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Fluorspar Deposits in the Eagle Mountains of Hudspeth County, Texas

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Studies of fluorite, or fluorspar, deposits in southwestern Hudspeth County, Texas, have been conducted recently by the Bureau of Economic Geology of The University of Texas, and deposits of important size have been revealed. This report covers the results of these studies and calls attention to the Eagle Mountains as a new district offering favorable possibilities for economic production of fluorspar.

INTRODUCTION

Fluorspar is an important industrial mineral needed in large quantities, particularly in time of war, for use in the manufacture of a number of essential products, including steel, aluminum, and high octane gasoline. The enormous expansion of industries using fluorspar, the development of new uses, and the necessary curtailment of imports, which formerly have supplied an appreciable part of the National consumption, have made an unprecedented demand on domestic supplies. New mine developments are now greatly needed to help fill the growing National requirements.

Fluorite and fluorspar are names applying to the mineral compound calcium fluoride (calcium = 51.1 per cent; fluorine = 48.9 per cent). Fluorite is the mineralogical name of the chemically pure compound, CaF, while fluorspar refers to the mineral of commerce containing varying percentages of impurities. Fluorspar has a hardness of 4 and a specific gravity of between 3.01 and 3.25. It is a transparent to translucent mineral with vitreous luster and exhibits good cleavage in all directions. Fluorspar occurs in a wide range of colors, but shades of green, purple, and yellow, as well as colorless varieties, are perhaps most common.

Distribution.—Fluorspar is widely distributed over the earth, and important deposits are known in many countries. The chief producing nations are the United States, Germany, and the United Kingdom. Most of the production in the United States has been in the Rosiclare and Cave-in-Rock districts of Illinois and Kentucky,[2] these districts constituting one of the greatest fluorspar-producing regions in the world. Substantial quantities, however, have been produced in Colorado, New Mexico, and other western states.[3] Texas deposits have been opened recently, and consequently the production to date has been small.

Production.—Production of fluorspar on a commercial scale was started in the United States about 1870, although mining had been attempted at different times in Kentucky and Illinois as early as 1835. Until 1888, when basic open-hearth steel production was begun in the United States, fluorspar was consumed mostly in the manufacture of hydrofluoric acid, glass and enamels, and the annual requirement amounted to only a few thousand tons. Since 1888 the growth of the fluorspar industry has been to a large extent a concomitant of the growth of the basic open-hearth method of steel making, in which process fluorspar serves as a flux and as an aid in the control of such objectionable elements as sulphur and phosphorous. About three-fourths of the domestic consumption of fluorspar is in the basic open-hearth steel furnaces. Smaller quantities of fluorspar are used in other metallurgical processes, such as in certain electric furnaces, in iron foundries, and in smelting ores of gold, silver, copper, lead, and zinc.

In addition to the metallurgical field, important outlets for fluorspar are found in chemical, glass, and enamel industries. Fluorspar is the basic raw material used in making hydrofluoric acid which, with its derivaties, enters importantly into various industries. One of the more important hydrofluoric acid derivaties is synthetic cryolite, used in the metallurgy of aluminum and in the manufacture of enamels and insecticides. Comparatively new developments which employ acid fluorspar are certain successful refrigerants and a process for production of high octane gasoline.

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[1]Preliminary statement issued May 4, 1943.

[2]Publications relating to these districts include the following:
Bain, H. F., Fluorspar deposits of southern Illinois: U. S. Geol. Survey Bull. 225, pp. 505-511, 1904; also printed as U. S. Geol. Survey Bull. 255, 75 pp., 1905.
Bastin, E. S., The fluorspar deposits of Hardin and Pope counties, Illinois: Illinois State Geol. Survey, Bull. 58, 116 pp., 1931.
Currier, L. W., Fluorspar deposits of Kentucky; a description and interpretation of the geologic occurrence and industrial importance of Kentucky fluorspar: Kentucky Geol. Survey, ser. 6, vol. 13, 198 pp., 1923.

[3]Allen, M. A., and Butler, G. M., Fluorspar: Univ. Arizona, Bull. 114, 19 pp., 1921.
Aurand, H. A., Fluorspar deposits of Colorado: Colorado Geol. Survey, Bull. 18, 94 pp., 1920.
Burchard, E. F., Fluorspar deposits in western United States (with discussion): Trans. Amer. Inst. Min. Met. Eng., vol. 109, pp. 370-396, 1934.
Johnston, W. D., Jr., Fluorspar in New Mexico: New Mexico Bur. Mines and Min. Res., Bull. 4, 128 pp., 1928.
See also various Annual Reports and Information Circulars of the U. S. Bureau of Mines.

Grades and treatment.—Fluorspar is marketed in four commercial grades: metallurgical, ceramic, acid, and optical. The grade is based upon mineral and chemical content and upon the particle size range of the material. A small percentage of raw fluorspar now being mined is a merchantable product, but by far the greatest amount requires some kind of finishing treatment before it can be marketed. Metallurgical grade, known as gravel fluorspar, is quantitatively by far the most important, making up about three-fourths of all the fluorspar consumed in this country, while most of the remaining consumption is of acid and ceramic grades in the order named. The grade ratios may have changed recently because of new uses for which statistics are not now available. Optical fluorspar has a very limited, although important, market.

Metallurgical-grade fluorspar is usually marketed in particle sizes passing the 1-inch square screen and retained on 20-mesh screens. The tolerance of fines, or particles passing the 20-mesh screens, is usually placed at 15 per cent. The steel trade generally requires material containing 85 percent calcium fluoride and not more than 5 per cent silica, but lower grade material is often accepted. The material must be free of or very low in such objectionable impurities as sulphides and barite, but calcium carbonate is not objectionable except as a diluent of the fluorspar. The finishing of raw fluorspar to metallurgical grade requires crushing to size, sorting, and washing. The treatment may be a simple or an elaborate operation, depending upon the character of the raw fluorspar and upon the volume being handled.

