Bull 4, p. 95, 1928.

About 150 feet northeast of shaft No. 1 a vein, thought to be vein No. 2, joins vein No. 1. The junction is exposed in a deep Y-shaped trench which contains only narrow fluorspar veins.

The No. 2 vein follows an irregular course north and southwest of shaft No. 2 but cannot be traced continuously on the surface. At the 110-foot level a drift follows the vein about 100 feet in a direction S. 10° W. from the shaft and then splits to follow a footwall and a hanging-wall vein, each about 3 feet thick. Much of the ore above this drift has been mined. Near the middle of the drift a winze descends on the vein to the 170-foot level, and a crosscut connects the bottom of the winze with the 180-foot level of vein No. 1. Northward from shaft No. 2 on the 110-foot level a curved drift follows the vein for about 100 feet and exposes ore 4 to 5 feet thick, which is estimated to contain 50 percent CaF_2 . The direction and position of the end of this drift indicate that the ore in it connects with that in the intersecting veins north of shaft No. 1.

Several pits and trenches farther up the hill from shaft No. 1 expose fluorspar veins from, 1 to 6 feet thick, but their relations are obscure and their continuity is not demonstrated. A large burrow was made at the contact of the monzonite porphyry and the Paleozoic rocks west of shaft No. 1. There fluorspar is exposed in veins, stringers, pods, and brecciated bodies that are too small to invite further work.

The vein material is composed of coarsely crystalline fluorite and quartz. The fluorite is generally aquamarine, but in crushed zones it is white, and where associated with ferruginous silica it is purple or red. The quartz forms drusy coatings, acicular veinlet-fillings, and red or brown cryptocrystalline growths in breccia and cavities. The cavities in places contain abundant cubes and pyritohedra of pyrite. All the varieties of quartz were deposited after the main period of fluorite deposition.

Hand-sorted ore from the upper workings contained 90 percent CaF_2 .³⁰ The veins in the lower workings average considerably less, the estimated CaF_2 content ranging from 50 to 70 percent.

GREENLEAF MINE

The Greenleaf mine is on the flats at the southeast end of Fluorite Ridge, 2,000 feet S. 60° E. from the Sadler mine (Plate 15). The deposit was first worked in 1939 by W. D. Howard of Deming, but from 1940 to the fall of 1944 it was operated by D. F. McCabe of Lordsburg, and since then for a short period by E. J. Marston of Colorado Springs, Colorado.

The data regarding the mine workings have been taken from the field notes and maps of James K. Grunig of the Federal

³⁰Darton, N. H., and Burchard, E. F., op. cit., p. 544.

Geological Survey. D. F. McCabe, Hiram. Harrison, and John Harrison also furnished much information.

Tertiary clastic rocks crop out at the mine, but bolson deposits overlap the extensions of the veins. Two isolated masses of cryptocrystalline quartz, shown on Plate 15, form prominent mounds a few feet northwest of the mine. Although the upper workings of the mine are in the clastic rocks, most of the underground workings are in monzonite porphyry, the top of which is at a depth of about 25 feet from the surface on the west side of the vein system and 190 feet on the east side.