Acid-grade fluorspar generally requires a content of not less than 98 per cent calcium fluoride and not more than 1 per cent each of silica and calcium carbonate. Other impurities in any but minute quantities are highly objectionable. The acid market accepts both lump and ground material. The lump consists of heterogeneous sizes of highly pure fluorspar, usually hand sorted from lower grade material at the mines or mills. Ground fluorspar of acid grade is the refined product, by flotation or other milling, of lower grade ore.

Ceramic-grade fluorspar is marketed in medium and finely ground form. The required content of calcium fluoride, although somewhat variable in different markets, is usually 95 per cent or more. Silica is not objectionable if present in not more than 2 to 3 per cent, and calcium carbonate should be less than 1.5 per cent. Iron, sulphur, lead, and zinc are extremely objectionable impurities. Unlike metallurgical and acid grades, ceramic grade must be practically snow-white for use in both glass and enamels. All ceramic-grade fluorspar requires mill treatment to obtain the necessary chemical standard and required state of fineness.

Optical fluorspar must be in lumps or crystals large enough to allow removal of pieces of flawless mineral having a minimum diameter of one-fourth of an inch. Optical grade is usually perfectly clear but is sometimes accepted with very faint color tints. Clouded and even minutely fractured specimens are of no value optically, and consequently great care must be exercised in collecting and packing to prevent ruining the specimens. While the market for optical fluorspar is extremely small as compared to that for industrial grades, the occurrence of good optical-grade crystals is correspondingly rare. Optical fluorspar commands a high price which justifies the great care necessary in its selection and handling.[4]

EAGLE MOUNTAINS FLUORSPAR DEPOSITS

Fluorspar deposits are known in Trans-Pecos Texas in the Eagle Mountains and Quitman Mountains of Hudspeth County, in San Antonio Canyon in the Chinati Mountains in Presidio County, and have been reported in the Franklin Mountains in El Paso County near the New Mexico line. While adequate studies have not been made in the various areas, the present state of knowledge indicates that the Eagle Mountain deposits have much the best possibilities for economic development.

Location.—The Eagle Mountains lie southward from the stations of Torbert and Hot Wells on the Southern Pacific Railroad in the southeastern part of Hudspeth County, Texas. (See fig. 1.) The fluorspar deposits examined are situated along the north and northeast sides of the mountains. The three areas of this region discussed in this report are: (1) the Eagle Springs area, comprising parts of sections 8 and 9, block 68, township 9, in the vicinity of the old Eagle Springs stage stand about 4½ miles west and 1 mile south of Hot Wells; (2) the Spar Valley area, including parts of sections 35 and 36(?), block 68, township 9, located about 5 miles south and 1½ miles west of Hot Wells; and (3) the Marine ranch locality, located about 6½ miles south and slightly west of Hot Wells. All of these areas may be reached from Hot Wells over unimproved ranch roads.

Characteristics of Deposits

The actual extent of these areas is somewhat indefinite, as exploration has not advanced far enough to define the limits of the groups of deposits comprising each of the areas. The boundaries shown in figure 1 are necessarily somewhat artibrary and probably will be extended with more exploration. Except where otherwise indicated, observations appearing in this report are drawn mainly from studies in the Spar Valley area, where most detailed work has been done and which contains all or nearly all of the conditions characteristic of the entire region examined. The geological conditions found in the three areas prevail over much larger unexplored areas in the Eagle Mountains; consequently new flourspar discoveries may be expected from further investigations.

Development.—The development work to date on the fluorspar deposits has been on a small scale and of a somewhat experimental nature. The first mining operations were conducted by Mr. W. B. Melton who produced and shipped six carloads of raw fluorspar from the Spar Valley area in the period from October 1941 to April 1942. Another locality, in the Eagle Spring area, was opened during the spring of 1943, and occasional carload shipments are being made from this new development. In both operations the attempt was made to secure commercial grade material without milling or other beneficiation—a practice which in these areas does not now appear commercially feasible, except possibly on a small scale.

Geology.—The Eagle Mountains consist of a central topographically prominent mass of Tertiary extrusive and intrusive rocks, bordered by lower ridges and hogbacks of older sedimentary strata. The sediments are dominantly Lower Cretaceous limestones,

[4]For a comprehensive treatment of the fluorspar industry see: Hatmaker, Paul, and Davis, H. W., The fluorspar industry of the United States with special reference to the Illinois-Kentucky district: Illionis State Geol. Survey, Bull. 59, 128 pp., 1938.
For a short general discussion see: Burchard, E. F., Fluorspar and cryolite, *in* Industrial Minerals and Rocks, Amer. Inst. Min. Met. Eng., New York, pp. 283-302, 1937.

sandstones, and quartzites which have been intruded to varying degrees by Tertiary igneous rocks. In two or more places on the north side of the mountains, Permian limestones outcrop beneath the outer fringe of the Cretaceous, and at one locality about 3 miles south of Hot Wells station the pre-Cambrian Carrizo Mountain schists are exposed in the core of a dissected structural dome. The Cretaceous strata lie next to the central igneous mass and outcrop on all sides of the mountains except where transected, particularly on the south and southwest sides, by broad areas of late alluvium. Figure 1 shows the general outcrop relationship of the sedimentary to the igneous rocks. Alluvial valley fill and pediment remnants extend well back into the mountains along all the larger drainage courses. In general, recent dissection in the alluvium has not advanced far enough to produce new exposures except in the headward portions of the valley.

The Cretaceous strata on the north and northeast sides of the Eagle Mountains maintain a general northwest-southeast strike and dip at angles between 20° and 60° to the southwest. Local structural conditions influence marked changes in the attitude of the strata. A structural dome bordered in part by a curving hogback which forms the north side of the Spar Valley area has dips ranging from an almost westerly direction on the west side of the uplift to a southeasterly direction on the east side. Quite pronounced local variations in the strike and dip of the strata are also found in the vicinity of the Marine ranch area where dips ranging from a southwesterly to a northeasterly direction were observed.

The Tertiary igneous rocks in the Eagle Mountains range from ultra-acidic to semi-basic in composition and from glassy and aphanitic to coarse porphyritic in texture. Baker[5] states that the volcanic series in the Eagle Mountains and in other parts of Trans-Pecos Texas began with the ultra-acidic rocks, passed to less acidic, and ended with more basic rocks such as basalts. Vulcanism seems to have lasted through most of the Tertiary period. A similar sequence is reported by Jones[6] in the volcanic flows of the Davis and Barrilla Mountains. The intrusives in the fluorspar areas are of rhyolitic composition and presumably, therefore, belong to the early stages of Tertiary igneous activity. At the site of the present fluorspar workings in the Eagle Springs area, Cretaceous sediments and Tertiary rhyolites are cut by somewhat younger dikes, also of rhyolitic composition. At least two stages of intrusives also are indicated in the southeast corner of the Spar Valley area where a band of relatively dark-colored, coarse-grained porphyry forms a sharply defined contact with a lighter colored and finer textured porphyry containing inclusions of the intruded sedimentary rocks. The two different rock types are believed to represent different stages of intrusion.

Along the innermost limits of the sedimentary rocks the intrusives which entered the strata mainly in the form of sills have through forces of mechanical stress and magmatic stoping expanded locally into somewhat irregularly bulbous masses before solidification and in so doing have considerably disrupted the invaded strata. These irregular masses have formed conspicuously in the horizons occupied by limestones and shales, while the intrusives extending into the more competent quartzites tend to be more uniform in thickness and concordant to the bedding. Typical of these irregular-shaped masses is a porphyry ridge forming a divide between the prongs of Spar Creek in the Spar Valley area. This porphyry, which extends outward from the central igneous mass of the Eagle Mountains, is expanded into a relatively massive body where it has invaded a thick limestone section. Crossing the limestone horizon the porphyry passes into a predominantly quartzite section where it narrows into comparatively uniform sills. The ridge formed by the porphyry within the horizon formerly occupied by limestone is similar in its alignment and slope profile to the hogbacks formed by sedimentary rocks in the vicinity. This conformity to the general structural pattern suggests that even the expanded portion has a general sill-like form.

In some places large segments of limestone beds appear to have been dislocated and partially or completely engulfed within the intrustives. Since the larger segments maintain strikes and dips similar to non-intruded strata of the vicinity, they probably have not been moved greatly from their original position. Smaller blocks and fragments of limestone and other rocks are locally very abundant as inclusions in the porphyries. Over much of the above described porphyry ridge and in other exposures in Spar Valley area, a peculiarly pitted weathering surface has developed due to partial removal by solution of imbedded limestone fragments accumulated by stoping but never assimilated in the magma.

Faulting and fracturing.—A persistent fracture system may be noted everywhere in the contact area on the north side of the Eagle Mountains. The fractures trend quite generally in a northeast-southwest direction and are often nearly parallel to the direction of dip in the sedimentary beds. These fractures cut both sedimentary and igneous rocks but are perhaps most conspicuous in the brittle quartzites. Small faults, with displacement ranging from 5 to 30 feet and striking generally parallel to the main fracture system, are found in the Spar Valley area and are probably generally present elsewhere in the mountains. The main fracture system has developed subsequent to the first rhyolite intrusives and previous to the fluorspar mineralization. That some fracturing and faulting have taken place since the flourspar mineralization, however, is shown in a silica and fluorspar-filled breccia zone on the north rim of Spar Valley which has been displaced by a small non-mineralized fault.

Origin and mineralization.—Any complete discussion of the genesis of the Eagle Mountain fluorspar deposits will involve more detailed field and laboratory studies than are possible until the deposits have been more extensively opened. The most probably source of the fluorspar is the magma from which the igneous rocks of the Eagle Mountains were derived. Fluorspar fillings in the more prominent fissues indicate that the mineralizing emanations followed these openings from the source to favorable environments of deposition. Development of the mineral deposits was probably due in part to the action of hydrofluoric acid and the volatile silicon fluoride on calcareous host rocks.

The fluorspar deposits thus far studied are related to the geologic phenomena which in the Tertiary period produced the Eagle Mountains. The mineralization occurred later than the main body of rhyolite intrusives, since fluorspar has accumulated within fractures formed in the rhyolites after their solidification. No certain evidence was found of more than one stage of mineralization. Whether the mineralization accompanied some later stage of intrusives or took place after volcanic activity had ceased has not been

[5]Baker, C. L., Exploratory geology of a part of southwestern Trans-Pecos Texas: Univ. Texas Bull. 2745, p. 34, 1927. [Note: The map accompanying this bulletin shows the principal structural features and areal geology of a region including the Eagle Mountains.]

[6]Jones, C. T., Cretaceous and Eocene stratigraphy of Barilla and eastern Davis Mountains of Trans-Pecos Texas: Bull. Amer. Assoc. Petr. Geol., vol. 22, pp. 1435-1438, 1938.

determined. The strong mineralizing influence to which the region was subjected is indicated by widespread occurrences of fluorspar and by the extensive development of some of the deposits. Emplacement of fluorspar into the host rocks was both by open-space filling and by replacement. Space filling deposits are most numerous, but replacement seems to have been the more important factor in the formation of larger deposits.

Description of deposits.—The fluorspar deposits examined are of various sizes and shapes and differ in their mineralogical character. Numerous small deposits, which form fillings in minor openings within both igneous and sedimentary rocks, are found in each of the fluorspar areas and in much of the contiguous territory examined. Larger, roughly tabular-shaped deposits occur in fracture zones in the porphyries, ranging in width from a few inches to 10 or more feet and traceable for distances from a few hundred feet to more than one-fourth of a mile. These mineralized zones are usually well defined where cutting porphyries, but, with some exceptions, tend to lose their sharp linear arrangement and widen markedly upon entering the limestone horizons. The widening of the mineralized zones in the limestones may be due in part to a wider distribution of the fractures in the less competent limestones and in part to replacement of fracture walls. The most important fluorspar accumulations noted were formed in fractured Cretaceous limestone in near contact with fairly large intrusive bodies. Since the intrusives antedate much or all of the mineralization, the proximity of the deposits to igneous bodies may be due mainly to fracturing of the contacting limestones, thus rendering them more susceptible to mineralization, to which the stresses accompanying the intrusives must have contributed. Minerals associated with the fluorspar in varying proportions are silica, calcium carbonate, and iron oxide. The silica is usually dense, non-crystalline material, but in the porphyries it also occurs as drusy quartz. Calcium carbonate occurs both as calcite and as amorphous caliche. Iron oxide occurs as thin crusts on crystals and in cracks and also as loose earthy material generally distributed in the deposit. Silica seems to be present in all of the porphyry deposits and is common at least locally in most of the limestone deposits, calcium carbonate is most abundant in the limestone deposits, and iron oxide is present in all types of deposits.