The mine is in a major zone consisting of closely spaced intersecting normal faults and fractures ; this zone has a maximum width of 40 feet and a length of about 400 feet. It trends about N. 20° E. The faults constituting it may be grouped in three minor zones, differentiated by their strikes. Numbers are arbitrarily assigned to them and the veins that they contain. Zone No. 1 strikes generally N. 30° E. (range, N. 10°-45° E.) ; it is cut by zone No. 2, which strikes generally N. 10° E. (range, N. 0°-30° E.). The intersection of these two fault zones is in the shaft at the surface, 30 feet north of the shaft at the 167-foot level, 80 feet north at the 190-foot level, and 65 feet north at the 350-foot level. Trenching by the Federal Bureau of Mines, and underground mapping by the Geological Survey, revealed a third zone of faults that strikes about N. 10° W. (range, N. 0°-30° W.) and cuts both the other zones. The downthrow along zone No. 3 is on the north and is about 45 feet. Underground this zone is much warped and appears to be represented by faults that strike N. 9°-26° W. at the 213-foot level, N. 1°-13° W. at the 260-foot level, and N. 18°-29° W. at the 350-foot level at distances of 120 feet, 130 feet, and 140 feet, respectively, northeast of the shaft. North of No. 3 fault zone on the 350-foot level two sub-parallel veins are probably segments of the Nos. 1 and 2 veins that have been offset eastward about 15 feet. The general dip of all the faults is 70°-80° E., but irregularities cause the dip to deviate from, these figures by several degrees ; in some places the faults even dip steeply to the west. Although these faults intersect one another, it is probable that they were formed almost contemporaneously and were modified by later stresses. The fault relations described above were established before the first period of fluorspar deposition, but faulting continued during and after deposition. The resultant of these movements is a throw of 165 feet, as shown by the position of the contact between the clastic rocks and the monzonite porphyry on opposite sides of the major fault zone.

Brecciated masses are common within the major fault zone. Some, the product of the original faulting, were replaced and

cemented during early periods of fluorite deposition. Others were formed after the first fluorspar veins had been deposited, and were recemented by later fluorite and quartz.

The dimensions of the ore bodies cannot be determined accurately, because many of the stopes have been filled with waste and others are inaccessible. Detailed mapping, however, shows that the fluorspar ore forms irregularly shaped tabular bodies and shoots having an average length of 60 to 100 feet. The average thickness of the ore bodies is 5 to 6 feet, but several are 15 feet thick ; a maximum thickness of 30 feet is reached in the stope south of the shaft on the 213-foot level.³¹ The weighted-average thickness of the ore remaining in the stopes in the summer of 1944 was 3.5 feet, and that in the floor of the 350-foot level was 5 feet. The depth to which the ore bodies extend varies. No. 1 vein pinches at the 40-foot level, but was mined again between the 113- and 192-foot levels and between the 170- and 250-foot levels. No. 2 vein was mined continuously from the surface to the 350-foot level, but the ore bodies were in small shoots above the 167-foot level and in tabular form below.

The ore bodies contain many narrow parts that are left as pillars. It is estimated that these constitute as much as 60 percent of the vein above the 167-foot level, but a much lower percentage in the lower workings. This estimate is corroborated by production figures furnished by D. F. McCabe, who states that about two-thirds of the fluorspar from the mine, mostly of high grade, was taken from below the 200-foot level. Since these levels are close to the lower contact of the clastic rocks with the monzonite porphyry, the difference in size of the ore bodies and in the composition of the ore above and below these levels is believed to be related to the difference in the character of the rocks on either side of the contact. The clastic rocks supplied poorer receptacles for the deposition of the fluorite, probably because they tend to pulverize and to break unevenly, providing channels that are less permeable than those in the more homogeneous and competent igneous rock. Furthermore, the greater amount of silica in the sedimentary rocks tends to make the breccia and gouge formed from them less susceptible to replacement than the feldspar-rich products of faulting in the porphyry. Other evidence in favor of lithologic control of fluorite deposition is the fact that the richest of the other mines in this locality, the Sadler mine, is entirely within the monzonite porphyry, whereas two smaller deposits, the Lucky mine and the Greenleaf No. 4 prospect, are entirely within the Tertiary clastic rocks.

The ore is aquamarine coarsely crystalline fluorite with a small percentage of tiny included quartz crystals and interstitial

³¹ Oral communication from Hiram Harrison.

quartz. Some of the fluorite was formed in open spaces and has euhedral crystals terminating in purple bands. This type of ore can be mined and sorted to yield a very high-grade product. A red and green mottled brecciated ore is prominent at the intersections of faults. It was formed by the brecciation of a coarsely crystalline vein, followed by cementation of the mass by fine-grained fluorite and cryptocrystalline red and brown quartz or jasper.

Accurate figures regarding the total yield of the mine are not available, but reliable estimates set the production at about 20,000 tons of ore up to the end of 1942. Of this amount approximately 18,000 tons of milling grade and 9,900 tons of metallurgical grade were sold during 1940-1944.³²

Mining methods at the Greenleaf mine are described on pages 201-202.