Fluorspar deposits in limestone horizons, particularly those consisting mainly of high grade and non-siliceous material, characteristically form poor exposures. The fractured and weakly resistant character of the fluorspar permits rapid erosion into low troughs which become mantled with residuum and talus. The deposit and portions of deposits which contain a large percentage of silica are relatively resistant and can usually be located by outcropping boulders and ridges. The criteria which were found to be most useful in recognizing concealed and partly concealed deposits include: (1) low weathering fracture zones; (2) the presence of outcropping siliceous boulders or beds with or without contained fluorspar; (3) the presence of caliche, soft decomposed limestone and calcite; (4) the presence of iron oxide stains in the overlying residuum and soil; and (5) the presence of fluorspar float in the mantle and in down-slope debris. Part or all of these conditions can be found at the surface over each of the deposits which have been proven in the various test trenches. Obviously these criteria would not be applicable to deposits covered by thick talus or alluvium, a condition often encountered, particularly in the lower Spar Valley area and in the wide alluviated valley extending from Spar Valley area to the Marine ranch area. Any exploration of such covered places can be accomplished only by excavation or by core drilling.

Eagle Springs Area

Fluorspar deposits are found in the Eagle Springs area in several southwest-trending veins varying in thickness from a few inches to 3 or 4 feet. At the site of the present workings, about one-fourth of a mile southwest of the old Eagle Springs stage stand, a steeply dipping, tabular-shaped fluorspar body up to 3.5 feet thick lies adjacent to a fine-grained rhyolitic dike which cuts both Cretaceous limestones and older Tertiary igneous rocks. The ore body being mined is traceable for only a short distance on the surface, and at the time of examination, excavations had not been carried deep enough to reveal much of the subsurface character and extent of the deposit.

The first two carloads of fluorspar shipped from the Eagle Springs workings are reported to have contained between 80 and 85 per cent calcium fluorid with most of the remainder being calcium carbonate. The shipped fluorspar was sorted from inferior grade material but was not washed or given any other finishing treatment. Exposures in other parts of the area contain fluorspar which appears comparable in grade to that being mined. Highly siliceous ores which occur rather commonly in other areas were not observed in the Eagle Springs area. Crusts of calamine (zinc carbonate) were found on the hanging wall of one of the small mine tunnels and at other places in the area disassociated from fluorspar. While the zinc carbonate does not seem to be intermixed with the fluorspar at the present shallow working level, its presence suggests the possibility of contaminated ores at greater depths.

Geological conditions which in other places in the Eagle Mountains were found favorable to the formation of large fluorspar deposits are present in the Eagle Springs area. This fact, together with the known occurrence of several mineralized veins and the comparative high grade of the ore, should offer strong inducement for much more thorough prospecting than has yet been done in the area.

Spar Valley Area

The most extensive fluorspar deposits examined in the Eagle Mountain district are in the Spar Valley area. The fact that most fluorspar can be seen in this area, however, is due in part to the several excavations made during the course of former prospecting and development which reveal details of the deposits impossible to see in the very poor natural exposures. Four or more localities in the area contain fluorspar bodies offering good possibilities for commercial developments. The most important of these are known as Main locality and Red Pit locality.

Main locality.—The Main locality is in a mineralized fracture zone or zones in a limestone section on the northeast slope of the divide between the two prongs of Spar Creek. The locality encloses a group of three prospect excavations shown in the central part of figures 2 and 3. The central excavation consists of an open pit 20 by 30 feet in area, from the floor of which a shaft has been sunk to an additional 22 feet, and an inclined tunnel has been driven about 20 feet inward from the southwest pit wall. The maximum exposed depth in combined pit and shaft is approximately 33 feet, while a total width and length of 20 and 50 feet have been exposed. Fluorspar is found to the lowest level and to the horizontal limits of the excavations. The prospects northwest and southeast of the central excavation are only 4 or 5 feet deep; both expose fluorspar beneath barren surface material. The excavations and small natural exposures between and beyond the pits indicate the areal extent of the deposit to be between 30,000 and 40,000 square feet. However, much of the deposit is obscured by talus, and accurate determinations must await more extensive trenching.

The details of the deposit can be satisfactorily examined only in the central excavation. The portion of the deposit seen in this excavation consists of fluorspar of varying texture and degrees of purity, with some bodies of barren or only weakly mineralized rock material. Some high-grade, coarsely crystalline fluorspar occurs in nearly vertical veins, but the greater part of the deposit consists of finer crystalline and granular material in irregular form and in imperfect bedded arrangement. Fine-grained gouge or kaolinized rock forms a part of the west wall of the inclined tunnel and is seen in thin streaks within the shaft. Lenses or pockets of laminated sands and pebbles are exposed at several places within the excavation. These sand lenses appear to have accumulated in post-mineral solution cavities and suggest that the deposit may have been to some extent impoverished by the solvent action of surface waters. Segments of unreplaced limestone beds are exposed in the shaft walls. The percentage of waste, barren, and weakly mineralized rock is estimated at between 20 and 30 per cent of the portion of the deposit now exposed. This estimate excludes the uppermost 1 to 5 feet of rock waste which covers the deposit.

Although fluorspar of all grades is present in the Main locality, the average quality is best indicated by the shipping returns of five carloads produced from the central excavations. The average calcium fluoride content of the individual cars shipped varied from 62.47 to 69.03 per cent, while the five-car average was 66.1 per cent. The shipped material had been to some extent sorted from lower grade material; consequently an average for the entire excavated area would be somewhat lower than the above figure, probably near 50 per cent calcium fluoride. Material of this grade includes an estimated 70 to 80 per cent of the total part of the deposit now open to examination. Calcium carbonate, silica, and a small percentage of iron oxide constitute the gangue of the raw fluorspar.

The total quantity of crude fluorspar in the Main locality is evidently very large, but no accurate tonnage estimates can be made on the basis of present knowledge. The areal extent of the deposit is imperfectly known, the percentage of barren rock in the deposit is known only from the comparatively limited central excavation, and no data whatever are available on the subsurface shape and dimensions. While final determination of the subsurface details of the deposit and the available tonnages can be made only with the aid of trenching and core drilling or shaft sinking, the quantity of fluorspar now know is sufficient to justify mining operations.

The most probably interpretation of the attitude of the fluorspar bodies which can be made at the present stage of knowledge is that some of the bodies dip in conformity to the structure of the replaced limestone beds following along the zone of fracturing, while other bodies of space filling occurrence follow the nearly vertical veins downward through, and possibly beyond, the limits of the limestone section. Evidence of selectivity in replacement of certain limestone beds is seen in the central excavation and in other localities; consequently mineral concentrations may occur at more than one horizon. An ideal program of prospecting the locality would include both excavating and core drilling. Excavations such as shafts, trenches, or tunnels would be most important, since the method permits actual following and examination of the ore bodies whatever vagaries of form they may assume. Core testing has obvious advantages in that it permits a much more rapid check of suspected subsurface conditions, particularly when at considerable depth. Core tests would be especially desirable in the fracture zone extending southwest from the central pit (paralleling the small fault shown in fig. 3).

Red Pit locality.—The Red Pit locality lies on the southeast side of Little Spar Creek and includes the two prospect pits about 500 feet apart shown in figure 3. These pits, which mark the extreme north and south limits of exposed fluorspar, are the only excavations yet made at the locality. The intervening area includes ridges of steeply dipping non-mineralized limestones, ridges and boulders of hard brown siliceous material containing fluorspar, and low-weathering zones covered in part by caliche and containing occasional fragments of fluorspar. A belt of alluvium up to 35 feet thick separates the limestone and fluorspar exposures of the Red Pit locality from the equivalent horizon exposed in the Main locality. Quite probably some fluorspar deposits are present beneath the alluvium.

The south excavation at the Red Pit locality exposes only a small area in a fluorspar deposit of unknown size. Some outcropping limestones adjacent to the pit show partial replacement by both silica and fluorspar which grade outward into the limestone from bedding planes and fracture openings. Within the pit, and in some limited exposures eastward along the strike of the beds, more complete replacement is noted. The deposit is delimited by barren limestone and porphyry a short distance up-slope from the pit, while talus obscures the underlying section. It is believed that the deposit represents irregular mineralization within a favorable horizon of the limestone section. Shallow trenches transverse to the strike of the strata would suffice to test this deposit.

The excavation known as Red Pit is irregularly circular in plan and extends to an overall depth of about 12 feet. The fluorspar revealed is granular and in small crystals rather intimately intermixed in a fine-grained siliceous groundmass. The fluorspar rock is in massive dislocated blocks overlain, and in part surrounded, by unconsolidated reddish-brown surface materials. The areal extent of the deposit is indicated by outcroppings and float of siliceous fluorspar which are found over several thousand square feet in the immediate vicinity of the pit. The deposit appears to terminate eastward against a fault which brings quartzites and igneous sills contiguous to the fluorspar. A trench leading northward from the pit exposes blocks of unreplaced limestone containing only minor veinlets and crusts of fluorspar. Similar unreplaced limestones outcrop in a low ridge a short distance west of the pit. Whether the barren limestone blocks and segments of beds represent the limits of the deposit or are only horses within a larger mineralized zone cannot be determined from surface indications. At other places in the locality, outcrops and float of siliceous fluorspar cover areas comparable to that surrounding the Red Pit. It seems probable that connections between the deposits will be only in the form of mineralized fractures.

The grade of the visible fluorspar in the Red Pit locality is not as high as in most of the other localities examined. One carload shipment from the Red Pit is reported to have contained 50.22 per cent calcium fluoride. The shipped material may be fairly representative of the surface and near-surface portions of the deposits over the locality. Since the highly siliceous fluorspar is more resistant than higher grade or calcareous-bonded material to both mechanical and chemical weathering, it seems possible that better grades will be found below the level of extensive surface weathering. Further testing at the locality by subsurface methods is amply justified by present indications.

Other deposits.—Additional fluorspar deposits occur along fracture and breccia zones trending generally northeast from the west-central to the north-central part of the Spar Valley area. These deposits are partially exposed in some small prospect pits, the location of which is shown in figure 3. While none of these deposits now appear to be as extensive as either the Main locality or the Red Pit locality, concentrations amounting to considerable tonnages are indicated at two or more places. The two pits in the western end of the area and on the southwest side of Little Spar Creek expose fluorspar within a section of broken and intruded limestone strata. The fluorspar represents both space filling and replacement modes of origin and is associated with varying amounts of calcite. Very little silica was observed at this locality. The extent of the deposit is unknown, but imperfect exposures indicate that mineralization may reach an average width of 25 feet over a length of 200 feet or more.

An interesting development of fluorspar is found within a fracture zone at the crest of a porphyry ridge some 500 feet northeast from the locality discussed in the preceding paragraph. This mineral body is of irregular thickness, reaching 10 feet or more at the crest of the ridge and pinching in both directions along the fracture. The deposit is bounded on the southeast side by a wall defined hanging wall. Much of the fluorspar, unlike most deposits within the porphyries, appears to be of a quality suitable for milling. The gangue or waste consists primarily of fragments and horses of porphyry and a small percentage of iron oxide. Both silica and calcium carbonate appear to be present only in subordinate quantities. There is a possibility that the wider outcrop of fluorspar may represent a portion of an ore shoot of workable dimensions.