SAN JUAN MINE

The San Juan mine, owned in 1943 by D. F. McCabe, is situated at the base of Fluorite Ridge about 800 feet east of the Sadler mine (Plate 15). In 1944 the workings consisted of No. 1 shaft, 260 feet deep, near the south end of the deposit ; No. 2 shaft, 620 feet north of No. 1; and at least 24 other excavations, including four pits from 20 to 50 feet deep and shallow cuts and trenches. The underground workings were not studied.

The workings are within the monzonite porphyry except in the northern end a short distance below the surface, where conglomerate forms the east wall of the principal veins. Some of the prospects east of the mine are entirely within the conglomerate. The deposit comprises two veins 50 to 90 feet apart: a west vein that strikes N. 10° W. and dips 65° E., and an east vein that strikes N. 12°-15° W. and dips 65°-85° E. Both shafts are on the west vein. Several small veins trending northeast branch from these two. In addition to the fluorspar veins there are numerous quartz veins that strike in various directions. One of them parallels the north end of the west vein for about 250 feet ; in the north central part of the claim the two veins merge and continue as a quartz vein for at least 200 feet farther. Some of these quartz veins contain barite, which was deposited before the quartz, but barite was not found in the fluorspar veins.

The fluorspar is in narrow veins, small pods, and stringers in fault breccias and fissures. The distance between the walls of the breccias is as great as 7 feet, but the fluorspar commonly occupies only a small fraction of this space. The mineralized zone is composed of medium- to coarse-grained aquamarine or white fluorite with penetrating veinlets of finely crystalline quartz and coatings of acicular quartz around some of the frag-

³² Data supplied by D. F. McCabe.

ments of rock included in the fluorspar. As most of the work on this deposit has been exploratory or for development, only a small tonnage of ore has been marketed.

GREENLEAF NO. 4 PROSPECT

In the fall of 1942 the Western Mining Corporation sank a shaft on the Greenleaf No. 4 claim, 550 feet southeast of the Greenleaf mine, to an approximate depth of 40 feet (Plate 15). It is entirely in fine-grained Tertiary sandstone and conglomerate. These rocks here dip 5°-10° eastward and are cut by a fault that strikes N. 14° E. and dips 65° W. Within a brecciated zone 1 to 2 feet wide along the fault, stringers and lenses of crystalline fluorspar range from a fraction of an inch to several inches in thickness. The dip of the vein is opposite to that of most of the other veins in this area, but the fault on which the vein occurs is one of the longer dislocations in the area. It can be seen in a shallow pit about 200 feet to the north and again in a small cut 1,150 feet N. 17° E. from the shaft, where there is a similar exposure of fluorspar. One hundred feet northward from this cut the fault offsets a basalt dike for at least 95 feet.

LUCKY MINE

The Lucky mine is in the foothills of Fluorite Ridge, 2,100 feet north-northwest of the Greenleaf mine (Plate 15). A small amount of prospecting was done on it prior to 1910,³³ but most of the ore from the mine has come from a cross vein opened during or shortly after World War I.³⁴ By 1928 this vein had been stoped for a distance of 75 feet and to a depth of 50 feet,³⁵ and a shaft had been sunk to a depth of 90 feet. From this shaft several stopes 20 to 40 feet long explored the vein north and south of the shaft. In 1942 the property was acquired by the Western Mining Corporation, which extended the shaft to a depth of 310 feet, excavated drifts 120 feet long on the 174-foot level (vertical distance) and 210 feet long on the 253-foot level, and did a small amount of stoping before abandoning the property in December 1943.

All the workings of the mine are in conglomerates and feldspathic siltstones of Tertiary age. These strata wedge out to the west on the slope of the hill that rises sharply from the mine shaft. The greater part of the hill is monzonite porphyry, but it is capped by a quartzose mass that is probably a silicified sedimentary rock.