Fluorspar deposits outcrop in two known places north of Spar Creek. One of these deposits is along the northwest edge of a limestone remnant at its contact with a porphyry dike or sill about midway up the north slope of Spar Creek valley. Fluorspar forms poor outcrops over a distance of 40 to 50 feet, while loose pieces or float are present in talus over a much larger area. Due to the lack of good exposures in the vicinity, the relationship of the mineralized limestone to the porphyry body on its northwest contact could not be accurately determined. If the porphyry has the form of a sill the fluorspar-bearing limestone may pass westward beneath it. A slickensided and tightly closed plane of movement, traceable to a point about 140 feet west of the fluorspar outcrop, is apparently a northeast extension from the fracture zone containing fluorspar deposits farther to the southwest. There is a possibility that mineralization extended outward from this fracture into the limestone. If so, a fairly large deposit of fluorspar may underlie the porphyry body separating the fracture trace and the fluorspar outcrop.

The second deposit north of Spar Creek is in a breccia zone shown near the center of the north side of figure 3. The southwest portion of the zone, which outcrops on the Spar Valley slope, is filled almost completely with silica and contains only a relatively low percentage of fluorspar. Farther northeast, however, the silica-fluorspar ratio reverses, and in the vicinity of the faulted offset, the breccia zone filling is primarily fluorspar. The mineralized zone attains a thickness up to 8 feet. It is doubtful whether the exposed mineralized breccia contains enough fluorspar to be profitably concentrated, but good deposits may have developed in underlying limestones cut by the breccia.

Some of the smaller deposits of the Spar Valley area contain workable quantities of fluorspar, particularly if they are worked in conjunction with other mining activities in the area. Furthermore, any of the described deposits could prove to be very much more extensive than is evident from their surface exposures.

Future development.—Even though the quantity of fluorspar now known to exist in the Spar Valley area seems adequate to justify even a fairly large scale operation, further testing is necessary for selecting the most favorable deposits and to determine the most practicable method of mining. Any successful large scale operation must be based on a method of economically concentrating the mill-grade material which comprises by far the greatest percentage of the known fluorspar. Selection of the type of milling equipment best adapted to concentrating the Spar Valley fluorspar should be based upon the market requirements for different commercial grades (acid, metallurgical, etc.) which could be produced in quantity and upon the response of the raw material to the different methods of treatment.[7] Much of the raw fluorspar now visible in the Main locality and in some of the smaller localities could be concentrated by comparatively simple methods into metallurgical-grade product, and also a small percentage of acid-grade lump could be obtained. However, a substantial part of the Main locality ore and almost all of the Red Pit material is rather intimately intermixed with the gangue minerals and will require grinding to a particle size below the metallurgical standard in order to liberate fluorspar from the gangue. This finer grained material can probably be most satisfactorily treated by flotation separation. Fortunately all of the known deposits are essentially free from objectionable impurities such as sulphur, base metal sulphides, and barite.

Marine Ranch Locality

Two fluorspar deposits are known on the Marine ranch, and float found mixed with slope debris at other places suggests the presence of other deposits. One deposit is located 1500 feet east of the Marine ranch camp house, which is 5900 feet south 13° east of the Main locality in the Spar Valley area. This deposit is very poorly exposed and occurs in a fractured belt within an isolated limestone outcrop.

The mineralized zone includes vein and replacement fluorspar associated with silica and masses of reddish-brown calcite. Blocks of siliceous limestone on the surface may represent horses within the mineralized zone. The deposit appears to have a total width of from 30 to 35 feet, while the length is indeterminate due to alluvial covering. In the very limited exposures some good milling grade fluorspar

[7]Publications dealing with the treatment of fluorspar include the following:

Clemmer, J. B., Duncan, W. E., DeVaney, F. B., and Guggenheim, M., Flotation of southern Illinois lead-zinc-fluorspar ores: U. S. Bur. Mines, Rept. In. 3437, 31 pp., 1939.

Coghill, W. H., Classification and tabling of difficult ores, with particular attention to fluorspar: U. S. Bur. Mines, Tech. Paper 456, 40 pp., 1929.

Coghill, W. H., and Greeman, O. W., Flotation of fluorspar ores for acid spar: U. S. Bur. Mines, Rept. In. 2877, 3 pp., 1928.

Dean, R. S., and others, Ore-testing studies, 1937-38: U. S. Bur. Mines, Rept. In. 3425, pp. 97-99, 1939.

Ladoo, R. B., Fluorspar: its mining, milling, and utilization, with a chapter on cryolite: U. S. Bur. Mines, Bull. 244, 184 pp., 1927.

Mitchell, D. R., Grass, H. E., Oehler, H. E., Froth flotation of fluorspar: Amer. Inst. Min. Met. Eng., Tech. Pub. 999, 13 pp., November, 1938.

Prater, Lewis I., Flotation tests on fluorite ore from Lemhi County, Idaho: Idaho Bur. Mines Geol., Pamph. 63, 8 pp., April, 1943.

Reeder, E. C., Milling methods and costs at the Hill side fluorspar mine, Rosiclare, Illinois: U. S. Bur. Mines, Inf. Circ. 6621, 20 pp., 1932.

can be seen, but no definite opinion as to the quality and quantity of material present can now be formed. One or two transverse trenches might prove the worth of this deposit.

A second fluorspar occurrence in a fracture and breccia zone in porphyry extends from about 200 feet west of the Marine ranch camp house in a general westerly direction for nearly one-fourth of a mile, where it disappears beneath an alluviated valley. The fluorspar fills open fractures and interlacing veinlets, approaching in some places the character of small stock works. The fluorspar zone pinches and widens irregularly and is only locally delimited by well defined vein walls. Siliceous vein filling occurs with the fluorspar, and in some parts of the zone it comprises essentially all of the introduced mineral matter. Near the western terminus of the zone, some veins 2 to 10 inches in thickness are filled with very high grade crystalline fluorspar. The main body of the deposit, however, includes a high percentage of silica and porphyry host rock, and it is very doubtful whether separation of the fluorspar would be economically feasible.

This deposit is of interest primarily because it indicates strong mineralization in the area which under favorable conditions would probably result in workable accumulations of fluorspar. The Marine ranch area can at present be recommended only for further surface prospecting and for test trenching, particularly in the first deposit described.