³³ Darton, N. H., and Burchard, E. F., Fluorspar near Deming, New Mexico: U. S. Geol. Survey Bull. 470, pp. 535-536, 1911.

³⁴ Oral communication from W. C. Siebring, Deming.

³⁵ Johnston, W. D., Jr., op. cit., p. 97, 1928.

The deposit is at the intersections of three faults that form an acute triangle 400 feet in maximum dimension. The triangle is bounded on the east by a fault striking irregularly north and dipping 65° E., on the west by a fault striking N. 9° E. and dipping 60° E., and on the south by a short cross fault striking N. 30° E. Striations on the west fault pitch southward 60°. The main shaft is at the intersection of the west fault and the cross fault.

Fluorspar occurs in sinuous veins and isolated pods in the brecciated fault zones, which range from 4 to 12 feet in width. The stopes on the cross fault were filled at the time of examination, but Johnston³⁶ reports that the ore body in the cross fault includes a vein 2½ feet thick and two parallel veins 1 foot or slightly less in thickness. Small stopes along the shaft to a depth of 90 feet contain veins that range from a few inches to 24 inches in thickness and are wider in the upper levels than in the lower ones. The drifts at the 174- and 210-foot levels contain no ore south of the shaft, but narrow veins are exposed in the north workings. On the 174-foot level a part of the vein from 20 to 30 feet long is 4 feet thick. On the 210-foot level the vein is about 100 feet long and ranges in thickness from 3 to 30 inches. One or two carloads of metallurgical-grade ore were sorted from a small stope on this vein, and some milling ore was sold to the General Chemical Company's mill at Deming.

A shaft about 40 feet deep was dug during the early years of development at the intersection of the east and west veins in the north end of the deposit. It was inaccessible when visited, but ore in the pillars near the surface appeared to be as much as 14 inches wide.

Fluorspar in the Lucky mine is coarse-grained, white or light green, and semi-transparent. In the upper levels weathering of the brecciated zone has reduced the vein to a crumbly rubble resembling the "gravel spar" of the Kentucky-Illinois fluorspar deposits.

HILLTOP SPAR PROSPECT

The Hilltop Spar prospect is 900 feet northwest of the Sadler mine, near the crest of a hill formed by Paleozoic rocks (Plate 15). When visited by J. K. Grunig in 1944 there was neither road nor trail to it. Ownership was claimed by W. B. Clary of Deming. The workings consisted of a shaft 16 feet deep and shallow cuts in the hillside.

The fluorspar occurs in many small bodies and stringers scattered through a cherty limestone, and as cavity fillings in boxwork with quartz walls. The shaft is along the strike of a series of these fluorspar bodies that can be traced for 70 feet.

³⁶ Idem, p. 97.

The sides of the shaft expose a zone of siliceous fluorspar ranging in width from 2 to 16 feet. Although the veinlets and small masses of fluorspar are quite pure, they are so small and irregular in distribution and the adjacent rock contains so much quartz that the prospect has not been developed further.

GRATTAN MINE

The Central group of fluorspar deposits on Fluorite Ridge (Table 29) is about 11½ miles northwest of the Southeast group; it is served by the same access road and by an old road that enters the area from the south. The earliest records show that the locality was prospected prior to 1910 by G. M. Sadler.³⁷ From 1934 to 1944 P. L. Grattan of El Paso, Texas, worked the Grattan, Deckert, and Grattan State Land deposits, except for a short period in 1944 when they were controlled by the Edgar J. Marston Company.

The Grattan mine, on Spar No. 1 claim, is on the southwest side of Fluorite Ridge, about 700 feet above the bolson. The principal workings are at shaft No. 1, which in 1943 was 225 feet deep and had several levels both north and south of the shaft to a depth of about 200 feet. North of this shaft deep trenches follow the vein for about 480 feet to shaft No. 2, which was 60 feet deep.

The mine is in a basalt dike that cuts an andesitic phase of the porphyry. The dike branches and varies considerably in direction and thickness but its general trend is N. 40° W. About 270 feet above the mine is the contact of the porphyry with the sedimentary rocks into which it was intruded.

The vein is in a crooked brecciated zone that dips 80° E. and generally follows the east side of the dike. The zone is rather finely brecciated within a few feet of the east wall of the vein, but elsewhere the rock is broken by more or less vertical fractures which on the west side extend as much as 40 feet from the finely brecciated zone. The larger veins of fluorspar occur in the finely brecciated rock, and the adjoining fractured rock contains fluorspar stringers. The deposit has a vertically banded appearance caused by wide strips and irregular masses of dark rock alternating with light fluorspar veins. The veins have been considerably shattered by post-mineral movement and contain many open fractures which increase the hazard of mining.

On the surface the vein has been trenched and stoped almost continuously for 480 feet, but the lengths underground are not so great. The longest ore body underground is at the 200-foot level, where ore was mined for 120 feet north and 160 feet south of shaft No. 1. The ore shoots have an average aggregate thick-

³⁷ Darton, N. H., and Burchard, E. F., op. cit., p. 541.

ness of 2 to 4 feet. Mining operations indicate that the depth of the ore body exposed at the surface is about 100 feet, whereas that of the body mined from the 200-foot level is at least 70 feet. The vein in the bottom of the shaft at a depth of 225 feet contained only narrow stringers of fluorspar, but when the shaft was deepened to 245 feet in 1945 another body of ore $2\frac{1}{2}$ feet thick was exposed.

The vein is composed of coarsely crystalline white or light green fluorite, with intimately associated quartz that forms incrustations on vein walls and around rock fragments. The intervening spaces are filled with fluorite except for scattered vugs some of which are lined with drusy quartz. Deposition of quartz thus took place chiefly before the crystallization of the fluorite, but some quartz was formed later. The grade of the ore mined during 1942-1944 was estimated to average 50-55 percent CaF_2 and 20-25 percent SiO_2 .³⁸

When the mine was in normal operation its output ranged from 5 to 15 tons of ore daily. It is estimated that 12,000 tons of ore had been mined from this deposit by the end of 1944.

The basalt dike was an especially favorable host for the fluorspar because of the open fractures that were formed in it. The best deposits occurred where the strike of the basalt and the fault zone deviated about 30° northward from the general trend. This structural condition may be expected to continue to considerable depth, forming other receptacles favorable for the deposition of ore bodies.