CONCLUSION

The fluorspar industry has grown with the industrial expansion of the Nation to an extent that is illustrated by the fact that the annual consumption, even in the comparatively average conditions of the immediate past war period, was greater than the entire National production during the last 30 years of the 19th century. Old uses have been maintained against competitive materials and new uses and applications are being developed. New developments of such deposits as those of the Eagle Mountain district should have an excellent opportunity for success and would help supply the demands of the present war-time industry.

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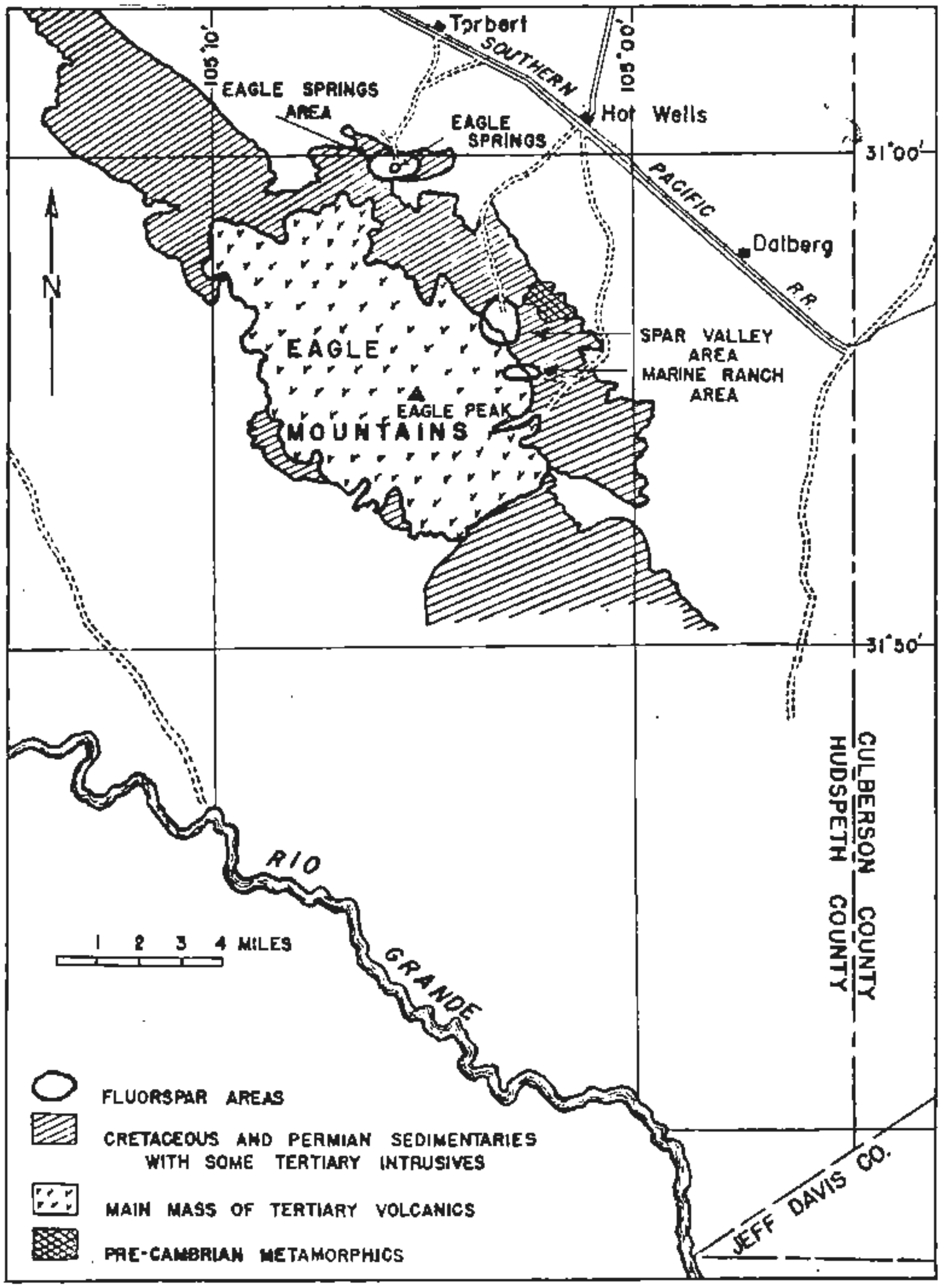

FIGURE 1. Sketch map of a part of Culberson and Hudspeth counties indicating location of fluorspar area. Adapted from The University of Texas Bulletin 2745.