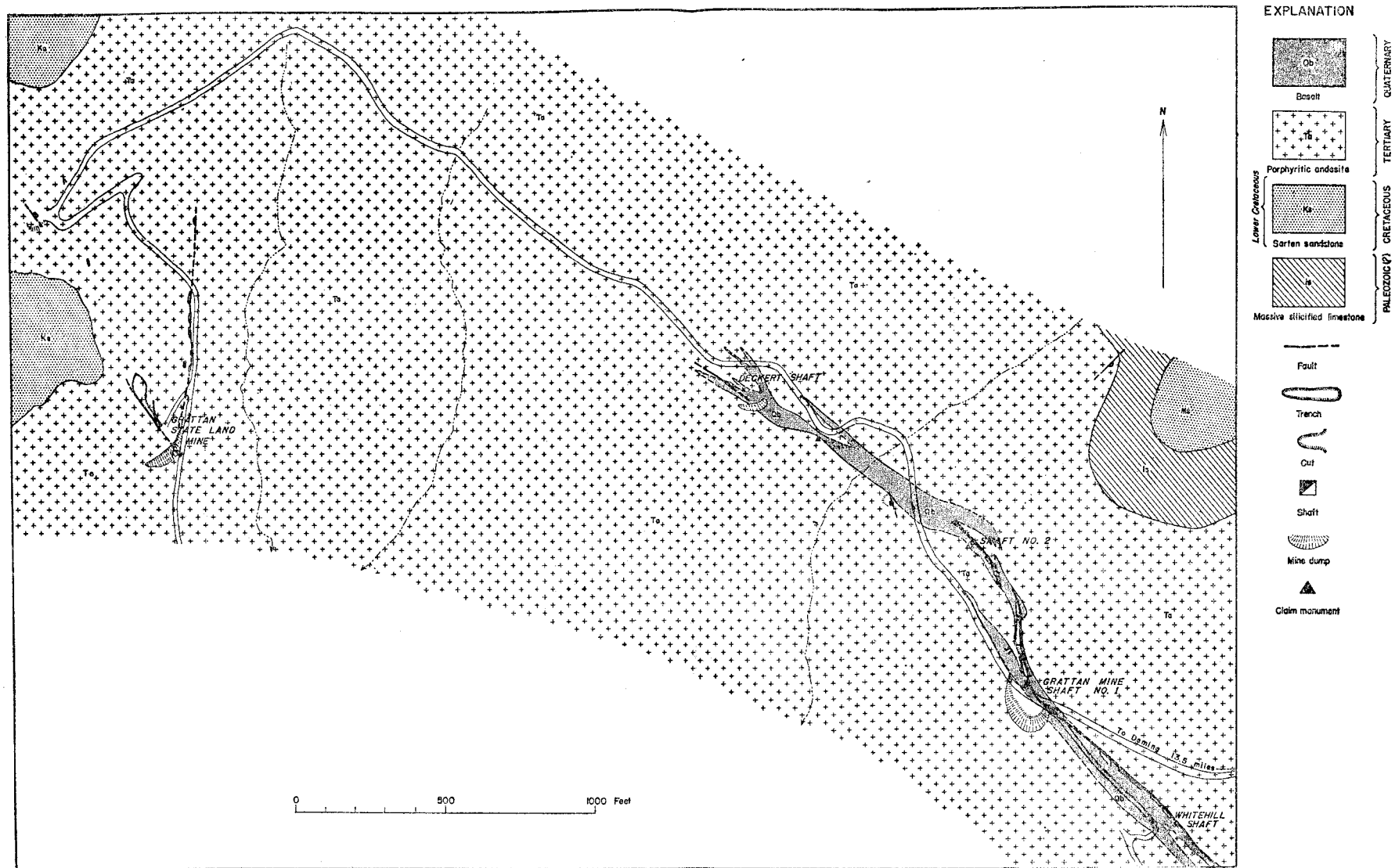
WHITEHILL PROSPECT

The vein of the Grattan mine extends southeastward for about 700 feet, following the basalt dike onto the Dorothy Bell claim, where a shaft called the Whitehill prospect has been sunk (Plate 16). Fluorspar occurs in stringers in the fractured basalt, and in only a few places has an aggregate thickness of more than 12 inches.

SPAR NO. 2 PROSPECT

There are two fluorspar prospects on Spar No. 2 claim, both on the northwest extension of the vein present in the Grattan mine. One, called the Deckert shaft, is 900 feet northwest of shaft No. 2 of the Grattan mine (Plate 16). It is about 30 feet deep and was sunk in a wide shattered zone that strikes $N. 45^\circ W.$ in basalt and porphyritic andesite. The southwest wall of the shaft is in fault gouge 18 inches thick and the remainder is in an intensely brecciated zone 6 feet wide. The breccia contains veinlets and vugs of fluorspar that constitute about 10 percent of its volume. In addition, near the southwest

³⁸Oral communication from Lynch Grattan, manager of the Grattan mines and mill.



Base from aerial photographs controlled by plane-table traverse

Geology by H. E. Rothrock, 1944

Geologic map showing fluorspar mines and prospects in the Central group, Fluorite Ridge, Luna County

wall of the breccia zone two veins of purple coarsely crystalline fluorspar range from a few inches to 12 inches in thickness.

The other opening is about 650 feet southeast of the Deckert shaft. It is in porphyry and consists of a shaft 25 feet deep and a short drift that could not be entered at the time of inspection. It was described by Johnston³⁹ as containing an ore body 3 to 5 feet wide composed of horizontal lenses of fluorspar in a matrix of clay, calcite, quartz, and chert breccia, with some basalt and porphyry in the fractured zone.