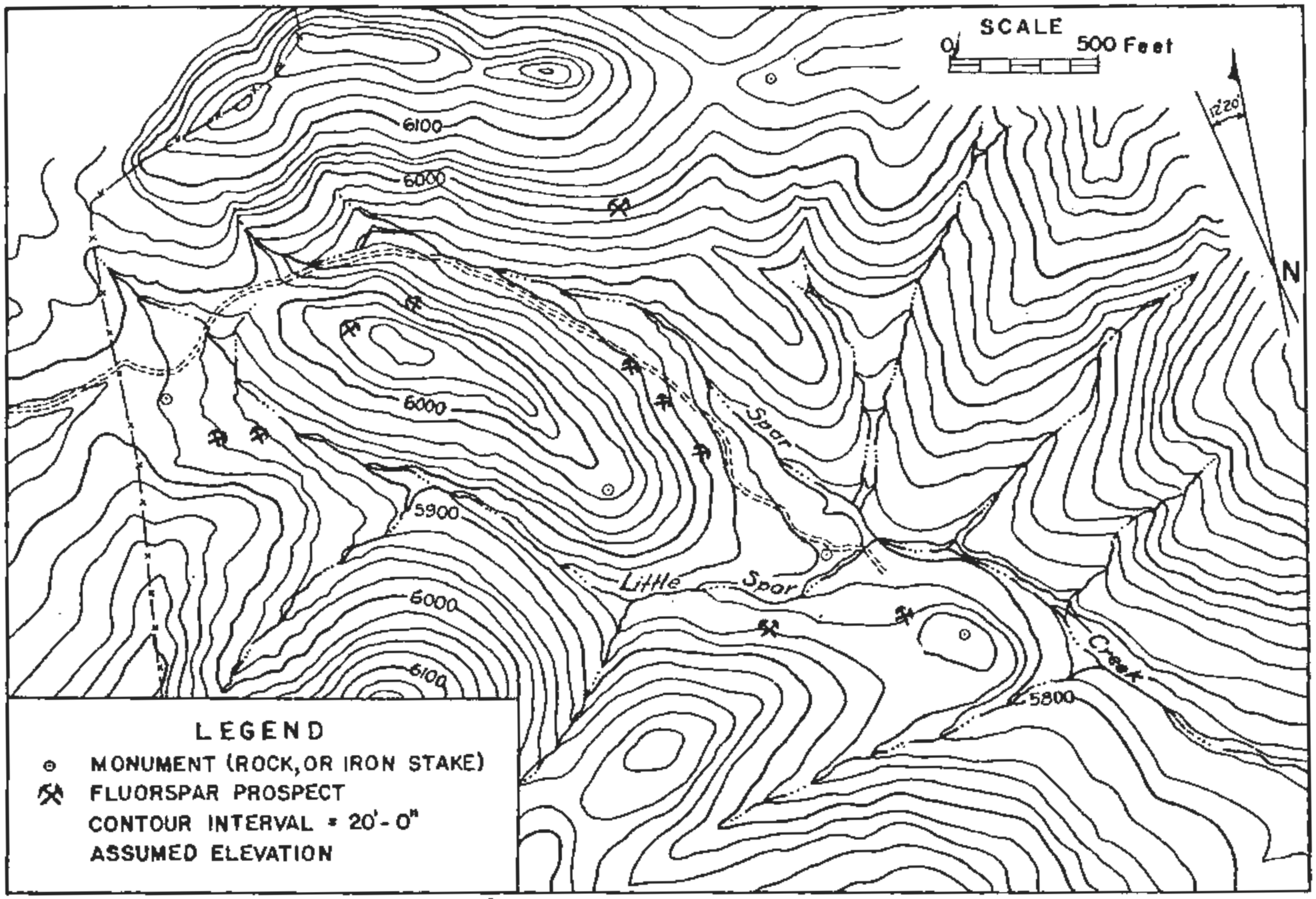

FIGURE 2. Topographic map of Spar Valley fluorspar area.

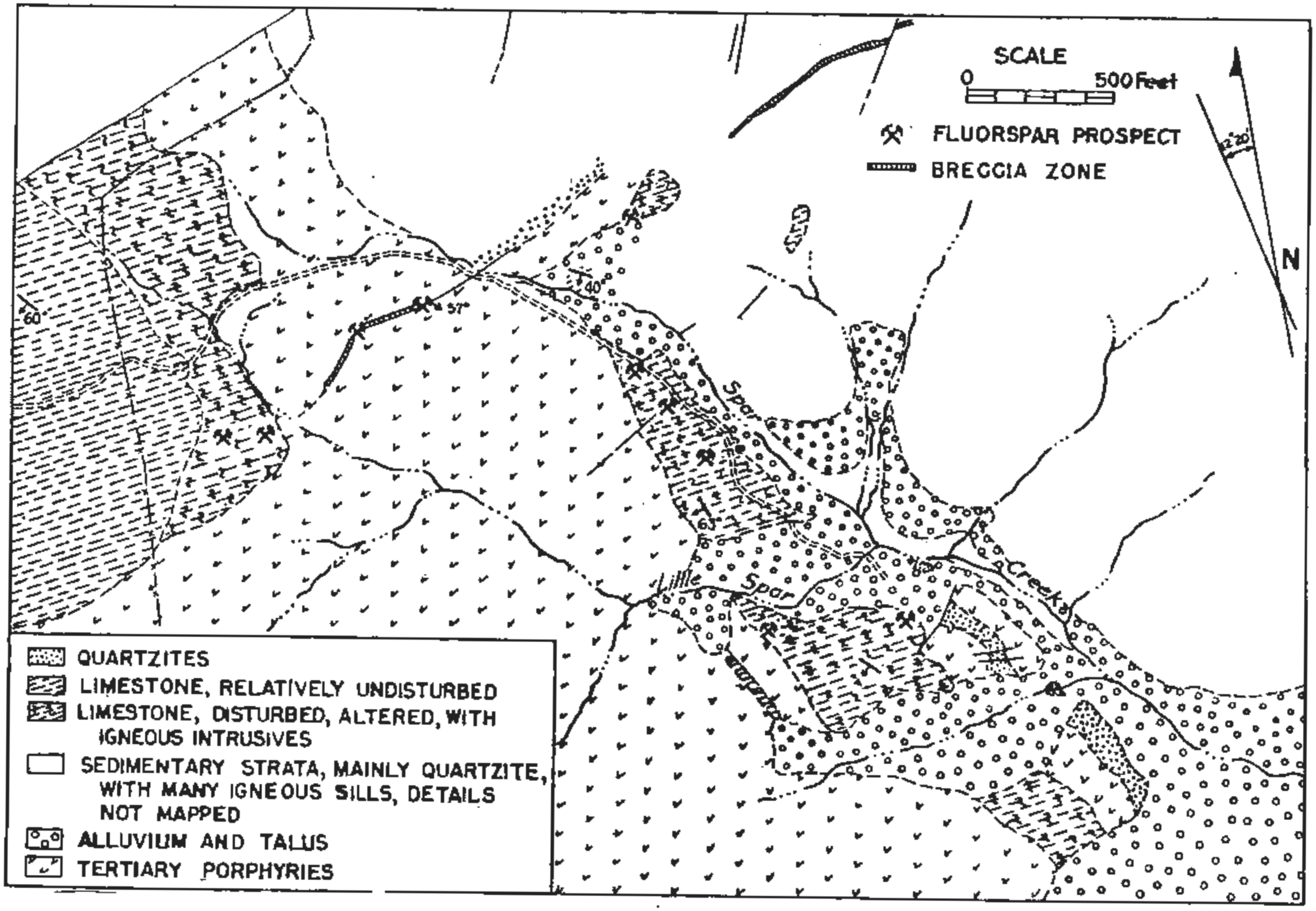

Figure 3. Geologic map of Spar Valley fluorspar area.