GRATTAN STATE LAND MINE

The Grattan State Land mine is about 1,700 feet west of the Deckert shaft on Greenspar No. 2 claim, leased from the State (Plate 16). It was visited in February 1944. The deposit is in porphyritic andesite from 100 to 200 feet below the contact of the andesite with the sedimentary rocks into which it was intruded. Development was begun in 1943 at the intersection of a brecciated zone striking northward with fractures striking N. 15° - 25° W. and dipping 75° - 85° W. The breccia is as much as 7½ feet wide and contains about 20 percent of interstitial fluorspar. The fractures contain solid veins of fluorspar ranging from a few inches to 3 feet in thickness. A grab sample from the bin assayed 67.5 percent CaF₂, 22.4 percent SiO₂, and 2.5 percent CaCO₃. The west wall of the cut follows the principal vein, which was mined for a distance of about 125 feet. A shaft was sunk to a depth of 50 feet and a drift driven northward from the bottom for 85 feet, but no ore bodies were found. It is doubtful that the principal vein was intersected in this drift. By the end of 1943 approximately 2,500 tons of ore had been taken from this deposit.

Northeast of the shaft are several trenches along a subsidiary vein that strikes N. 10° E. and dips 70° - 80° W. A projection of this vein would intersect the main vein about 70 feet south of the shaft in an area that was largely covered with waste at the time of the visit. The fluorspar, which occurs in fissures, is commonly less than 12 inches thick. Numerous veinlets and small lenses of fluorspar have been found on the higher slopes close to the contact of the porphyry and the overlying sedimentary rocks, but none has proved to be minable.

TIP TOP PROSPECT

The fluorspar prospects on the Tip Top claims, owned in 1943 by Mary B. Whitehill of Deming, are on the northeast, east, and south sides of the flat-topped hill that forms the crest of Fluorite Ridge. There are three openings, from 1,000 to 1,200

³⁹ Johnston, W. D., Jr., op. cit., p. 99.

feet apart and about 300 feet above the level of the access road at the Grattan mine (Figure 11) . They are reached by foot trails only.

The prospects are in vuggy solution cavities in the limestone where fluorite has been deposited. The process was chiefly one of void-filling by which thin incrustations, botryoidal masses, and rows of fluorite crystals in seams were formed. Drusy quartz then filled the interstices and replaced most of the limestone unaffected by the previous mineralization. The mineralized areas thus contain a large percentage of quartz, and the size of the fluorspar pockets is unpredictable owing to the irregularity of the cavities in which they were formed.

SANDOVAL COUNTY

Fluorspar has been reported⁴⁰ in the northern part of the Sandia Mountains, an area where difficulty of access is a serious deterrent to development. The geology of this part of the mountains is similar to that of the remainder of the range, which is described in the section on Bernalillo County, pages 36-39.

The fluorspar occurs as an abundant gangue mineral in the lead-silver-copper veins of the La Luz mine and the Montezuma prospect. The La Luz mine is about 1 mile north of South Sandia Peak in the steep escarpment that forms the west face of the Sandia Mountains. The deposit is a fissure vein 2 to 4 feet thick that strikes about N. 25° W. and dips 75° NE. The ore body is in pre-Cambrian granite close to the contact with the overlying limestone of the Magdalena group.

The Montezuma prospect is about 1 mile north of Placitas, on the west side of Montezuma Mountain near its base. The prospect has been explored for lead-copper ore that occurs in pre-Cambrian schists near their contact with sedimentary rocks.

SIERRA COUNTY

GENERAL RELATIONS

Most of the prospecting and all the mining of fluorspar in Sierra County has been in the Sierra Caballos in the southeastern part, but deposits are known in the northwestern part, in Iron Mountain and Sierra Cuchillo. The deposits in Sierra Caballos are served by U. S. Highway 85, and by the Atchison, Topeka, and Santa Fe Railway, which traverses the Jornada del Muerto east of the range (Plate 1) . The deposits on the east side of the mountains are only a few miles from the railroad. Ore from

⁴⁰ Ellis, R. W., Geology of the Sandia Mountains: N. Mex. Univ. Bull. 4 (geol. ser. 3), pp. 42-43, 1922.